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Environmental Report for the SEA of the Scottish Government's Preferred Policy Position on Unconventional Oil and Gas in Scotland

Final Report
Prepared by LUC
October 2018

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Glossary

Abbreviations	
AQMA	Air Quality Management Area
Bcf	Billion cubic feet
BGS	British Geological Survey
C	Carbon
CAR	Water Environment (Controlled Activities) (Scotland) Regulations 2011
CBM	Coal bed methane
CCC	Committee on Climate Change
CCRA	Climate Change Risk Assessment
CCS	Carbon Capture and Storage
CH ₄	Methane
CO	Carbon monoxide
COMAH	The Control of Major Accident Hazards Regulations 2015
CO ₂	Carbon dioxide
COPD	Chronic Obstructive Pulmonary Disease
DAS	Distributed Acoustic Sensing
DECC	Department of Energy and Climate Change (incorporated into newly formed Department for Business, Energy & Industrial Strategy in July 2016).
DTS	Distributed Temperature Sensing
DWQR	Drinking Water Quality Regulator
EC/EU	European Commission/European Union
EIA	Environmental Impact Assessment
EPS	European Protected Species
ESCAPE	European Study of Cohorts for Air Pollution Effects
EU ETS	EU Emissions Trading System
FBG	Fibre Bragg gratings
FP	Flowback and Produced (water)
Ft	Foot – unit of length
GCR	Geological Conservation Review
GHG	Greenhouse gas
HAP	Hazardous air pollutant
HES	Historic Environment Scotland
HPS	Health Protection Scotland

Abbreviations	
HRA	Habitats Regulations Appraisal
HSE	Health and Safety Executive
H ₂ O	Water (liquid or vapour)
ICF	International Climate Fund
IPCC	Intergovernmental Panel on Climate Change
Km ²	Square kilometres
KPMG	An accounting firm and one of the Big Four Auditors. KPMG stands for Klynveld Peat Marwick Goerdeler
Kt	Kilotonnes
LNG	Liquefied natural gas
m ³	Cubic metres
MEW	The Management of Extractive Waste (Scotland) 2010 Regulations
M _L	Richter Magnitude (or Local Magnitude) – measure of earthquake magnitude
MMBOE	Million barrels of oil equivalent
Mt	Million tonnes
MtCO ₂ e	Million tonnes of carbon dioxide equivalent
NDPB	Non Departmental Public Body
NH ₃	Ammonia
NMVOC	Non-methane volatile organic compounds
NNR	National Nature Reserves
N ₂ O	Nitrous oxide
NO	Nitric oxide
NORM	Naturally Occurring Radioactive Material
NO _x	Nitrogen oxides
NPF	National Planning Framework
NRW	Natural Resources Wales
NSA	National Scenic Area
O ₃	Ground level ozone
ONS	Office for National Statistics
PAH	Polycyclic Aromatic Hydrocarbons
PAN	Planning Advice Note
PEDL	Petroleum Exploration and Development Licence
PM ₁	Particulate matter up to 1 micrometre in diameter

Abbreviations	
PM _{2.5}	Particulate matter up to 2.5 micrometres in diameter
PM ₁₀	Particulate matter up to 10 micrometres in diameter
PPC	Pollution Prevention and Control (Scotland) Regulations 2012
RBMP	River Basin Management Plan
RSA	Radioactive Substances Act 1993
SAC	Special Area of Conservation
SEA	Strategic Environmental Assessment
SEPA	Scottish Environment Protection Agency
SNH	Scottish Natural Heritage
SO ₂	Sulphur dioxide
SO _x	Sulphur oxides
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
Tcf	Trillion cubic feet
tCO ₂	Tonnes CO ₂
TWh	TeraWatt
UKCP09	UK Climate Projections 2009
UN	United Nations
UOG	Unconventional Oil and Gas
VOC	Volatile organic compounds
WHO	World Health Organisation

Definitions	
Abandonment	A phase of decommissioning for an oil and gas well.
Associated liquids	Natural liquids that are produced as an associated product to shale gas. It is estimated that 75% of 'existing' shale gas pads also produce associated liquids.
Associated gas	Natural gas produced with crude oil from the same reservoir.
Barrel	A unit of volume measurement used for oil and its products.
Borehole	A hole drilled into the earth. Boreholes can be used to remove core samples of rock for geologic analysis. A borehole that is used to extract oil or gas or water is sometimes called a well.
Carbon Capture and Storage (CCS)	Carbon capture and storage is a technology that can capture the carbon dioxide emissions produced from the use of fossil fuels, preventing the carbon dioxide from entering the atmosphere.
Casing	Metal pipe inserted into a wellbore and cemented in place to protect subsurface formations.
Coal bed methane	Coal bed methane is considered to be an unconventional source of gas because the gas is absorbed in the coal rather than being held in pore spaces.
Coal field	An extensive area containing a number of underground coal strata.
Completion	The installation of permanent downhole and wellhead equipment for the production of oil and gas.
Conventional oil and gas	Oil and gas that is recovered by drilling a well in porous rock, with the oil or gas flowing out under its own pressure.
Decommissioning	The process to remove all the equipment used for production of unconventional oil and gas and return the site to its original condition and use.
Drilling pad	A hard standing area for development of drilling wells and production of gas and oil.
Drilling rig	The equipment used to drill holes into the earth called boreholes and wells.
Exploration well	Drilling carried out to determine whether hydrocarbons are present in a particular area or structure.
Field	A geographical area under which an oil or gas reservoir lies.
Fugitive emission	Emissions of gasses or vapours from industrial equipment due to leaks or other unintended or irregular releases, during industrial activities.

Definitions	
Gas field	A field containing natural gas but no oil.
Greenhouse gas	A greenhouse gas is any gaseous compound in the atmosphere that is capable of absorbing infrared radiation, thereby trapping and holding heat in the atmosphere.
Hazard/risk	A hazard is a potential source of harm, e.g. electricity, chemicals, stress. A risk is the likelihood, or chance, that something will cause harm.
Hydraulic fracturing	A drilling technique, commonly referred to as 'fracking', that fractures rock to release the oil and gas contained in the rocks.
Hydrocarbon	A compound containing the elements hydrogen and carbon. May exist as a solid, a liquid or a gas. The term is mainly used in a catch-all sense for oil, gas and condensate.
Liquefied natural gas	Gas, chiefly methane, liquefied for transportation.
Moratorium	A temporary prohibition in an activity.
Natural gas	Natural gas is a source of energy. It is typically composed of a mixture of hydrocarbons such as methane, hydrogen, carbon monoxide, carbon dioxide and nitrogen.
Natural gas liquids	The portions of gas from a reservoir that can be liquefied. Ethane, propane, butane, isobutene, and pentane are all natural gas liquids.
Oil	A mixture of liquid hydrocarbons.
Operator	A company that has legal authority to drill wells and to access hydrocarbons.
Pad	Onshore development and production platform/area which can have multiple wells associated with it.
Petrochemicals	Chemical products obtained from petroleum/natural oil and gas. Companies supply petrochemicals for use in manufacturing and production.
Petroleum	A generic name for hydrocarbons, including crude oil, natural gas liquids, natural gas and their products.
Reserve	The amount of technically and economically recoverable oil and gas in a particular location.
Reservoir	The underground formation where oil and gas has accumulated. It consists of a rock formation to hold the oil or gas, and a cap rock that prevents its escape.
Resource	The amount of estimated oil and gas in a particular location.
Seismic activity	Vibration of the ground or earthquakes due to natural or artificial causes.
Shale gas	Shale gas is a form of natural gas trapped within shale rock or other formations of low permeability.

Definitions	
Shale oil	Shale oil is a form of oil trapped within shale rock or other formations of low permeability.
Shale rock	Shale is an impermeable rock from which natural oil and gas can be extracted.
Unconventional oil and gas	The term 'unconventional' refers to the types of geology in which the oil and natural gas are found. For the purpose of this SEA, unconventional oil and gas includes shale gas, associated liquids and coal bed methane.
Well	The hole drilled by a drilling rig to explore for or develop oil and/or natural gas.
Wellhead	The equipment at the surface of a well that is used to control the pressure; the point at which the hydrocarbons and water exit the ground.

Non-Technical Summary

Introduction to the Scottish Government's Preferred Policy Position

The Scottish Government has taken a cautious, evidence-led approach to considering onshore unconventional oil and gas in Scotland. This included the establishment of an Independent Expert Scientific Panel ('the Expert Panel') to examine the evidence on unconventional oil and gas, including hydraulic fracturing, or 'fracking', and coal bed methane extraction.

In January 2015, the Scottish Government announced a moratorium on onshore unconventional oil and gas development in Scotland. The moratorium created space to explore issues identified by the Expert Panel, and to carry out a full public consultation. A series of independent research studies were commissioned on issues such as climate, seismic activity, transport and health impacts.

On 24 October 2017, the Scottish Parliament voted in favour of the Scottish Government's preferred policy position of not supporting onshore unconventional oil and gas development in Scotland.

A Strategic Environmental Assessment (SEA) on the Scottish Government's preferred policy position is required to be undertaken, and the findings are set out in this Non-Technical Summary and the Environmental Report.

Unconventional oil and gas in Scotland

What is unconventional oil and gas?

Unconventional oil and gas deposits are contained in impermeable rocks, such as shale or coal deposits. The term 'unconventional' in unconventional oil and gas refers to the types of geology in which the oil and natural gas are found. For the purpose of this study, unconventional oil and gas includes shale gas, associated liquids and coal bed methane.

Hydraulic fracturing (or 'fracking') is a drilling technique that is used to fracture rock to release the oil and gas contained in those rocks. It is most commonly used to extract oil and gas from shale. The rock is fractured by injecting pressurised fluids to open small spaces which allow the release of oil or gas.

Coal bed methane (CBM) is also considered to be an unconventional source of gas. This is because the gas is present in the coal rather than being held in pore spaces within rock. To extract the gas, water is drained from the coal seam to release pressure (known as dewatering). This may be undertaken with or without hydraulic fracturing, depending on local geological conditions.

What is unconventional oil and gas used for?

Unconventional oil and gas can contribute to the provision of natural gas (for energy or energy production) and natural gas liquids as a raw material for the petrochemical industry.

Where is unconventional oil and gas found in Scotland?

Most of Scotland's unconventional oil and gas deposits occur in and around former coalfields and oil shale fields in Scotland's Central Belt as well as in the area around Canonbie, Dumfriesshire.

What is involved in the development of onshore unconventional oil and gas?

Unconventional oil and gas development typically involves the following phases of activity: exploration, appraisal, production and decommissioning.

- The **exploration phase** tests the commercial viability of a site and can include drilling boreholes, seismic surveys, horizontal drilling and hydraulic fracturing tests in relation, most commonly, to shale oil or gas developments.
- Where the exploration phase suggests sites are likely to be viable, the **appraisal stage** involves more detailed tests to ensure the oil and/or gas can be extracted. Concrete pads and access roads will normally be built, drilling rigs erected and vertical and horizontal drilling undertaken. The exploration and appraisal phases may last between two and six years.
- If a site is suitable for **production** it is likely that more wells will be drilled and hydraulically fractured (in the event shale oil and/or gas is being targeted or if hydraulic fracturing is required in the pursuit of coal bed methane), with accompanying site activity. After around two years, when the well is established, activity is likely to be limited to maintenance. Production may continue for around 15 years. If the site is targeting gas from coal seams, operations are also likely to include the pumping and treatment of water to release methane that is trapped in the rock.
- Once a site is no longer able to supply oil and gas viably, it will be **decommissioned** with wells being plugged and abandoned. Surface buildings and equipment will be removed and monitoring and aftercare regimes put in place. Decommissioning can take between two and five years.

How much potential for unconventional oil and gas development is there in Scotland?

There is considerable uncertainty about the scale of unconventional oil and gas development that could take place in Scotland, in the absence of the Scottish Government's preferred policy position. This includes uncertainty about the amount of oil and gas that it would be economic to extract. This would influence the scale of development that could take place across Central Scotland.

To help understand the possible effects of unconventional oil and gas development in Scotland, this environmental assessment has drawn on three scenarios each reflecting a different scale of development, developed by KPMG as part their Economic Impact Assessment of unconventional oil and gas in Scotland¹ which is one of a suite of research studies commissioned by the Scottish Government to inform the evidence base,. The scenarios are:

¹ KPMG (2016) Economic Impact Assessment and Scenario development of unconventional oil and gas in Scotland. A Report for the Scottish Government. Available at: <http://www.gov.scot/Resource/0050/00509321.pdf>

- **Low:** 10 developments, each with 10 wells; and two CBM developments, each with 15 wells.
- **Central:** 20 developments, each with 15 wells; and two CBM developments, each with 15 wells.
- **High:** 31 developments, each with of 30 wells; and two CBM developments, each with 15 wells.

This environmental report has drawn on a wide range of evidence sources about the environmental effects of unconventional oil and gas development, including the suite of studies commissioned by the Scottish Government².

What is Strategic Environmental Assessment?

Strategic Environmental Assessment (SEA) is a way of considering the environment when preparing public plans, programmes and strategies. It identifies potential significant environmental effects and, where necessary, describes how these effects can be avoided or reduced. Through consultation, SEA also provides an opportunity for the public to express their views on proposed policies and their potential environmental impacts.

In this case, SEA is being used to assess the likely environmental effects of the Scottish Government's preferred policy position of not supporting onshore unconventional oil and gas development in Scotland.

How was the Strategic Environmental Assessment undertaken?

SEA is an assessment of the likely significant environmental effects of the preferred policy position and alternatives to it. The Environmental Report first considers the environmental effects of unconventional oil and gas development on each of the SEA topics (air, water, soil, climate, biodiversity, flora and fauna, cultural and archaeological heritage, landscapes and geodiversity, material assets and population and human health). It then considers:

- How do these effects relate to the current environmental pressures and trends?
- What current regulatory processes control these effects?
- What stages of unconventional oil and gas development result in these effects, and what is the nature of these effects? This is considered for each of the following scenarios:
 - Business as usual
 - Pilot project
 - Preferred policy position

The evidence base does not consistently make clear differences between the environmental impacts of coal bed methane and shale oil and /or gas extraction. However, where different effects can be identified these are drawn-out in the assessment. Cumulative, secondary and synergistic effects are considered,

² The studies are available at the following website: <https://www.gov.scot/Topics/Business-Industry/Energy/onshoreoilandgas/EvidenceGathering>

followed by potential mitigation. Findings are then presented in a summary table for each of the SEA topics.

The assessment identifies positive and negative environmental effects and the significance of these, considers whether they would be temporary or permanent, and notes where they would arise in the short, medium or long term. It also distinguishes between effects arising directly from the preferred policy position and any 'secondary' effects, which would indirectly impact on the environment. 'Cumulative' effects are also identified, including where there will be several impacts in particular areas, or on specific environmental features.

Which reasonable alternatives have been considered?

Part of the assessment involves considering alternative policy positions (referred to as 'reasonable alternatives'). The Scottish Government's preferred position is that it does not support the development of unconventional oil and gas in Scotland. The Scottish Government considers the development of an onshore unconventional oil and gas industry in Scotland would make achieving its ambitious energy and climate change commitments even more challenging. The Scottish Government acknowledges the important role of gas in the transition to a low carbon energy future. However, the addition of an onshore unconventional oil and gas industry would not promote Scotland's ability to meet the established greenhouse gas emissions targets and objectives in relation to protecting and enhancing the environment.

It is recognised that some may regard the development of the industry, subject to the relevant licensing and permitting regimes, as alternatives to the preferred policy position. These alternatives are described in the report as:

- 'business as usual';
- pilot project.

While the Scottish Government is not minded to view these as reasonable alternatives it does, however, wish to invite views on their assessment.

What are the key environmental challenges relating to unconventional oil and gas development in Scotland?

Air: Air quality across Scotland is generally good. In most areas, pollution levels are well below limits set to protect human health and the environment. Poor air quality is, however, a particular concern in a number of towns and cities across central Scotland. Road transport and industrial emissions account for a large share of air pollution, with localised hotspots tending to be in locations with high traffic volumes. Unconventional oil and gas development could affect air quality through leakage of gas, by pollution from on-site 'flaring' and from the exhausts of on-site equipment and transport movements.

Water: Scotland has large water resources relative to its total land area. Recent decades have seen significant improvements in the quality of water in many rivers, canals and estuaries, though more work is required to improve the quality of many rivers across the Central Belt. Flooding is a significant issue in a number of urban centres in central Scotland, often coinciding with areas where communities are particularly vulnerable to the impacts of flood events. Flood risk has increased as a result of development, changes in the way farmland is managed, changing rainfall

patterns associated with climate change and, along the coast, sea level rise. Natural habitats including woodlands, wetlands and peatlands are recognised as playing an important role in managing the risk of flooding. Unconventional oil and gas development could pollute ground and surface water due to the release of contaminated water or other hazardous materials. Where water is pumped out of the ground to release methane, there could be impacts on the levels of ground and surface water, with knock on effects for biodiversity and the supply of water for other uses.

Soil: Scotland's soils are diverse and are important for biodiversity, agriculture and forestry, play a significant role in absorbing and storing carbon from the atmosphere, and absorb and filter water. Unconventional oil and gas development could increase the amount of soils lost to development, could increase the risk of soil pollution from leaks and accidental release of materials and could result in the release of greenhouse gases from high carbon soils.

Climate: Scotland's climate is characterised by generally cool summers, mild winters and rainfall spread throughout the year. There is growing evidence that Scotland's climate has changed over the past century and scientific projections suggest that patterns of change will continue. Key trends include drier summers, wetter winters and more frequent heavy rainfall. Total annual rainfall is increasing in Scotland. Warming trends are resulting in rising sea levels, whilst an increase in storminess could increase the risk of storm surges or increased wave heights. Climate change could have adverse effects on other aspects of the environment, including water and air quality, as well as biodiversity and human health. Scotland has made good progress in cutting its greenhouse gas emissions so as to play its part in global efforts to slow the rate of climate change. Unconventional oil and gas development could result in greenhouse gas emissions as a consequence of leakage, processing, transport and use of gas.

Biodiversity, flora and fauna: Scotland has a rich natural heritage, with a network of nationally and internationally important sites supporting many rare plants, birds and animals. Biodiversity across Central Scotland has historically been under pressure from new development, agricultural change and the loss of semi-natural habitats such as wetlands, woodlands and hedgerows. Unconventional oil and gas development could add to these pressures by further fragmenting habitats, increasing noise and disturbance, affecting water dependent habitats, the accidental release of polluting materials and adding to the risk of climate change and the spread of invasive species.

Cultural and archaeological heritage: Scotland's historic environment includes thousands of historic buildings and monuments. Within central Scotland, important historic assets include World Heritage Sites, Conservation Areas, battlefields, archaeological sites, historic buildings, historic designed landscapes and former industrial sites. Continued development and factors such as climate change mean that many historic sites, including those not protected by designation, are under pressure. Unconventional oil and gas development could contribute to these pressures.

Landscape and geodiversity: Scotland contains a wide variety of landscapes including mountains, moorland, farmland, coasts and islands. Together these landscapes contribute to the attractiveness of Scotland as a place to live, visit and invest. New development, together with changes in agriculture and forestry are increasing pressure on Scotland's landscapes, whilst further impacts result from

changing climate and our efforts to slow and adapt to it. Unconventional oil and gas development could add to development pressures on the landscape across central Scotland as well as contributing to climate related landscape change.

Material assets: Scotland has many natural resources and material assets, not least its high quality agricultural land, and extensive areas of forestry and woodland. Scotland's transport infrastructure is also a key asset, connecting our urban and more remote rural areas. Unconventional oil and gas development could reduce opportunities to access some natural resources whilst increasing pressure on transport infrastructure.

Population and human health: The population in Scotland is estimated to be 5 million people and is concentrated in central Scotland in Glasgow and the Clyde Valley, the Lothians, Fife, Falkirk, Stirling, Clackmannanshire and Ayrshire. Scotland's population is continuing to grow, though there is significant variation in trends within the Central Belt and across Scotland more widely. The population is, however, aging, with an increase in the proportion of older people. The contribution of a high quality environment to people's health and wellbeing is increasingly well understood, with factors such as air pollution and water quality, as well as access to outdoor recreation playing an important role. Unconventional oil and gas development could affect population and human health in a number of ways including noise and light pollution, odour, the risk of accidental release of polluting materials, increases in road traffic, visual impacts, health and safety impacts and concerns about minor earth tremors that could be associated with exploration and extraction.

Which existing environmental protection objectives are relevant?

There are many established environmental protection objectives, which form the context for the assessment. International and national level policies and strategies aim to protect and enhance our environment. Biodiversity objectives focus on sites and species which are of particular value, and aim to protect and improve natural heritage networks. Objectives for water, soil and air aim to reduce pollution, and to reverse the effects of past emissions. Landscape objectives protect our most scenic areas, reflect the importance of the interaction between people and the land, and aim to enhance areas where landscape qualities have been eroded over time. Cultural heritage objectives range from protection of internationally and nationally important assets to recognition and management of more locally important buildings and archaeology, and their wider setting. Cutting across all of these objectives, international and national climate change objectives are expressed in targets for reducing greenhouse gas emissions, and also support adaptation to changing weather patterns.

Proposals for unconventional oil and gas development would be subject to a number of regulatory and consenting processes designed to ensure that these environmental protection objectives are met. These include regulations governing emissions to air and water, the assessment of impacts on important nature conservation sites, requirements for environmental monitoring, health and safety measures and the management of accidental release of hazardous material. The following bodies act as regulators:

- Scottish and UK Governments;
- Oil and Gas Authority;

- Coal Authority;
- Health and Safety Executive;
- Scottish Environment Protection Agency;
- Scottish Natural Heritage;
- Historic Environment Scotland; and
- individual local authorities through the planning process.

This range of regulatory and consenting processes would mean that some of the more significant environmental effects of unconventional oil and gas development could be avoided or reduced in significance.

Findings of the Strategic Environmental Assessment

What would happen to the environment without the preferred policy position?

Business as usual

In the absence of the preferred policy position, proposals for unconventional oil and gas development may come forward. Subject to gaining planning consent and meeting other regulatory requirements, development could take place at locations across central Scotland.

There is considerable uncertainty as to the amount of development that would occur, whilst a number of potential impacts would depend on the locations where development took place. The assessment has therefore drawn on assumptions based on previous technical studies commissioned by the Scottish Government.

Where appropriate the assessment has distinguished between different types of unconventional oil and gas development and between the various operations that these activities entail. The detailed findings are set out in the Environmental Report with a summary of the main effects presented here.

The development of an unconventional oil and gas industry in Scotland has the potential for significant negative effects on:

- **air** as a result of direct gas emissions, and of exhaust emissions from construction activities and traffic serving the developments;
- **water quality** as a result of the pollution of ground and surface water due to the release of contaminated water, hazardous materials or saltwater intrusion. The combined effects of pollution and the abstraction of water could result in more significant impacts on the water environment;
- **climatic factors** as a result of the uncontrolled and controlled release of produced gas to the atmosphere, the release of greenhouse gases as a result of site development and the release of greenhouse gases from the processing and use of Scottish unconventional oil and gas. The combined effects of these greenhouse gas emissions could be significant. The development of an unconventional oil and gas industry in Scotland would make achieving the Scottish Government's energy and climate change commitments even more challenging and would not promote its objectives in relation to decarbonising the economy;

- **biodiversity flora and fauna** as a result of the loss and fragmentation of habitats and due to the risks associated with accidental spills of hazardous materials, the spread of invasive species and impacts on wetland systems upon which particular species depend. The combined impact of these effects, together with disturbance and the effects of accelerated climate change, could be significant;
- **cultural and archaeological heritage** as a result of changes affecting the setting of important historic sites;
- **landscapes and geodiversity** as a result of the impact of unconventional oil and gas development on the character and quality of landscapes, and the associated visual impacts of oil and gas extraction sites; and
- **population and human health** as a result of potential risks to physical health and safety. The combined effect of this with a range of other impacts (noise, light pollution, odours, recreation and amenity and road safety), could also be significant.

Several of these effects could combine to result in more significant effects on population and human health (for example as a consequence of cultural heritage, landscape, water, air and climatic impacts) and on biodiversity, flora and fauna (for example, as a consequence of air, water and climate impacts).

Pilot project

An alternative development scenario, based on a single unconventional oil and gas pilot project was also assessed as a further alternative to the preferred policy position. The very limited scale of development implied by this alternative would result in much lower environmental impacts. The potential for significant effects would remain depending on the pilot's location relative to sensitive communities, habitats, waterbodies or historic sites, while the risk of pollution associated with accidents or unplanned emissions would remain. There could also be significant population and human health effects as a result of physical health and safety risks.

What are the environmental implications of the preferred policy position?

The effect of the preferred policy position would be to avoid the environmental impacts associated with the development of unconventional oil and gas in Scotland listed above. The avoidance of these impacts means that the preferred policy position would result in significant positive environmental effects across all of the SEA topic areas.

The preferred policy position would also avoid significant cumulative environmental impacts that could result from an unconventional oil and gas industry in Scotland.

What measures could be put in place to avoid, reduce or manage the environmental effects of the preferred policy position or Reasonable Alternatives to it?

The assessment has concluded that the preferred policy position would not result in significant negative impacts on the environment, so additional measures to avoid, reduce or manage its environmental effects are not required.

The assessment did, however, find that an alternative policy approach, based on allowing unconventional oil and gas development in Scotland, could result in significant negative effects on the environment, even when taking account of

existing regulation and consenting processes. Therefore, mitigation measures are identified for alternatives to the preferred policy position. These include:

- monitoring and regular site inspections during all stages of development to identify and address air or water pollution, noise, light or odour impacts;
- use of technology to limit greenhouse gas emissions or for the treatment, re-use and disposal of waste water;
- management of traffic movements and sharing of infrastructure for adjacent sites;
- measures to reduce the risk and severity of accidental pollution spills;
- best practice in site selection, design, construction and restoration methods and programming; and
- carbon off-setting measures such as woodland planting or investment in low carbon energy development.

The effectiveness of many of these measures would depend on the characteristics of the development in question, so it is not possible to describe their effectiveness accurately. While they would help reduce the scale and severity of effects, it is, however, likely that environmental impacts would remain.

What monitoring is proposed?

It is important to monitor the implementation of the preferred policy decision to identify and address any potential or unforeseen negative environmental effects.

There is a strong relationship between the preferred policy position on unconventional oil and gas in Scotland and the Scottish Government's energy policy. It is anticipated that any unforeseen environmental effects would be most likely to relate to the energy sector, and the sourcing, production and use of different energy sources.

Therefore the proposed monitoring and reporting mechanism for unforeseen adverse effects will be the Annual Energy Statement which will be published by the Scottish Government. This Statement will set out:

- the latest energy statistics;
- the progress made towards existing targets and the new 2030 targets progress made under each of the six Strategic Priorities;
- changes within the UK energy market and international frameworks; and
- an assessment of technological changes and advances with a bearing on Scotland's energy system.

Official Statistics on Scotland's greenhouse gas emissions inventory are published annually by the Scottish Government. Independent reports on Scotland's progress in reducing emissions are published annually by the Committee on Climate Change. The Scottish Government's current Climate Change Plan has established a new monitoring framework, with annual reports on progress towards a suite of policy output and implementation indicators.

How can I comment on this Environmental Report?

The consultation on the preferred policy position on unconventional oil and gas development and the Environmental Report and partial Business and Regulatory Impact Assessment (BRIA) runs for an eight week period from 23 October 2018 until 18 December 2018. Comments on the preferred policy position, Environmental Report and partial BRIA can be submitted to the Scottish Government's consultation platform Citizen Space. You can view and respond to the consultation online at: <https://consult.gov.scot/energy-and-climate-change-directorate/preferred-policy-position-on-uog/>.

You can save and return to your responses while the consultation is still open. Please ensure that consultation responses are submitted before the closing date of 18 December 2018. If you are unable to respond online, please complete the Respondent Information Form (see 'Handling your Response' below) and send it to:

Onshore Oil and Gas Team

The Scottish Government

3F South

Victoria Quay

Edinburgh EH6 6QQ

If you respond using Citizen Space you will be directed to the Respondent Information Form. Please indicate how you wish your response to be handled and, in particular, whether you are happy for your response to be published.

If you are unable to respond via Citizen Space, please complete and return the Respondent Information Form included in this document. If you ask for your response not to be published, we will regard it as confidential, and we will treat it accordingly.

All respondents should be aware that the Scottish Government is subject to the provisions of the Freedom of Information (Scotland) Act 2002 and would therefore have to consider any request made under the Act for information relating to responses made to this consultation exercise.

How will responses be considered?

Following the consultation period, the consultation responses on the preferred policy position, this Environmental Report and the partial BRIA will be analysed.

Responses to the consultation will be taken into account in the preparation of the final policy position.

Finalising the Scottish Government's position

Following analysis of the consultation responses, Ministers will finalise their policy on unconventional oil and gas development in Scotland and publish a SEA post-adoption statement.

Suggested questions for responses to this Environmental Report and the Scottish Government's preferred policy position

Respondents may find the following questions helpful to provide a focus for their responses to this Environmental Report and the preferred policy position.

- What are your views on the accuracy and scope of the information used to describe the SEA environmental baseline set out in the Environmental Report?
- What are your views on the predicted environmental effects as set out in the Environmental Report?
- What are your views on the 'reasonable alternatives' outlined in the Environmental Report? Please provide any other 'reasonable alternatives' which you think should be considered.
- What are your views on the findings of the SEA and the proposals for mitigation and monitoring of the environmental effects set out in the Environmental Report?
- Do you have any views on the proposals contained within the Scottish Government's preferred policy position statement? There is no need to restate views already expressed in relation to the Talking "Fracking" public consultation as these have been, and will continue to be, taken into account as we move towards finalising the Scottish Government's policy position.

1 Introduction

Background to the Scottish Government's preferred policy position on Unconventional Oil and Gas development

- 1.1 The Scottish Government has taken a cautious, evidence-led approach to considering onshore unconventional oil and gas in Scotland. This included the establishment of an Independent Expert Scientific Panel ('the Expert Panel') to examine the evidence on unconventional oil and gas, including hydraulic fracturing, or 'fracking', and coal bed methane extraction.
- 1.2 In January 2015, the Scottish Government announced a moratorium on onshore unconventional oil and gas development in Scotland. This followed the publication of the Expert Panel's report. The moratorium created space to explore specific issues and evidential gaps identified by the Expert Panel, and undertake comprehensive public consultation. A series of independent research studies were commissioned covering issues such as climate, seismic activity, transport and health impacts and a public consultation was held which received over 60,000 responses.
- 1.3 On 24 October 2017, following a Parliamentary debate, the Scottish Parliament voted in favour of the Scottish Government's preferred policy position of not supporting onshore unconventional oil and gas development in Scotland.
- 1.4 In accordance with statutory responsibilities under the Environmental Assessment (Scotland) Act 2005, a Strategic Environmental Assessment (SEA) on the Scottish Government's preferred policy position is required to be undertaken and in January 2018, the Government commissioned LUC to undertake this assessment. Once finalised, the policy on onshore unconventional oil and gas in Scotland will be reflected in the next iteration of the National Planning Framework.

Unconventional oil and gas

- 1.5 The oil and gas industry use a range of techniques to extract oil and gas from underground reserves. Conventional oil and gas reserves can be exploited by drilling a well, with oil or gas then flowing out under its own pressure.
- 1.6 Conventional deposits are contained in porous rocks with interconnected spaces, such as limestone and sandstone. These interconnected spaces give rise to permeability that allows oil or gas to effectively flow through the reservoir to the well.
- 1.7 Unconventional oil and gas deposits are contained in impermeable rocks, such as shale or coal deposits. In these cases, the oil or gas cannot easily flow through the reservoir. To extract the oil and gases, techniques such as hydraulic fracturing (commonly referred to as 'fracking') or dewatering for coal bed methane are used.
- 1.8 Most of Scotland's unconventional oil and gas deposits occur in and around former coalfields and oil shale fields in Scotland's Central Belt, which contains some of the most densely populated areas of the country, as well as in the area around Canonbie, Dumfriesshire.

- 1.9 Hydraulic fracturing (or ‘fracking’) is a drilling technique that is used to fracture rock to release the oil and gas contained in those rocks. It is most commonly used to extract oil and gas from shale. The rock is fractured by injecting pressurised fluids into the rock to prise open small spaces in the rocks, which release the oil or gas.
- 1.10 Coal bed methane is also considered to be an unconventional source of gas. This is because the gas is present in the coal rather than being held in pore spaces. To extract the gas, water is drained from the coal seam to release pressure (known as dewatering). This may be undertaken with or without hydraulic fracturing, depending on local geological conditions.

Unconventional Oil and Gas in Scotland

Introduction

- 1.11 This section of the Environmental Report sets out further detail on onshore unconventional oil and gas in Scotland. It explains what is within the scope of the assessment, and how different issues are addressed. The information in this section draws on the existing evidence base and references the relevant documents where appropriate.

What is unconventional oil and gas?

- 1.12 It is important to define unconventional oil and gas as reflected in the preferred policy position. KPMG’s (2016) report “Economic Impact Assessment and Scenario development of unconventional oil and gas in Scotland”³, provides a useful definition which is reproduced below and is used for the purpose of the SEA:

The term ‘unconventional’ in unconventional oil and gas refers to the types of geology in which the oil and natural gas are found. For the purpose of this study, unconventional oil and gas includes shale gas, associated liquids and coal bed methane.

- 1.13 Unconventional oil and gas takes a number of different forms. The sources of unconventional oil and gas as defined by KPMG (2016) include:
- Gas extracted from onshore shale sources using hydraulic fracturing;
 - Associated liquids extracted from onshore shale sources using hydraulic fracturing; and
 - Coal bed methane (CBM).

What do we use unconventional oil and gas for?

- 1.14 Unconventional oil and gas can contribute to the provision of natural gas (for energy or energy production) and natural gas liquids as a raw material for the petrochemical industry. These uses are explained in more detail in Scottish Government

³ KPMG (2016) Economic Impact Assessment and Scenario development of unconventional oil and gas in Scotland. A Report for the Scottish Government. Available at: <http://www.gov.scot/Resource/0050/00509321.pdf>

consultation (2017) *Talking "Fracking"*⁴. Both these products are included in the scope of the SEA.

Where are sources of unconventional oil and gas found?

- 1.15 There are a number of shale deposits in Scotland, most notably across an area of Scotland's Central Belt known as the Midland Valley which extends from Ayrshire in the west, to Fife in the east. There are also coal deposits from which coal bed methane could be extracted in the Midland Valley and in south-west Scotland.
- 1.16 The British Geological Society (BGS) estimate that the Midland Valley holds between 49.4 – 134.6 tcf (trillion cubic feet) of shale gas, however there is uncertainty over the proportion of resources viable for extraction. The BGS has identified the area of the Central Belt considered prospective for shale oil and gas. This includes the local authority areas of West Lothian, City of Edinburgh, East Lothian, Midlothian, Falkirk, North Lanarkshire, South Lanarkshire, City of Glasgow, East Dunbartonshire, South Lanarkshire, Clackmannanshire, Stirling, and Fife.

What stages are involved in the development of onshore unconventional oil and gas?

- 1.17 Unconventional oil and gas development involves a number of stages, which take place over different time periods. A prospective development would usually undergo four stages, which are explained in Table 1.1.
- 1.18 The first stage of development involves the construction of a drilling pad. A drilling pad is a base built to provide space for the drilling rig, piping and storage equipment, and other site facilities such as mobile cabins for workers. Pads are usually around the size of a football pitch (5,000-8,000 square metres). The average height of a typical drilling rig is about 38 metres, which is equivalent to a 10 or 11 storey building. Drilling rigs are temporary features, and are on-site while drilling takes place. The initial phases of production entail similar activities to an exploration and appraisal phase. Once these activities cease, the primary activities at a site would be maintenance and movement of goods from the site, although further wells may be drilled. The final stage of decommissioning involves restoration of the site, the wells are plugged and surface infrastructure is removed.
- 1.19 Coal bed methane development involves:
 - exploration to locate suitable deposits, drawing on a combination of geological information and data from existing boreholes and previous gas and oil production;
 - drilling of two or more boreholes into the target coal seam, with deviations running horizontally along the coal seams;
 - dewatering of the coal seams using high capacity pumps to reduce the pressure within the coal, in turn allowing the release and capture and movement of methane gas to surface facilities for processing and use;
 - Where there is low coal seam permeability, additional borehole drilling, including the horizontal linking of boreholes, and hydraulic or other fracturing of the coal seam may be used to increase flow;

⁴ Scottish Government (2017) *Talking 'Fracking'* A consultation on Unconventional Oil and Gas. Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

- Disposal of pumped water (production water), either to sewer or surface water (following any required treatment) or by reinjection into the coal seam;
- Site restoration will take place once production ceases. Boreholes are plugged, surface infrastructure removed and aftercare monitoring regimes implemented. Decommissioning and site restoration may take place sooner if the boreholes prove to be unviable.

Table 1.1 Typical stages of unconventional oil and gas development⁵

Stage 1	Stage 2	Stage 3	Stage 4
Exploration	Appraisal	Production	Decommissioning
Initial phase of testing commercial viability of a site. Boreholes to obtain core samples to analyse the rock structure and viability for oil or gas production. Seismic surveys may also be undertaken. Horizontal drilling and hydraulic fracturing tests may be undertaken to test flow properties.	Commercial viability of a site is explored further. Concrete drilling pads and roads are built. Drilling rigs will be erected. Additional boreholes are drilled accompanied by horizontal drilling. Hydraulic fracturing tests may be undertaken to test flow properties.	If a site is suitable for production, more wells will be drilled and hydraulically fractured with accompanying site activity. After around two years, the major on site activity will cease and will be replaced by routine maintenance, although some further wells may be drilled.	Site restored to original condition. Wells are plugged and abandoned. Surface infrastructure is removed. Aftercare monitoring regimes put in place. This work could take place at any stage of a development if site does not develop into the next one.
2—6 years		Approximately 15 years	2-5 years

What is the likely scale of development of unconventional oil and gas in Scotland, without the preferred policy position?

1.20 There is considerable uncertainty over the likely scale of development of unconventional oil and gas in Scotland in the absence of the preferred policy position. This includes uncertainty over the proportion of resources viable for extraction, which influences the scale of development that would otherwise occur. However, KPMG (2016) sets out three potential exploration, appraisal and extraction scenarios, for the development of the unconventional oil and gas industry in Scotland, in the absence of the preferred policy position:

- Central: 20 pads of 15 wells (each built over 11 years starting in 2023-2024) and two CBM pads of 15 wells⁶.

⁵ Extracted from Scottish Government (2017) Talking 'Fracking' A consultation on Unconventional Oil and Gas. Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

⁶ KPMG (2016) notes that at current gas prices, the development of two coal bed methane pads and associated production volumes would not generate high enough revenues to justify the investment.

- Low: 10 pads of 10 wells (built over nine years starting in 2027-2028) CBM as central production scenario.
- High: 31 pads of 30 wells (each built over 13 years starting in 2021-2022) CBM as central production scenario.

1.21 It is however recognised that there remains considerable uncertainty even within these scenarios, not least around whether and to what extent the necessary permissions and licenses would be forthcoming. In line with best practice, the SEA will therefore utilise these scenarios to inform the assessment of a ‘broad range of impact scenario’. This is further explained in Section 2 Methodology.

What is the existing evidence base for unconventional oil and gas in Scotland?

1.22 The SEA is based on information within the existing evidence base, including the following research commissioned by the Scottish Government.

- Independent Expert Scientific Panel – Report on Unconventional Oil and Gas (Scottish Government, 2014)
- Economic Impact Assessment and Scenario Development of Unconventional Oil and Gas in Scotland – A Report for the Scottish Government (KPMG, 2016)
- Compatibility with Scottish greenhouse gas emissions targets (Committee on Climate Change, 2016)
- Unconventional Oil and Gas Development: Understanding and Monitoring Induced Seismic Activity (British Geological Survey, 2016)
- Unconventional oil and gas development: understanding and mitigating community impacts from transportation (Ricardo Energy & Environment, 2016)
- Unconventional Oil and Gas Development in Scotland: Decommissioning, Site Restoration and Aftercare – Obligations and Treatment of Financial Liabilities (Aecom, 2016)
- A Health Impact of Unconventional Oil and Gas in Scotland (Health Protection Scotland, 2016)

Plus:

- Talking “Fracking” – A Consultation on Unconventional Oil and Gas (Scottish Government, 2017) Scottish Parliament – Statement on Unconventional Oil and Gas (Scottish Government, 2017)
- Preferred Policy Position statement on unconventional oil and gas (Scottish Government, 07 December 2017), updated October 2018.

1.23 Any additional documents are referenced in this Environmental Report.

Scope of the SEA

1.24 The development of the preferred policy position falls under Section 5(3) of the Environmental Assessment (Scotland) Act 2005 (the “2005 Act”). A Strategic Environmental Assessment (SEA) is therefore required. The required stages comprise scoping and the preparation of an Environmental Report, analysis of the responses to the consultation on the Plan and the Environmental Report and the production of a post-adoption statement.

However the development of coal bed methane is included in the economic scenarios and Scottish Government has confirmed that these should be included in the business as usual scenarios.

- 1.25 The Environmental Report is being consulted on alongside the Preferred Policy Position statement for an 8 week period between 23 October 2018 and 18 December 2018.

Strategic Environmental Assessment

- 1.26 The SEA Directive⁷ is given effect in Scotland through the Environmental Assessment (Scotland) Act 2005 ('the SEA Act')⁸, and is a means to assess, report and consult on the likely impact of the plan, programme or strategy on the environment and to seek ways to minimise adverse effects, if likely to be significant.
- 1.27 The SEA process comprises a number of stages as identified in Table 1..

Table 1.2 Main stages of SEA

Stage A: Setting the context and identifying environmental objectives, establishing the baseline and deciding on the scope.

Stage B: Developing and refining reasonable alternatives and assessing effects.

Stage C: Preparing the Environmental Report.

Stage D: Consulting on the Preferred Policy Position and the Environmental Report.

Stage E: Monitoring the significant effects of implementing the Preferred Policy Position.

- 1.28 An overview of how the Environmental Report meets the requirements of the SEA Act is included in **Appendix 4**.

Report Structure

Structure of the SEA Report

- 1.29 The Environmental Report is fully compliant with the reporting requirements of the SEA Act. The Environmental Report includes a non-technical summary and is structured as set out below:
- **Summary** – provides a non-technical summary of the information contained in the Environmental Report.
 - **Chapter 1 Introduction** – describes the background to the Scottish Government's preferred policy position and outlines its content; the purpose of SEA and the Environmental Report; key dates and milestones; and, the structure of the Environmental Report.
 - **Chapter 2 Methodology** – describes the method used in carrying out the SEA; the approach to reasonable alternatives, and describes any difficulties encountered and data limitations.

⁷ [Directive 2001/42/EC](#)

⁸ The Environmental Assessment (Scotland) Act 2005

- **Chapter 3 Relationship of Plans, Programmes and Strategies and Environmental Protection Objectives** - describes links to other plans, programmes and strategies and how these have been taken into account in the SEA process;
- **Chapters 4 - 14 SEA Findings** - identifies environmental problems and presents the findings from the assessment of the preferred policy position and reasonable alternatives.
- **Chapter 15 Mitigation** – describes the mitigation measures that have been considered and incorporated to avoid or mitigate any potential (significant) adverse impacts.
- **Chapter 16 Monitoring** – presents a proposed framework for monitoring the significant effects identified in the Environmental Report.
- **Chapter 17 Conclusion** – summarises the key findings from the SEA and describes the next steps to be undertaken.

1.30 The main body of this report is supported by a number of appendices:

- Appendix 1 – Environmental Baseline and Figures
- Appendix 2 – Review of Plans, Programmes and Strategies
- Appendix 3 – Consultation Authority responses
- Appendix 4 – Meeting the requirements of the SEA Act.

2 Methodology

- 2.1 This section of the Environmental Report sets out:
- the approach to the assessment, including the use of environmental baseline information and its level of detail;
 - the approach to the SEA and the assessment of reasonable alternatives;
 - background information on the development parameters associated with unconventional oil and gas development.

SEA baseline and other information / reference sources

- 2.2 The purpose of the environmental baseline is to provide a description of the environmental characteristics against which the changes arising from the policy are assessed. It is usual to consider how the environmental baseline would have continued to evolve in the absence of the policy that is being assessed. Environmental trends are therefore taken into account.

Environment baseline information

- 2.3 The environmental baseline for the SEA is structured around the following SEA topics, all of which have been **scoped in** to the SEA:

- Air
- Biodiversity, flora and fauna
- Population and human health
- Soil
- Water
- Climatic factors
- Cultural heritage, including architectural and archaeological heritage
- Landscape and geodiversity
- Material assets.

- 2.4 The baseline reflects the nature of the unconventional oil and gas issues for each SEA topic and the likely spatial extent of these. Some SEA topic areas have a national and international relevance, e.g. climate change. Others are more local to the areas where unconventional oil and gas is most likely to develop in the absence of the preferred policy position, e.g. impacts on heritage assets or their setting. Local authorities in the areas identified with the most likely potential for unconventional oil and gas development include West Lothian, City of Edinburgh, East Lothian, Midlothian, Falkirk, North Lanarkshire, South Lanarkshire, Glasgow, East Dunbartonshire, South Lanarkshire, Clackmannanshire, Stirling, and Fife. Where relevant, information which relates to these areas is included in the baseline. The baseline also includes reference to broader national trends.

- 2.5 The scope of baseline information included under each SEA topic area is informed by the Scottish Government commissioned research on unconventional oil and gas and the relevant environmental issues. The environmental baseline is presented in Appendix 1 and additional information is referred to in the assessment in Sections 4 to 14.
- 2.6 As described above, the scope of the environmental baseline collated under each SEA topic is informed by the commissioned research on unconventional oil and gas e.g. for air quality this reflects the pollutants identified from unconventional oil and gas development, for health this focuses on the issues identified relevant to the potential health effects of unconventional oil and gas development.

Approach to the SEA

- 2.7 A narrative approach is used for the SEA based on the description of the environmental effects of the alternatives under each of the SEA topic areas:
- Air
 - Biodiversity, flora and fauna
 - Climatic factors
 - Cultural heritage, including architectural and archaeological heritage
 - Population and human health
 - Landscape and geodiversity
 - Material assets
 - Soil
 - Water.
- 2.8 The description of environmental effects under each topic area is informed by:
- the environmental protection objectives of relevant plans, programmes and strategies;
 - the baseline information and analysis of existing environmental problems; and
 - the existing evidence base documents which have been prepared for Unconventional Oil and Gas in Scotland and within the UK. Other available evidence is drawn upon as required to inform the assessment.
- 2.9 As noted previously, it is recognised that there are different levels of detail in the evidence base surrounding different SEA topics, and some impacts are more location specific. However, within the scope of the area of the Midland Valley identified as having potential for unconventional oil and gas, the SEA is not site-specific, and the SEA describes the broad impacts for some topic areas, and more detail for others.

Regulatory framework

- 2.10 In order to provide context for the assessment, the role of relevant regulatory controls is taken into account within the assessment of each SEA topic. This is

summarised in the plan, programme and strategy review (Section 3 and Appendix 2) within the topic areas for the assessment findings, and in Section 15, Mitigation.

Reasonable alternatives

- 2.11 The 2005 Act requires that the Scottish Government also identify, describe and evaluate the likely significant effects on the environment of any reasonable alternatives to the preferred policy position, taking into account the objectives and geographical scope of the plan or programme. This section outlines what has been assessed, including the reasonable alternatives that have been considered.
- 2.12 In considering what a “reasonable” alternative is, the Scottish Government’s commitment to decarbonise the whole energy system and tackle climate change has been taken into account.
- 2.13 The Climate Change (Scotland) Act 2009 sets a long-term target to reduce greenhouse gas emissions by 80% from the baseline (which is 1990 or 1995 depending on the gas). The Act also contains annual targets for each year to 2050. All of these targets are set on the basis of territorial emissions across the Scottish economy as a whole. On 24 May 2018, Scottish Ministers brought forward a draft Climate Change Bill that proposes, in response to the UN Paris Agreement, to increase the 2050 target to a 90% reduction and keep the setting of a further target for net-zero greenhouse gas emissions under regular review. In its advice to the Scottish Government on how the Bill might be drafted, the Committee on Climate Change (CCC), said⁹: “In order to achieve a 90% target, strong and well-designed policies would be required”.
- 2.14 In 2016 the Scottish Government commissioned the CCC to carry out a study into the compatibility of unconventional oil and gas with Scottish statutory climate change targets.¹⁰ It concluded that fossil fuel consumption must remain in line with the requirements of these targets. Therefore, Scottish unconventional oil and gas production must displace imported gas, rather than increase domestic consumption. It also concluded that additional production emissions from unconventional oil and gas extraction in Scotland would make meeting existing Scottish climate change targets more challenging, and in order to be compatible with Scottish climate change targets, emissions from production of unconventional oil and gas would require to be offset through reductions in emissions elsewhere in the Scottish economy.
- 2.15 The Scottish Government’s preferred position is that it does not support the development of unconventional oil and gas in Scotland. This is on the basis that the development of an unconventional oil and gas industry in Scotland would make achieving Scotland’s ambitious energy and climate change commitments even more challenging. The Scottish Government acknowledges the important role of gas in the transition to a low carbon energy future. However, the addition of an onshore unconventional oil and gas industry would not promote Scotland’s ability to meet the

⁹ Advice to the Scottish Government on the New Climate Change Bill (2017) <https://www.theccc.org.uk/wp-content/uploads/2017/03/Advice-to-Scottish-Government-on-Scottish-Climate-Change-Bill-Committee-on-Climate-Change-March-2017.pdf>

¹⁰ Unconventional Oil and Gas: Compatibility with Scottish Greenhouse Gas Emissions Targets (2016) <http://www.gov.scot/Publications/2016/11/1380>

established greenhouse gas emissions targets and objectives in relation to protecting and enhancing the environment.

- 2.16 It is recognised that some may regard the development of the industry - the 'business as usual' option described below - or a pilot project, subject to the relevant licensing and permitting regimes, as alternatives to the preferred policy position. While the Scottish Government is not minded to view these as reasonable alternatives it does, however, wish to invite views on their assessment.

Business as Usual

- 2.17 As an alternative to the preferred policy position of no support for the development of unconventional oil and gas in Scotland, under this option an unconventional oil and gas industry could continue to develop in Scotland. This is defined as 'business as usual'. Applications for planning permission and all other consents would be dealt with in the normal manner and in line with applicable procedural requirements and relevant policy. In particular, applications for planning permission would be determined in accordance with the development plan then in force unless other material considerations indicated otherwise. Scottish Ministers would also exercise their newly devolved powers in relation to onshore oil and gas licensing in Scotland to consider the timing of future onshore licensing rounds.
- 2.18 The assessment of this option also draws out the environmental impacts of de-watering for coal bed methane (CBM), where these differ from hydraulic fracturing for shale oil or gas. As described previously, CBM is also considered to be an unconventional source of gas. This is because the gas is present in the coal, rather than being held in the pore spaces. CBM may be extracted through dewatering, with or without hydraulic fracturing, depending on local geological conditions (though currently it is usually extracted without the use of hydraulic fracturing). The Scottish Government does not however consider that it would be a reasonable alternative to differentiate between CBM extraction and hydraulic fracturing in finalising the preferred policy position. This is because many of the impacts associated with unconventional oil and gas, including impacts on local communities, arise irrespective of whether hydraulic fracturing or de-watering techniques are used. Indeed, the social impacts identified in the responses to the Talking "Fracking" public consultation, while not captured in this SEA, are significant factors which will be considered by the Scottish Government in reaching a view on the finalised policy.

KPMG scenarios

- 2.19 The assessment of the 'business as usual' reasonable alternative is based on the KPMG (2016) development scenarios of a) central, b) low and c) high levels of exploration, appraisal and extraction of onshore unconventional oil and gas, as representing a 'broad range of impact scenario' of extraction within which broad locational effects, concentrated within central Scotland, can be considered. The assessment draws out any differences between the three unconventional oil and gas development scenarios where identified. There are similarities in the effects for all three scenarios identified under some of the SEA topic areas due to the general nature of the effects. Therefore conclusions relate principally to the scale of development and the associated effects. The environmental effects of the preferred policy position include the environmental effects of unconventional oil and gas development avoided, and any wider high level effects identified which will also occur within Scotland.

Pilot project

- 2.20 The assessment includes consideration of the development of a theoretical single pilot project in one of three alternative locations within the Midland Valley and within a PEDL area where resource has been identified. The purpose of a theoretical pilot project would be to further inform the evidence base, including increasing understanding of the potential resource, and impacts associated with its extraction. The theoretical pilot project is based on a number of assumptions including that a project would have research and geoscience as its key driver, and be required to be delivered in collaboration with an independent research body or an academic institution and demonstrate whole lifespan of development (exploration, appraisal, production, and decommissioning) over approximately 10 years. To ensure that the range of potential effects of a single pilot project are considered, the assessment considers how effects would vary if the pilot were located in an unspecified rural or semi-urban or urban fringe geographical location.
- 2.21 For the purposes of the assessment a theoretical pilot project is assumed to be one pad with multiple wells. The number of wells is not defined, however it is assumed that more wells would result in greater impacts. Table 2.1 below illustrates the assumed parameters for the three alternative pilot locations.

Table 2.1 Assumed parameters for the three alternative hypothetical pilot locations

SEA topic area	Pilot 1 Rural	Pilot 2 Semi-urban	Pilot 3 Urban fringe
Air	Outside of AQMA	Close to AQMA	Outside of AQMA
Water	Area of higher water quality	Area of moderate water quality	Area of poor water quality
Soil	Area of high carbon soil	Area of moderate carbon concentration	Area of moderate carbon concentration
Biodiversity flora and fauna	National biodiversity importance (proximity to SSSI)	Direct pathways to area of international biodiversity importance	Local biodiversity importance
Population and human health	Small villages, low deprivation, rural road network	Close to medium sized centre of population with higher levels of deprivation, urban road network	Close to larger urban area and many settlements, several with higher levels of deprivation, major urban transport infrastructure
Cultural and archaeological heritage	Unknown archaeology only	Unknown archaeology only	Unknown archaeology only
Climatic factors	<i>Climatic factors impacts same for all pilots</i>	<i>Climatic factors impacts same for all pilots</i>	<i>Climatic factors impacts same for all pilots</i>

Landscape	Area of local landscape value, rural character	Lower landscape value, close proximity to urban area	Lower landscape value, urban industrial character
Material assets	<i>Waste disposal impacts same for all pilots</i>	<i>Waste disposal impacts same for all pilots</i>	<i>Waste disposal impacts same for all pilots</i>

Approach to the assessment

2.22 The approach to the assessment includes the following stages:

- Identify the environmental effects of the reasonable alternatives and preferred policy position on each of the SEA topics and the stage of unconventional oil and gas development to which they relate;
- Describe the current pressures and trends on that SEA topic area, as relevant to the environmental effects identified;
- Describe the existing regulatory processes which control the effects identified;
- For each environmental effect the scale of effect, timescale of effect, whether the effect is temporary or permanent, and any spatial variation is described for each alternative.

2.23 The assessment considers the potential for cumulative effects across each SEA topic, and between topics (e.g. potential impacts across water and air and their cumulative impact on population and human health). It also identifies areas where the existing review of the regulatory framework has identified that regulation could be strengthened, helping to mitigate environmental effects described.

- The assessment is presented as a narrative, framed around key questions and with the use of tables as appropriate. The structure is as follows: What are the environmental effects of unconventional oil and gas development on [SEA topic]?
- How do these effects relate to the current pressures and trends?
- What current regulatory processes control these effects?
- What stages of unconventional oil and gas development result in these effects, and what is the nature of these effects? This is considered in relation to the alternatives identified:
 - 'Business as usual'–Pilot project
 - Preferred policy position
- Cumulative, secondary and synergistic effects.
- Summary table.

Uncertainty

- 2.24 The subject matter of this assessment mean that there are a number of areas of uncertainty, some of which would only be resolved if exploration and production of unconventional oil and gas were to take place. These include:
- The extent of unconventional oil and gas deposits present in central Scotland their technical and commercial viability;
 - In the absence of the preferred policy position, the likely scale and phasing of any exploitation of these unconventional oil and gas deposits;
 - The need to secure all relevant permissions and licenses; and
 - The geographic distribution of pads and wells across Central Scotland, including location with respect to sensitive human, natural and cultural receptors.
- 2.25 While existing regulatory processes, allied to good working practices and monitoring, would help ensure that many of the most serious adverse effects would be avoided, significant areas of uncertainty remain and are highlighted throughout this report.
- 2.26 There is also uncertainty regarding the impacts of a new supply of unconventional oil and gas on the wider energy market. However, the Scottish Government commissioned research^{11, 12} identified that the relative small scale of potential Scottish production relative to the scale of US production and a highly interconnected European energy market would likely mean there was no impact on domestic or global energy prices. The commissioned research also highlighted the potential for domestically produced unconventional oil and gas to have a positive impact for manufacturing companies which use it as a feedstock, should import substitution lead to lower costs of their primary input through avoiding importing and transportation costs. However, it did not quantify these potential impacts given the uncertainties.
- 2.27 The impact of Scottish production at an EU or global emissions level is unlikely to be significant. At the domestic level, total Scottish GHG emissions will rise as a result of GHG emissions associated with the exploration, exploitation, processing and transport of unconventional oil and gas, all other factors being equal. As a result, this SEA focuses on the environmental effects of the preferred policy position, and reasonable alternatives that are likely to occur within Scotland. Where appropriate, however, it does refer to potential wider effects whilst highlighting the very high levels of uncertainty associated with these.

Assessment of significance

- 2.28 In line with the requirements of the Environmental Assessment (Scotland) Act 2005, the assessment of significance is based on the following:
- a) the probability, duration, frequency and reversibility of the effects;
 - (b) the cumulative nature of the effects;

¹¹Committee on Climate Change (2016) Scottish Unconventional oil and gas: Compatibility with Scottish greenhouse gas emissions target. Available at: <https://www.gov.scot/Resource/0050/00509324.pdf>

¹²KPMG (2016) Economic Impact Assessment and Scenario development of Unconventional Oil and Gas in Scotland p.27 Available at: <http://www.gov.scot/Resource/0050/00509321.pdf>

- (c) the transboundary nature of the effects;
- (d) the risks to human health or the environment (for example, due to accidents);
- (e) the magnitude and spatial extent of the effects (geographical area and size of the population likely to be affected);
- (f) the value and vulnerability of the area likely to be affected due to—
 - (i) special natural characteristics or cultural heritage;
 - (ii) exceeded environmental quality standards or limit values; or
 - (iii) intensive land-use; and
- (g) the effects on areas or landscapes which have a recognised national, Community or international protection status.

2.29 Within the assessment, the assignment of a minor or significant effect is based on a judgement of a combination of the above matters. The factors influencing these judgements are presented in summary tables for each topic covered by the assessment. None of the effects identified for the SEA topic areas are identified as having transboundary effects. Although issues affecting climate change have global implications, this is inherent within that topic area and it does not result in identifiable impacts on other member states.

Mitigation

2.30 As outlined in the approach to the assessment for the 'business as usual' options, existing environmental regulation and mitigation is taken into account as 'assumed mitigation' and factored into the assessment of the significance of effects. Areas of potential further mitigation identified from the evidence base are also included where they impact on the scale of effects avoided by the preferred policy position. These are likely to be considered at a project scale and implemented through consenting processes.

Risk and uncertainty

2.31 The issue of risk is of particular relevance to this assessment due to the challenges in quantifying the likelihood of some of the potential environmental effects identified.

2.32 There are a range of uncertainties that in the absence of the preferred policy position would influence the development of unconventional oil and gas and the potential impacts that would result. This includes uncertainties over the scale and location of unconventional oil and gas development and uncertainties over the environmental effects arising.

2.33 While the positive influence of regulatory processes has been taken into account in making judgements about the likely significance of environmental impacts, the risk of more significant impacts has been noted within the text where levels of certainty allow. This is based on a high level comparison of the scale of development, the level of certainty about its environmental effects and the potential for significant adverse effects in the absence of regulation. While this is recognised as a simplistic approach, it does highlight areas of risk and key uncertainties, particularly related to accidents or other unplanned events, or failures in adherence to regulatory procedures.

Monitoring

- 2.34 Recommendations are made for monitoring the likely significant environmental effects identified. The focus is on the use of existing monitoring frameworks, within other relevant plans, programmes and strategies.

Difficulties encountered and data limitations

- 2.35 This is a strategic level assessment of a high level policy position and the approach has been designed to reflect this. The evidence base does not consistently make clear the differentiation between the environmental impacts of coal bed methane and shale gas extraction. However, where different effects can be identified these are drawn-out in the assessment. The environmental impacts of shale oil production are assumed to be the same as the environmental impacts of shale gas production. This reflects the similarity in the two processes and is consistent with the treatment of the two processes within Scottish Government Expert Panel report (2014)¹³, which also recognises that it is not yet clear whether any such possibility of shale oil production exists in Scotland.
- 2.36 Scotland currently imports shale gas. The preferred policy position is likely to result in some oil and gas products continuing to be sourced from elsewhere. However, as decisions on this lie beyond the scope of the policy, and given the difficulty in defining such sources and predicting the associated environmental effects (extraction, processing, transport) with any degree of certainty, it is considered appropriate that the scope and focus of this SEA is on the effects that would occur within Scotland. As noted above, uncertainties about the market response to the production of unconventional oil and gas in Scotland make it equally difficult to judge the likely effects of changing production patterns and demand, including indirect effects on the wider take-up of low carbon energy sources.

Assumptions on development parameters to inform assessment

- 2.37 In order to ensure consistency in assessment, the following table summarises the parameters of unconventional oil and gas development, identified from the existing evidence base, which have been used to inform the assessment.

2.38

¹³ Scottish Government (2014) Independent Expert Scientific Panel- Report on Unconventional Oil and Gas. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

Table 2.2 Development parameters used to inform assessment

Development	Parameter
Area of a well pad	Pads are usually around the size of a football pitch (5,000-8,000 square metres) ¹⁴ . For the purposes of the assessment the area of 8,000m ² is assumed.
Pad infrastructure	A drilling pad is a base built to provide space for the drilling rig, piping and storage equipment, and other site facilities such as mobile cabins for workers. ¹⁵
	Flood lighting, generators, sealed container units for chemicals and waste materials and fluids. Portable offices and work amenities ¹⁶
	The average height of a typical drilling rig is about 38 metres ¹⁷
	Perimeter fencing ¹⁸ Assumed part of site construction and safety, and illustrated in diagram of exploration and appraisal at Figure 7 within Talking “Fracking” consultation document.
	Combination of all the above references gives the description of potential pad infrastructure during exploration, appraisal and early years of production as: <i>Drilling rig, piping and storage equipment, flood lighting, generators, sealed container units for chemicals and waste materials and fluids, portable offices and work amenities and perimeter fencing.</i>
Traffic movements	Traffic movements to be sustained at around 190 per week for a period of approximately two years during the exploration and appraisal phase ¹⁹ . After the well is completed, it can be expected to operate with much lower levels of traffic movements for a period around 5 to 10 years until the decommissioning and site restoration phase. As a result, the rate of vehicle movements greatly fluctuates throughout the life of each well ²⁰ . Each shale gas well pad could require between 13,000 and

¹⁴ Scottish Government, 2017. Talking ‘Fracking’ – A Consultation on Unconventional Oil and Gas. P.20 Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

¹⁵ Scottish Government, 2017. Talking ‘Fracking’ – A Consultation on Unconventional Oil and Gas. P.20 Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

¹⁶ Scottish Government, 2017. Talking ‘Fracking’ – A Consultation on Unconventional Oil and Gas p. 22 Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

¹⁷ Scottish Government, 2017. Talking ‘Fracking’ – A Consultation on Unconventional Oil and Gas. P.20 Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

¹⁸ Scottish Government, 2017. Talking ‘Fracking’ – A Consultation on Unconventional Oil and Gas. P.22 Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

¹⁹ Scottish Government, 2017. Talking ‘Fracking’ – A Consultation on Unconventional Oil and Gas. p.22 Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

²⁰ Ricardo Energy & Environment, 2016. *Unconventional oil and gas development: Understanding and mitigating community impacts from transportation*. Available at: <https://beta.gov.scot/publications/unconventional-oil-gas-understanding-mitigating-community-impacts-transportation/documents/00509327.pdf>

Development	Parameter
	<p>93,000 vehicle movements, spread over about a 20 year period. A coal bed methane well pad is estimated to require about 93,000 vehicle movements over about 12 years²¹.</p> <p>It is important to note that these figures do not reflect vehicle size. For instance, the impact from a Heavy Goods Vehicle (HGV) is judged to have more adverse environmental impacts compared to basic workforce transportation vehicles. The movement of vehicles to and from unconventional oil and gas sites is influenced by several factors including the location and size of the facility, the nature of the underlying geology, and the availability of a local water source.</p>
Number of wells and pads:	<p>KPMG low scenario</p> <p>Shale: 10 pads 10 wells per pad 15-year life span CBM: 2 pads 15 wells per pad 12-year life span²² Total area approx.: 9.6ha</p> <p>KPMG central scenario</p> <p>Shale: 20 pads 15 wells per pad 15-year life span CBM: 2 pads 15 wells per pad 12-year life span²³ Total area approx.: 13.6ha</p> <p>KPMG high scenario</p> <p>Shale: 31 pads 30 wells per pad 15-year life span CBM: 2 pads 15 wells per pad 12-year life span²⁴ Total area approx.: 26.4ha</p>
Peak production year ²⁵	<p>Low scenario</p> <p>Shale gas: 2047 Associated liquids: 2048</p> <p>Central scenario</p> <p>Shale gas: 2048</p>

²¹ Ricardo Energy & Environment, 2016. *Unconventional oil and gas development: Understanding and mitigating community impacts from transportation*. Available at: <https://beta.gov.scot/publications/unconventional-oil-gas-understanding-mitigating-community-impacts-transportation/documents/00509327.pdf>

²² Scottish Government, 2017. Talking 'Fracking' – A Consultation on Unconventional Oil and Gas. p.28 Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

²³ Scottish Government, 2017. Talking 'Fracking' – A Consultation on Unconventional Oil and Gas. P.28 Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

²⁴ Scottish Government, 2017. Talking 'Fracking' – A Consultation on Unconventional Oil and Gas. P.28 Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

²⁵ KPMG (2016) Economic Impact Assessment and Scenario development of Unconventional Oil and Gas in Scotland p. 7 Available at: <http://www.gov.scot/Resource/0050/00509321.pdf>

Development	Parameter
	Associated liquids: 2044 High scenario Shale gas: 2049 Associated liquids: 2048

3 Relationship of Plans, Programmes and Strategies and Environmental Protection Objectives

Introduction

- 3.1 This section of the Environmental Report provides a summary of the most relevant plans, programmes or strategies (including their environmental objectives) that influence the preferred policy position. A full review is included in Appendix 2.

The Policy Context

- 3.2 The preferred policy position on onshore unconventional oil and gas is relevant to the principal policy areas of energy and climate change and the planning system, and these are summarised below.

Energy and Climate Change

The Scottish Energy Strategy

- 3.3 The Scottish Energy Strategy (The Scottish Government, 2017) sits alongside the Climate Change Plan. Three key themes underpin the Strategy:
- A whole-system view in which energy supply and consumption are seen as equal priorities;
 - A stable energy transition towards renewable energies and sustainable transport;
 - A smarter model of local energy provision which promotes local energy, community involvement and community ownership of energy generation.
- 3.4 The Strategy's vision for 2050 is built around six priorities:
- Promote consumer engagement and protect consumers from excessive or avoidable costs;
 - Improve the energy efficiency of Scotland's homes, buildings, industrial processes and manufacturing;
 - Ensure homes and businesses can continue to depend on secure, resilient and flexible energy supplies;
 - Empower communities by supporting innovative local energy systems and networks;
 - Champion Scotland's renewable energy potential, creating new jobs and supply chain opportunities; and
 - Continue to support investment and innovation across our oil and gas sector, including exploration, innovation, subsea engineering, decommissioning and carbon capture and storage.

Climate Change (Scotland) Act

- 3.5 The Climate Change (Scotland) Act 2009 sets statutory targets for the reduction of greenhouse gas emissions and makes further provision about energy efficiency and about the reduction and recycling of waste. The Act sets an interim 42 per cent reduction target by 2020 and an 80 per cent reduction target for 2050. A range of secondary legislation has been made under the Act, including setting annual emission reduction targets for the years to 2032 and limits on carbon units that may be credited to the net Scottish emissions account (the statutory basis upon which targets are set) for periods up to 2022.

Scotland's Climate Change Plan

- 3.6 The Climate Change Plan: Third Report on Policies and Proposals (2018) details how the Scottish Government will achieve its current emissions reduction target over the period to 2032.
- 3.7 Section 35 of the Climate Change (Scotland) Act 2009 requires Scottish Ministers to lay a report in Parliament setting out their proposals and policies for meeting annual emissions reduction targets. This Climate Change Plan (the Plan) is the Scottish Government's third report on proposals and policies for meeting its climate change targets. It sets out how Scotland can deliver its targets over the period 2018 to 2032, towards the 2032 target which equates to a 66% reduction in emissions from baseline levels. The plan shows the emissions reductions pathway to 2032, addresses the impacts on the economy of both action and inaction and describes the Scottish Government's international ambitions and activities.

Planning

- 3.8 The Town and Country Planning (Scotland) Act (1997), as amended, governs the use and development of land within Scotland. The Act forms the basis of the Scottish planning system. It sets out the roles of Scottish Ministers and designates local authorities as 'planning authorities' with a responsibility for producing local development plans and handling most aspects of development management and enforcement, including primary responsibility for the determination of planning applications.
- 3.9 The National Planning Framework 3 (2014) sets the context for development planning in Scotland and provides a framework for the spatial development of Scotland as a whole. It sets out the Scottish Government's development priorities over the next 20-30 years and identifies national developments which support the spatial strategy. It is a long-term strategy to promote environmental sustainability, equality in opportunity, technological progress and human well-being and health. One of four key outcomes established through the framework is reducing carbon emissions and adapting to climate change. The Scottish Government will begin preparation of its National Planning Framework 4 following the passage of the Planning Bill through Parliament.
- 3.10 Scottish Planning Policy is a statement of Scottish Government policy on how nationally important land use planning matters should be addressed across the country. In relation to promoting responsible extraction of resources it sets out a number of policy principles which include that the planning system should:
- recognise the national benefit of indigenous coal, oil and gas production in maintaining a diverse energy mix and improving energy security;

- safeguard workable resources and ensure that an adequate and steady supply is available to meet the needs of the construction, energy and other sectors;
- minimise the impacts of extraction on local communities, the environment and the built and natural heritage; and
- secure the sustainable restoration of sites to beneficial after use after working has ceased.

3.11 The Planning Bill proposes that in future the Scottish Planning Policy will form part of the National Planning Framework, which in turn would form part of the statutory development plan.

Scotland's Regulatory Framework

3.12 Also relevant to the SEA of the preferred policy position is the regulatory framework for onshore oil and gas in Scotland. The regulatory framework supports the existing environmental protection regime for onshore oil and gas. In relation to unconventional oil and gas the core regulators include:

- The Scottish Government: Scottish licensing authority with responsibility for:
 - the granting and regulation of licences to search and bore for and get petroleum within the Scottish onshore area;
 - determining the terms and conditions of licences; and
 - regulating the licensing process, including administration of existing licences.
- The UK Government retains responsibility for the regulation, including setting, of the consideration payable (the land rental) for Scottish licences. In addition, the UK Government has powers to revoke a licence on the basis of failure to make payments due under the licence.
- The Oil and Gas Authority: undertakes role of regulator in respect of the UK Government responsibilities above.
- Local Authority / Planning Authority: consider planning applications for development associated with unconventional oil and gas and local authorities have responsibility for Environmental Health matters.
- Scottish Environment Protection Agency: regulates activities that may cause pollution or that pose other risks to the environment throughout the life cycle of an unconventional oil and gas development.
- Health and Safety Executive: regulates to ensure the operator is managing the health and safety risks appropriately throughout the life cycle of an unconventional oil and gas development.

Further to the above:

- Scottish Natural Heritage (SNH) is the statutory advisor to the Scottish and UK Governments on Scotland's nature and landscapes. It is a statutory consultee for oil and gas related SEAs, EIAs, Habitats Regulations Appraisals, Marine Licences, and for any proposals that could affect European Protected Species.
- Historic Environment Scotland (HES) has a statutory role in the planning system to provide advice on the potential impacts of development on the historic environment. HES also performs statutory functions relating to various

consenting processes including listed building consent, conservation area consent and scheduled monument consent, and is a statutory consultee for EIA.

- Any activity which intersects, disturbs or enters coal seams requires prior written authorisation from the Coal Authority.

3.13 The role of regulatory controls is incorporated in the assessment chapters. On the basis of current legislation, applicants for onshore petroleum licences are required to prepare an Environmental Awareness Statement as part of their application to the Licensing Authority. There are three sections required for the Environmental Awareness Statement: legislative awareness, awareness of the specific environmental concerns of the area and proposed mitigation measures for identified hazards.

4 SEA findings

- 4.1 The following sections of the environmental report set out the assessment findings of the alternatives and the preferred policy position. The findings are presented by SEA topic area and identify:
- effects for each topic area associated with unconventional oil and gas development and the activity which causes that effect;
 - how the effects relate to current pressures and trends;
 - current regulatory processes which control those effects;
 - assessment of how the identified effect relates to each of the alternatives being considered;
 - the overall significance of the effect; and
 - cumulative, secondary and synergistic effects within each SEA topic area.
- 4.2 In section 14, Table 14.1 *Summary of environmental effects* provides a high level summary of all of the judgements of significance.
- 4.3 The order of the findings for the SEA topic areas is presented to reflect the interlinkages between the topic areas. The order is particularly relevant in relation to cumulative effects between topic areas, and those listed which come previously typically influence the subsequent topic areas.
- Air
 - Water
 - Soil
 - Climatic factors
 - Biodiversity, flora and fauna
 - Cultural and archaeological heritage
 - Landscape and geodiversity
 - Material assets
 - Population and human health.

5 Air

- 5.1 The overlap between topic areas is recognised within the SEA, and therefore some issues which are associated with some SEA topic areas are addressed under the main topic area to which the effects relate.
- Impacts of GHG emissions on climate change associated with air emissions are addressed under the SEA topic 'climatic factors'.
 - Impacts of GHG emissions on biodiversity are addressed under the SEA topic 'biodiversity'.
- 5.2 This SEA topic focuses on the potential impacts of air pollutants on public health and the environment such as impacts on plant health. Other potential impacts of unconventional oil and gas developments on public health will be dealt with in the section 'Population and Human Health'.

What are the environmental effects of unconventional oil and gas development on air?

- 5.3 Unconventional shale gas/oil development and CBM development result in the emission of air pollutants from a number of stages of unconventional oil and gas development exploration, appraisal, production and decommissioning. The following sources of air pollution are identified:
- fugitive emissions;
 - vented emissions;
 - incomplete combustion emissions;
 - traffic air pollution;
 - leakage from decommissioned wells; and
 - emissions associated with land use change (see climatic factors)
- 5.4 These sources are discussed in greater detail below.
- 5.5 **Fugitive emissions** are direct air emissions arising from unintentional leaks in unconventional oil and gas developments²⁶. There are various potential sources of fugitive emissions. These include leaks from valves and pipe joints, compressors, well heads; accidental releases that result from routine wear, tear, and corrosion; or the overpressure of gases or liquids in the system. Methane (CH₄) is the predominant type of greenhouse gas emitted as a fugitive emission. Other noteworthy fugitive emissions include volatile organic compounds (VOCs), carbon dioxide (CO₂), hazardous air pollutants (HAPs), sulphur dioxide (SO₂), and nitrous

²⁶ Tyndall Manchester, 2014. *The Greenhouse Gas Emissions Profile of Coal Bed Methane (CBM) Production: A Review of Existing Research*. Available at: https://www.research.manchester.ac.uk/portal/files/33717093/FULL_TEXT.PDF

oxide (N₂O)^{27,28}. Fugitive emissions may also contain hazardous air pollutants (HAPs) which refer to a group of toxic and/or carcinogenic air pollutants. Examples of HAPs include benzene, asbestos, mercury and lead compounds²⁹.

- 5.6 The exact composition of fugitive emissions is variable and depends on the geology of the reservoir. Coal bed methane typically contains a higher proportion of methane than shale gas/oil³⁰. A large proportion of the fugitive emissions have been found to come from a small group of 'super emitters'. Super emitters have been identified as a key source of greenhouse gas (GHG) emissions, if they are left unchecked for extended periods of time. The emissions can occur during well, development, production and decommissioning. There is recent evidence that 2% of sites on the Barnett shale in Texas, United States, were responsible for half of the methane emissions³¹ from that location.
- 5.7 **Vented emissions** are a type of fugitive emissions, and are the result of intentional releases of unburned gases into the atmosphere. These include releases during 'flowback', releases for certain maintenance operations and releases for safety reasons to guard against over-pressuring^{32,33}. During venting operations, a number of gases and air pollutants are released. These typically include methane (CH₄), carbon dioxide (CO₂), volatile organic compounds (VOCs) and sulphur compounds³⁴.
- 5.8 **Incomplete combustion emissions** occur from on-site burning of fossil fuels associated with unconventional oil and gas developments. The emissions come from engines and other equipment used in unconventional oil and gas developments, as well as from any flaring of gas³⁵. Gas flaring is the controlled burning of natural gas. It is used during well production testing as a means to determine the pressure, flow and composition of the gas or oil from the well or as a safety device to minimise explosive conditions^{36,37}. According to a study

²⁷ Intergovernmental Panel on Climate Change, 2001. *Fugitive emissions from oil and natural gas activities*. Available at: https://www.ipcc-nggip.iges.or.jp/public/gp/bgp/2_6_Fugitive_Emissions_from_Oil_and_Natural_Gas.pdf

²⁸ Congressional Research Service, 2016. *An Overview of Air Quality Issues in Natural Gas Systems*. Available at: <http://nationalaglawcenter.org/wp-content/uploads/assets/crs/R42986.pdf>

²⁹ United States Environmental Protection Agency, 2018. *What are hazardous air pollutants?* Available at: <https://www.epa.gov/haps/what-are-hazardous-air-pollutants>

³⁰ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

³¹ Committee on Climate Change, 2016. *Scottish unconventional oil and gas: Compatibility with Scottish greenhouse gas targets*. Available at: <https://www.theccc.org.uk/wp-content/uploads/2016/11/Scottish-Unconventional-Oil-and-Gas-Committee-on-Climate-Change-2016.pdf>

³² Department of Energy & Climate Change, 2013. *Potential Greenhouse Gas Emissions Associated with Shale Gas Extraction and Use*. Available at:

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/237330/Mackay_Stone_shale_study_report_09092013.pdf

³³ Committee on Climate Change, 2016. *Scottish unconventional oil and gas: Compatibility with Scottish greenhouse gas targets*. Available at: <https://www.theccc.org.uk/wp-content/uploads/2016/11/Scottish-Unconventional-Oil-and-Gas-Committee-on-Climate-Change-2016.pdf>

³⁴ Congressional Research Service, 2016. *An Overview of Air Quality Issues in Natural Gas Systems*. Available at: <http://nationalaglawcenter.org/wp-content/uploads/assets/crs/R42986.pdf>

³⁵ Scotland, 2017. *'Talking Fracking' – A Consultation on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

³⁶ Ohio EPA, 2014. *Fact Sheet – Understanding the Basics of Gas Flaring*.

³⁷ Congressional Research Service, 2016. *An Overview of Air Quality Issues in Natural Gas Systems*. Available at: <http://nationalaglawcenter.org/wp-content/uploads/assets/crs/R42986.pdf>

commissioned by the Department of Energy & Climate Change³⁸, incomplete combustion emissions would be mainly carbon dioxide (CO₂). However, incomplete combustion could also result in other emissions such as methane (CH₄), volatile organic compounds (VOCs), nitrogen oxides (NO_x), carbon monoxide (CO), trace amounts of sulphur dioxide (SO₂), particulate matter (PM) and black carbon. Coal and, to a lesser extent, heavy fuel oils contain non-combustible materials such as minerals including calcium, and trace quantities of other metals like selenium, cadmium and so on. Furthermore, polycyclic hydrocarbons (PAHs) are produced when fuel sources such as coal, oil, gas, wood and garbage are burned. PAHs generated from these sources can bind to, or form, small particles in the air³⁹.

- 5.9 The increases in vehicle movements associated with unconventional oil and gas developments is likely to result in an increase in **traffic air pollution**⁴⁰. Traffic air pollution is the result of indirect emissions that arise from transporting materials, water supplies and waste to and from the unconventional oil and gas site⁴¹. Heavy truck movements for delivery of water which are particularly known to generate nuisance from dust and increased levels of particulate matter, NO_x and exhaust fumes⁴². However, it is important to note that the exact emissions will depend on the types of vehicle used and their emission standards. Vegetation surrounding the areas with higher vehicle movements can also influence pollution levels through the filtering and removal of particulate matter⁴³.
- 5.10 **Leakage from decommissioned wells** is another issue associated with unconventional oil and gas developments. There is a risk that a small proportion of wells may fail. The main cause is cement shrinkage, which often occurs a few years after decommissioning. There also remains a residual risk of failure of well integrity if conventional hydrocarbons in permeable rocks such as sandstones and limestones overlie unconventional oil and gas resources. These relatively soft rock formations may become a potential source of leaks if high formation pressures exist in the reservoir⁴⁴. There is evidence to suggest that these emissions are low⁴⁵.

³⁸ Department of Energy & Climate Change, 2013. *Potential Greenhouse Gas Emissions Associated with Shale Gas Extraction and Use*. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/237330/Mackay_Stone_shale_study_report_09092013.pdf

³⁹ Centres for Disease Control and Prevention, 2009. *Polycyclic Aromatic Hydrocarbons (PAHs)*. Available at: https://www.epa.gov/sites/production/files/2014-03/documents/pahs_factsheet_cdc_2013.pdf

⁴⁰ Ricardo Energy & Environment, 2016. *Unconventional oil and gas development: Understanding and mitigating community impacts from transportation*. Available at: <http://www.gov.scot/Resource/0050/00509327.pdf>

⁴¹ Committee on Climate Change, 2016. *Scottish unconventional oil and gas: Compatibility with Scottish greenhouse gas targets*. Available at: <https://www.theccc.org.uk/wp-content/uploads/2016/11/Scottish-Unconventional-Oil-and-Gas-Committee-on-Climate-Change-2016.pdf>

⁴² Ricardo Energy & Environment, 2016. *Unconventional oil and gas development: Understanding and mitigating community impacts from transportation*. Available at: <http://www.gov.scot/Resource/0050/00509327.pdf>

⁴³ Jones, L., Vieno, M., Morton, D., Cryle, P., Holland, M., Carnell, E., Nemitz, E., Hall, J., Beck, R., Reis, S., Pritchard, N., Hayes, F., Mills, G., Koshy, A., Dickie, I. (2017). *Developing Estimates for the Valuation of Air Pollution Removal in Ecosystem Accounts*. Final report for Office of National Statistics, July 2017. Available at: <https://www.ons.gov.uk/economy/environmentalaccounts/articles/developingestimatesforthevaluationofairpollutioninecosystemaccounts/2017-07-25>

⁴⁴ Aecom, 2016. *Unconventional Oil and Gas Development in Scotland: Decommissioning, Site Restoration and Aftercare – Obligations and Treatment of Financial Liabilities*. Available at: <http://www.gov.scot/Resource/0050/00509373.pdf>

- 5.11 **Emissions associated with land use change** occur when land is converted from one use to another. Land use changes affect sources of carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O). Emissions of CO₂ and CH₄ are addressed under the Climatic factors SEA topic. Examples of such changes include the clearing of forests or development of land formerly in agricultural use⁴⁶. Emissions associated with land use change can also result from land remediation during decommissioning⁴⁷.
- 5.12 The nature, scale, duration and significance of these effects in relation to this SEA topic will be further discussed below.

How do these effects relate to the current pressures and trends?

- 5.13 Air pollution remains the single largest environmental health hazard in Europe, resulting in a lower quality of life due to illnesses and an estimated 467,000 premature deaths per year⁴⁸.
- 5.14 The main pollutants of current concern in Scotland are nitrogen oxides (NO_x), particulate matter (PM₁₀ and PM_{2.5}), sulphur dioxide (SO₂), non-methane volatile organic compounds (NMVOCs), ground level ozone (O₃) and ammonia (NH₃)⁴⁹. Of these pollutants, nitrogen oxides (NO_x) and particulate matter (PM) are currently of greatest concern, as these are considered to be the most damaging to human health⁵⁰. Emissions associated with unconventional oil and gas developments contain these pollutants – to lesser or greater extent.

Table 4.1 Air pollutants associated with unconventional oil and gas

Source	Air pollutants
Fugitive emissions	Methane (CH ₄), carbon dioxide (CO ₂), volatile organic compounds (VOCs) and sulphur compounds, hazardous air pollutants (HAPs) and nitrous oxide (N ₂ O)
Incomplete combustion emissions	Mainly carbon dioxide (CO ₂) Other pollutants: methane (CH ₄), volatile organic compounds (VOCs), non-methane volatile

⁴⁵The Committee on Climate Change, 2016. *Scottish unconventional oil and gas: Compatibility with Scottish greenhouse gas targets*. Available at: <https://www.theccc.org.uk/wp-content/uploads/2016/11/Scottish-Unconventional-Oil-and-Gas-Committee-on-Climate-Change-2016.pdf>

⁴⁶ Intergovernmental Panel on Climate Change, 2000. *Land Use, Land-Use Change and Forestry*. Available at: http://www.ipcc.ch/ipccreports/sres/land_use/index.php?idp=0

⁴⁷ Committee on Climate Change, 2016. *Scottish unconventional oil and gas: Compatibility with Scottish greenhouse gas targets*. Available at: <https://www.theccc.org.uk/wp-content/uploads/2016/11/Scottish-Unconventional-Oil-and-Gas-Committee-on-Climate-Change-2016.pdf>

⁴⁸ European Environment Agency, 2016. *Air quality in Europe – 2016 report*. Available at: <https://www.eea.europa.eu/publications/air-quality-in-europe-2016/download>

⁴⁹ Transport Scotland, 2017. *Scottish Transport Statistics No 35: 2016 Edition*. Available at: <https://www.transport.gov.scot/media/33814/sct01171871341.pdf>

⁵⁰ The Scottish Government, 2016. *SPICe Briefing – Air Quality in Scotland*. Available at: http://www.parliament.scot/ResearchBriefingsAndFactsheets/S5/SB_16-35_Air_Quality_in_Scotland.pdf

Source	Air pollutants
	organic compounds (NMVOCs), nitrogen oxides (NO _x), carbon monoxide (CO), trace amounts of sulphur dioxide (SO ₂), sulphur oxides (SO _x), particulate matter (PM) and black carbon
Emissions associated with land use change ⁵¹	Carbon dioxide (CO ₂), methane (CH ₄), nitrous oxide (N ₂ O) and particulate matter.

NMVOCs and VOCs

- 5.15 Volatile Organic Compounds (VOCs) are a large group of gases and easily vaporisable liquids that differ widely in their chemical composition but display similar behaviour in the atmosphere. VOCs include both human-made and naturally-occurring chemical compounds. Non-methane volatile organic compounds (NMVOCs) are identical to VOCs, but with methane excluded⁵².
- 5.16 The largest categories of NMVOC emissions in 2016 were industrial processes and product use (54% of the UK total), followed by extraction and distribution of fossil fuels (16%) and agriculture (14%). By comparison, only 8% of the NMVOC emissions in 2016 arose from transport and other mobile sources. Between 1990 and 2016, UK emissions of NMVOC have decreased by 71%. This reduction is largely due to controls on emissions from road vehicles, which have delivered a 96% reduction in road transport sector emissions since 1990^{53,54}.
- 5.17 NMVOCs are typically emitted during unconventional oil and gas site development activities such as the use of diesel-powered equipment for site construction activities and transport⁵⁵.
- 5.18 NMVOCs have the potential to adversely impact upon human health. Some NMVOCs damage the ozone layer in the upper atmosphere, thus reducing protection from harmful UV rays⁵⁶. Other NMVOCs are toxic to humans. For instance, benzene and 1,3 butadiene have shown to be carcinogenic when there is sufficient exposure⁵⁷.

⁵¹ ClimateXChange, 2014. *Life-Cycle Assessment of Greenhouse Gas Emissions from Unconventional Gas in Scotland*. Available at: https://www.climateexchange.org.uk/media/1570/life-cycle_assessment_of_greenhouse_gas_emissions_from_unconventional_gas_in_scotland_full_report_updated_8dec14.pdf

⁵² Scottish Environment Protection Agency, undated. *Non-methane volatile organic compounds (NMVOCs)*. Available at: <http://apps.sepa.org.uk/spria/Pages/SubstanceInformation.aspx?pid=123>

⁵³ National Atmospheric Emissions Inventory, 2016. *Pollutant Information: Non Methane VOC*. Available at: http://naei.beis.gov.uk/overview/pollutants?pollutant_id=9

⁵⁴ Transport Scotland, 2017. *Scottish Transport Statistics No 35: 2016 Edition*. Available at: <https://www.transport.gov.scot/media/33814/sct01171871341.pdf>

⁵⁵ Health Protection Scotland, 2016. *A Health Impact Assessment of Unconventional Oil and Gas in Scotland – Summary*. Available at: <http://www.hps.scot.nhs.uk/resourcedocument.aspx?resourceid=3101>

⁵⁶ Scottish Environment Protection Agency, undated. *Non-methane volatile organic compounds (NMVOCs)*. Available at: <http://apps.sepa.org.uk/spria/Pages/SubstanceInformation.aspx?pid=123>

⁵⁷ European Environment Agency, 2015. *Non-methane volatile organic compounds (NMVOC) emissions*. Available at: <https://www.eea.europa.eu/data-and-maps/indicators/eea-32-non-methane-volatile-1>

Particulate matter

- 5.19 Particulate matter (PM) refers to the sum of all solid and liquid particles suspended in the air, many of which are hazardous to health. Major components of PM are sulphate, nitrates, ammonia, sodium chloride, black carbon, mineral dust and water. The release of PM constitutes a health risk as inhaled particles form a complex mixture of hazardous chemical compounds and there is no safe threshold for exposure. Recent evidence shows that PM affects more people than any other air pollutant⁵⁸. Pollutant particles are measured using a system based on the size of the individual particle; this is measured into micrometres (μ). Commonly, PM are divided into PM₁₀, PM_{2.5} and PM₁. The general rule is that the lower the size (μ), the more dangerous the pollutant is because smaller particles can penetrate and lodge more deeply into the lungs. Therefore, PM_{2.5} and PM₁ constitute a more serious health concern than PM₁₀⁵⁹.
- 5.20 A study for the European Study of Cohorts for Air Pollution Effects (ESCAPE)⁶⁰ has found that low air concentration of fine particulate matter seem to be associated with mortality. A recent report by Health Protection Scotland (HPS)⁶¹ estimated that PM_{2.5} pollution could have contributed to the deaths of 2094 people aged 25 and over in Scotland in 2010. The areas in Scotland with the highest attributable fraction of total deaths being associated with particulate matter (PM) pollution are: Edinburgh (4.9%), Glasgow City (4.7%), Falkirk (4.3%) and North Lanarkshire (4.3%)⁶².
- 5.21 Road transport accounts for a considerable share (13%) of particulate matter emissions⁶³, and at least 21% of coarse particulate matter (PM₁₀)⁶⁴. In addition, residential combustion, agriculture and industrial processes each account for over 10% of emissions. In 2015, an estimated 12kt of PM₁₀ was produced⁶⁵. Since 1992, emissions from diesel vehicles have been decreasing due to the increased uptake of new vehicles meeting tighter PM₁₀ emission regulations⁶⁶. It is estimated that PM₁₀ emissions have declined by 63% since 1990. Reductions in emissions from

⁵⁸ Health Protection Scotland, 2018. *Air Pollution & Health Briefing Note – Mortality Associated with exposure to fine particulate matter (PM_{2.5} attributable mortality) in Scotland*. Available at: <http://www.hps.scot.nhs.uk/resourcedocument.aspx?id=6660>

⁵⁹ NHS, 2013. 'Safe' levels of air pollution could still be harmful. Available at:

<https://www.nhs.uk/news/lifestyle-and-exercise/safe-levels-of-air-pollution-could-still-be-harmful/>

⁶⁰ European Study of Cohorts for Air Pollution Effects, undated. Published/accepted ESCAPE papers. Available at: <http://www.escapeproject.eu/publications.php>

⁶¹ Health Protection Scotland, 2014. *Air Quality (PM_{2.5} particulate air pollution) and Mortality in Scotland. – A Briefing Paper*. Available at: <http://www.hps.scot.nhs.uk/resourcedocument.aspx?id=1743>

⁶² Public Health England, 2014. *Estimating Local Mortality Burdens associated with Particulate Air Pollution*. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/332854/PE_CRCE_010.pdf

⁶³ Transport Scotland, 2017. *Scottish Transport Statistics No 35: 2016 Edition*. Available at: <https://www.transport.gov.scot/media/33814/sct01171871341.pdf>

⁶⁴ The Scottish Government, 2016. *SPICe Briefing – Air Quality in Scotland*. Available at: http://www.parliament.scot/ResearchBriefingsAndFactsheets/S5/SB_16-35_Air_Quality_in_Scotland.pdf

⁶⁵ National Atmospheric Emissions Inventory, 2017. *Air Quality Pollutant Inventories for England, Scotland, Wales and Northern Ireland: 1990-2015*. Available at: https://uk-air.defra.gov.uk/assets/documents/reports/cat07/1710060932_DA_Air_Quality_Pollutant_Inventories_1990-2015_v01-01.pdf

⁶⁶ Transport Scotland, 2017. *Scottish Transport Statistics No 35: 2016 Edition*. Available at: <https://www.transport.gov.scot/media/33814/sct01171871341.pdf>

energy industries, particularly due to the closure of coal fired stations, have had the most notable impact on this trend⁶⁷.

Ground level ozone

- 5.22 Unlike stratospheric ozone, which forms naturally in the upper atmosphere, ground-level (or tropospheric) ozone is created through the interactions of man-made (and natural) emissions of volatile organic compounds (VOCs) and nitrogen oxides (NO_x). The sun's direct ultraviolet rays convert VOCs and NO_x emissions into ground-level ozone. Many factors impact ground-level ozone development, including temperature, wind speed and direction, time of day, and driving patterns. Due to its dependence on weather conditions, ground-level ozone is typically a summertime pollutant.
- 5.23 High concentrations of ground level ozone can be harmful to people, particularly to children, the elderly and people of all ages who have lung diseases such as asthma. Ground level ozone can also have harmful effects on sensitive vegetation, ecosystems, animals and crops.

Carbon monoxide

- 5.24 Carbon monoxide (CO) is a colourless, odourless gas. Carbon monoxide is a product of incomplete combustion emissions associated with unconventional oil and gas developments. Exhaust emissions from transport are another key source of carbon monoxide, particularly in urban areas. Poorly maintained vehicles are known to increase carbon monoxide emissions⁶⁸.
- 5.25 In large amounts, carbon monoxide (CO) can be harmful as it reduces the amount of oxygen that can be transported in the blood stream critical to organs like the heart and the brain. It is important to note that mortality associated with carbon monoxide poisoning generally occurs in enclosed spaces indoors. Very high levels of carbon monoxide (CO) are not likely to occur outdoors. However, when carbon monoxide levels are elevated outdoors, particularly through exhausts from vehicles, they can be of particular concern for people with some types of heart disease. In addition, they are especially vulnerable to the effects of carbon monoxide (CO) when exercising or when they are under increased stress⁶⁹.
- 5.26 Therefore, it is judged that elevated carbon monoxide concentrations associated with unconventional oil and gas developments may be a consideration in urban areas characterised by high traffic flows and in locations where there are higher levels of health deprivation— particularly in areas with a relatively high density of people with heart conditions.

⁶⁷ National Atmospheric Emissions Inventory, 2017. *Air Quality Pollutant Inventories for England, Scotland, Wales and Northern Ireland: 1990-2015*. Available at: https://uk-air.defra.gov.uk/assets/documents/reports/cat07/1710060932_DA_Air_Quality_Pollutant_Inventories_1990-2015_v01-01.pdf

⁶⁸ Stravros G. Pouloupoulos and Vassilis J. Inglezakis, 2016. *Environment and Development – Basic Principles, Human Activities, and Environmental Implications*. Available at: <https://www.elsevier.com/books/environment-and-development/pouloupoulos/978-0-444-62733-9>

⁶⁹ United States Environmental Protection Agency, 2016. *Carbon Monoxide (CO) Pollution in Outdoor Air*. Available at: <https://www.epa.gov/co-pollution/basic-information-about-carbon-monoxide-co-outdoor-air-pollution>

Nitrogen oxides (NO_x)

- 5.27 There are seven nitrogen oxides (NO, NO₂, NO₃, N₂O, N₂O₃, N₂O₄, N₂O₄ and N₂O₅). The most important ones are nitric oxide (NO) and nitrogen dioxide (NO₂), which are together referred to as NO_x. It is estimated that 90% of NO_x comes from natural sources, while the remaining anthropogenic emissions are mainly attributed to combustion processes associated with transport⁷⁰. Road transport accounts for one-third (33%) of nitrogen oxide (NO_x) emissions⁷¹.
- 5.28 Transport movements account for a large share of particulate matter emissions. In 2014, emissions of nitrogen oxides were estimated to be 91kt, of which transport accounted for 41%. Since 1990, transport emissions have declined by 70%. There are a number of reasons why transport emissions have declined; the requirement for new petrol cars to be fitted with three-way catalysts since 1989 and the introduction of 'Euro standards' for new cars⁷². Since 2007, emissions of NO_x have declined notably due to reductions in road transport emissions and the power generation sector⁷³.

Sulphur

- 5.29 Sulphur oxides (SO_x) may be formed during the combustion of the sulphur contained in either fuel, inorganic and organic compounds. They are corrosive by nature, and have the potential to have adverse effects on public health and the wider environment because of the role they play in creating acid rain. Sulphur dioxide (SO₂) is particularly harmful for public health, as it can affect the respiratory system and cause irritation of the eyes, nose and throat⁷⁴.
- 5.30 When sulphur dioxide combines with water, it forms sulphuric acid – the main component of acid rain⁷⁵. In the UK, the predominant source of sulphur dioxide is the combustion of sulphur – containing fossil fuels, principally coal and heavy oils⁷⁶.
- 5.31 In 2015, emissions of sulphur dioxide were estimated to be 23kt. Emissions have declined by 92% since 1990, due to reductions in energy industries emissions – particularly coal fired power. Road transport emissions have also declined.

⁷⁰ Stavros G. Pouloupoulos and Vassilis J. Inglezakis, 2016. *Environment and Development – Basic Principles, Human Activities, and Environmental Implications*. Available at:

<https://www.elsevier.com/books/environment-and-development/pouloupoulos/978-0-444-62733-9>

⁷¹ The Scottish Government, 2016. *SPICe Briefing – Air Quality in Scotland*. Available at:

http://www.parliament.scot/ResearchBriefingsAndFactsheets/S5/SB_16-35_Air_Quality_in_Scotland.pdf

⁷² Transport Scotland, 2017. *Scottish Transport Statistics No 35: 2016 Edition*. Available at:

<https://www.transport.gov.scot/media/33814/sct01171871341.pdf>

⁷³ National Atmospheric Emissions Inventory, 2017. *Air Quality Pollutant Inventories for England, Scotland, Wales and Northern Ireland: 1990-2015*. Available at: https://uk-air.defra.gov.uk/assets/documents/reports/cat07/1710060932_DA_Air_Quality_Pollutant_Inventories_1990-2015_v01-01.pdf

⁷⁴ Stavros G. Pouloupoulos and Vassilis J. Inglezakis, 2016. *Environment and Development – Basic Principles, Human Activities, and Environmental Implications*. Available at:

<https://www.elsevier.com/books/environment-and-development/pouloupoulos/978-0-444-62733-9>

⁷⁵ Stavros G. Pouloupoulos and Vassilis J. Inglezakis, 2016. *Environment and Development – Basic Principles, Human Activities, and Environmental Implications*. Available at:

<https://www.elsevier.com/books/environment-and-development/pouloupoulos/978-0-444-62733-9>

⁷⁶ Scottish Government, 2018. *Pollutant information*. Available at:

<http://www.gov.scot/Topics/Environment/waste-and-pollution/Pollution-1/16215/6273#anchor9>

Restricting sulphur in road fuels, both petrol and diesel, has drastically reduced the emissions of sulphur dioxides from vehicles in Scotland⁷⁷.

- 5.32 People with pre-existing health conditions (such as heart disease, lung conditions and asthma) may be adversely affected by day-to-day changes in air pollution levels⁷⁸.
- 5.33 Emissions of these air pollutants are judged to have particularly adverse impacts in urban areas, as most AQMAs are located in the densely populated Midland Valley – the City of Edinburgh, East Dunbartonshire, East Lothian, Falkirk, Fife, Glasgow Midlothian, North Lanarkshire, South Lanarkshire and West Lothian⁷⁹, and the local authorities with AQMA are illustrated on Figure 1, Appendix 1. The number of AQMAs has increased from 26 in 2011 to 38 in 2018. Most AQMAs have been declared due to emissions from traffic⁸⁰. It is important to note that AQMAs are generally confined to small geographic areas which may limit their strategic importance in relation to future unconventional oil and gas developments.
- 5.34 In existing literature, it is recognised that a number of gaps remain because the full range of emissions and air pollutants from drilling, well completion and other activities remains unknown⁸¹.

What current regulatory processes control these effects?

- 5.35 There is regulation in place to protect air quality in Scotland. SEPA currently regulates over 500 major industrial sites that have the potential to cause air pollution through the *Pollution and Prevention and Control (PPC) (Scotland) Regulations 2012*⁸². In this context, SEPA sets limits for certain pollutants emitted⁸³.
- 5.36 In Scotland, releases of VOCs, NO_x, SO₂, particulate matter and carbon monoxide (amongst other polluting substances) are controlled under the *Pollution and Prevention and Control (PPC) (Scotland) Regulations 2012*⁸⁴; and the *National Air Quality Strategy*⁸⁵, which provides a framework for improving air quality, in which

⁷⁷ National Atmospheric Emissions Inventory, 2017. *Air Quality Pollutant Inventories for England, Scotland, Wales and Northern Ireland: 1990-2015*. Available at: https://uk-air.defra.gov.uk/assets/documents/reports/cat07/1710060932_DA_Air_Quality_Pollutant_Inventories_1990-2015_v01-01.pdf

⁷⁸ Scotland's Environment, 2014. *June 2014 State of the Environment Report*. Available at: <https://www.environment.gov.scot/media/1170/state-of-environment-report-2014.pdf>

⁷⁹ Air Quality in Scotland, 2017. *Air Quality Management Areas*. Available at: <http://www.scottishairquality.co.uk/laqm/aqma>

⁸⁰ Scotland's Environment, undated. *Air Quality*. Available at: <https://www.environment.gov.scot/our-environment/air/air-quality/>

⁸¹ Macey et al., 2014. *Air concentrations of volatile compounds near oil and gas production: a community-based exploratory study*. Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4216869/>

⁸² The Pollution Prevention and Control (Scotland) Regulations 2012 (Scottish Statutory Instrument 2012 No. 360)

⁸³ Scottish Environment Protection Agency, undated. *SEPA's role in air quality*. Available at: <https://www.sepa.org.uk/making-the-case/air/sepas-role-in-air-quality/>

⁸⁴ The Pollution Prevention and Control (Scotland) Regulations 2012 (Scottish Statutory Instrument 2012 No. 360)

⁸⁵ Department for Environment, Food and Rural Affairs in partnership with the Scottish Executive, Welsh Assembly Government and Department of Environment Northern Ireland, 2015. *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland*. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69336/pb12654-air-quality-strategy-vol1-070712.pdf

VOCs (1,3 butadiene and benzene) are one of the main air pollutants targeted for reduction⁸⁶. The World Health Organisation (WHO) have guidelines for ambient VOCs, but these are recommendations and therefore not mandatory.

- 5.37 In 2016, Scotland became the first country in Europe to adopt the WHO recommended limit for PM_{2.5}. However, a small proportion of Scotland is still characterised by air pollution levels above the limits contained in Scotland's air quality regulations⁸⁷.
- 5.38 Any unplanned release of fluids (liquid or gas) from an oil or gas well must be reported to HSE under Schedule 2, Part 1, Section 20 of the *Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013*⁸⁸. The *Management of Extractive Waste (Scotland) Regulations 2010*⁸⁹ requires that extractive waste will be managed without using processes or methods which could adversely impact upon local air quality and harm the wider environment.
- 5.39 Furthermore, the *Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017*⁹⁰ relate to the assessment of the impact of certain public and private projects on the environment through the planning system.⁹¹ This would require consideration of impacts on local air quality where unconventional oil and gas developments are of a size and scale to require EIA.
- 5.40 Baseline monitoring and post-decommissioning monitoring are critical in the assessment of the long-term risk of leakage from wells, because leaks typically start within several years following well abandonment. For this reason, monitoring for leakage from decommissioned unconventional oil and gas wells is required by SEPA to allow environmental authorisations to be surrendered. Where leaks are identified, the unconventional oil and gas operator should take remedial action based on a risk assessment – all in accordance with the steps that SEPA consider necessary⁹².
- 5.41 A study by the Committee on Climate Change⁹³ concludes that there are gaps in the current regulatory framework in Scotland for greenhouse gases from unconventional oil and gas developments. The current framework lacks clarity over the responsibilities and roles of the various actors and that there are gaps in relation to emissions to the atmosphere, particularly fugitive methane emissions. Following from this, the report states that the regulatory framework should be enhanced to

⁸⁶ Scottish Environment Protection Agency, undated. *Non-methane volatile organic compounds (NMVOCs)*. Available at: <http://apps.sepa.org.uk/spripa/Pages/SubstanceInformation.aspx?pid=123>

⁸⁷ The Scottish Government, 2016. *SPICe Briefing – Air Quality in Scotland*. Available at:

http://www.parliament.scot/ResearchBriefingsAndFactsheets/S5/SB_16-35_Air_Quality_in_Scotland.pdf

⁸⁸ The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013

⁸⁹ The Management of Extractive Waste (Scotland) Regulations 2010 (Scottish Statutory Instrument 2010 No. 60)

⁹⁰ The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017 (Scottish Statutory Instrument 2017 No. 102)

⁹¹ Historic Environment Scotland, *Assessing Impacts on the historic environment*.

⁹² Aecom, 2016. *Unconventional Oil and Gas Development in Scotland: Decommissioning, Site Restoration and Aftercare – Obligations and Treatment of Financial Liabilities*. Available at: <http://www.gov.scot/Resource/0050/00509373.pdf>

⁹³ Committee on Climate Change, 2016. *Scottish unconventional oil and gas: Compatibility with Scottish greenhouse gas targets*. Available at: <https://www.theccc.org.uk/wp-content/uploads/2016/11/Scottish-Unconventional-Oil-and-Gas-Committee-on-Climate-Change-2016.pdf>

ensure that regulation covers all emissions of both CO₂ and methane, which requires strict limiting of these emissions and entails long-term monitoring.

What stages of unconventional oil and gas development result in these effects, and what is the nature of these effects?

Fugitive emissions

Business as usual – shale oil and gas extraction

- 5.42 Emissions associated with unconventional oil and gas development primarily come from the well development and production stages. There is little information available on emissions associated with the exploration stage. Most studies either ignore this phase or assume that the emissions are negligible. Therefore, it should not be assumed that emissions from exploration will be low, especially for any extended well tests⁹⁴.
- 5.43 It is important to note that there is mixed evidence about the level of fugitive emissions potentially arising from unconventional oil and gas developments. In the United States, the level of fugitive emissions from shale gas operations has been estimated to range from 0.42-7.9% of total gas production. Other recent airborne measurements of methane fluxes in Pennsylvania indicated that seven well pads accounted for 4-30% of the flux in a 2800 km² area. However, these recent levels cannot be assumed to represent the Scottish situation due to contrasts in geology and source material. Therefore, there is **uncertainty** as to the extent to which results from US case studies could apply in Scotland⁹⁵.
- 5.44 The potential impacts of vented emissions could occur with **immediate effect** during the exploration, appraisal and production stage. These stages together could occur over a period of approximately **20 years**. The effects of vented emissions are anticipated to be **temporary**, due to the fact that these disturbances are caused by the venting of gases on site (when necessary). The scale of the effects is **uncertain**, depending on the size of the unconventional oil and gas pad and the sensitivity of the receiving environment.
- 5.45 Fugitive emissions could occur with **immediate effect** during the exploration, appraisal, production and decommissioning stage. These stages together could occur over a period of approximately **30 years** for an individual development.
- 5.46 The potential impacts of super-emitter sites could occur with **immediate effect** during the exploration, appraisal, production and decommissioning stage. These stages together could occur over a period of approximately **30 years** for an individual development. The scale of these effects is uncertain, however the impact of the effects on health could be permanent for those affected. As mentioned previously, there is recent evidence that 2% of sites on the Barnett shale in Texas,

⁹⁴ Committee on Climate Change, 2016. *Scottish unconventional oil and gas: Compatibility with Scottish greenhouse gas targets*. Available at: <https://www.theccc.org.uk/wp-content/uploads/2016/11/Scottish-Unconventional-Oil-and-Gas-Committee-on-Climate-Change-2016.pdf>

⁹⁵ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

United States, are responsible for half of the methane emissions from this location⁹⁶. However, these recent levels cannot be assumed to represent the Scottish situation due to contrasts in geology and source material⁹⁷. Therefore, there is **uncertainty** as to the extent to which results from US case studies could apply in Scotland.

- 5.47 In addition, further work is required to understand the characteristics that cause individual sites to be a ‘super-emitter’⁹⁸. Therefore, there is **uncertainty** as to the extent to which ‘super-emitters’ could occur in Scotland, and therefore the risk of these events occurring.
- 5.48 Leakage from decommissioned wells can occur from the decommissioning stage. Evidence shows that leakages are most likely to happen within a few years of well abandonment and decommissioning, and that cement shrinkage is the main cause of leakage⁹⁹. Should leakage from decommissioned wells occur, it is judged that the duration of these effects would be temporary – provided that monitoring results in appropriate remediation measures. However, the nature of the effects in terms of emission of greenhouse gases and climate change are effectively **permanent**. The probability, risk and scale of this effect is **uncertain**, as it depends on the construction of the well and/or the approach to monitoring and remediating leaks.
- 5.49 In addition, the plugs intended to prevent further fluid migration can deteriorate, releasing methane that has built up in the well. There is recent evidence to suggest that these methane emissions from decommissioned wells are low^{100,101}.
- 5.50 The current regulatory framework identifies potential areas of uncertainty in relation to fugitive emissions, and the potential impacts on air quality associated with this uncertainty. The level of unconventional oil and gas development under the high KPMG scenario increases the number of wells from which these potential impacts may occur. It also potentially increases the density of pad and well development, with cumulative effects on local air quality. These effects are likely to be lower for the central and low KPMG scenarios. Taking the known issues with air quality in the Central Belt into account, the overall impacts on air quality are therefore judged to be **significant negative** but **uncertain**.

⁹⁶ Committee on Climate Change, 2016. *Scottish unconventional oil and gas: Compatibility with Scottish greenhouse gas targets*. Available at: <https://www.theccc.org.uk/wp-content/uploads/2016/11/Scottish-Unconventional-Oil-and-Gas-Committee-on-Climate-Change-2016.pdf>

⁹⁷ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

⁹⁸ Committee on Climate Change, 2016. *Scottish unconventional oil and gas: Compatibility with Scottish greenhouse gas targets*. Available at: <https://www.theccc.org.uk/wp-content/uploads/2016/11/Scottish-Unconventional-Oil-and-Gas-Committee-on-Climate-Change-2016.pdf>

⁹⁹ Aecom, 2016. *Unconventional Oil and Gas Development in Scotland: Decommissioning, Site Restoration and Aftercare – Obligations and Treatment of Financial Liabilities*. Available at: <http://www.gov.scot/Resource/0050/00509373.pdf>

¹⁰⁰ Boothroyd et al., 2016. *Fugitive emissions of methane from abandoned, decommissioned oil and gas wells*. Available at: <http://www.refine.org.uk/media/sites/researchwebsites/1refine/papers/Well%20Integrity%20-%20Accepted%20Manuscript.pdf>

¹⁰¹ Committee on Climate Change, 2016. *Scottish unconventional oil and gas: Compatibility with Scottish greenhouse gas targets*. Available at: <https://www.theccc.org.uk/wp-content/uploads/2016/11/Scottish-Unconventional-Oil-and-Gas-Committee-on-Climate-Change-2016.pdf>

Business as usual – CBM

- 5.51 In the case of CBM exploration, cores have typically low fugitive emissions – particularly in the initial development stages. The reason for this is that dewatering processes associated with CBM operations have not started at this stage, suppressing potential gas flows. Pilot CBM wells are often not associated with collection and processing infrastructure and so initial gas flows may be vented or flared¹⁰².
- 5.52 As noted for shale oil and gas vented emissions, there is some uncertainty around the potential scale and regulatory control of these emissions. The duration of the impacts of the effects from the release of emissions would be effectively **permanent** for the health of those affected. However, the lower risk of fugitive emissions from CBM, and the smaller potential scale of effects from the two CBM pads is significantly lower than that for the KPMG scenarios for shale oil and gas and therefore **minor negative** but **uncertain** effects are identified.

Pilot project

- 5.53 The PPC regulations are designed to control emissions to the environment from certain specified activities. SEPA note that the activities carried out at the initial exploration stage, such as drilling and core sampling, may not fall within the current PPC Regulations. However, it is likely that a PPC permit will be required at a later stage, such as refining of natural gas, and this must be in place before specific PPC activities commence. The scope of a pilot project is not defined, but is assumed to be subject to regulatory control through PPC regulations. Before a pilot project commences, the application of PPC and other regulatory regimes such as the Management of Extractive Waste (Scotland) 2010 Regulations may need reviewed, as highlighted in the HPS report. (2016)¹⁰³. The development of a pilot project is assumed to involve the development of a single pad and an unknown number of wells, and the duration of the pilot project is unknown. The location of a pilot within the semi-urban or urban fringe location may have greater impacts on air quality than for a rural pilot, due to the assumed current levels of poorer air quality in these areas. However, the scale and extent of emissions on local air quality from a single pilot is judged to be **negligible**.

Preferred policy position

- 5.54 The preferred policy position means that adverse impacts on air quality associated with fugitive emissions from shale oil and gas production (greatest for the KPMG high production scenario, and less for the central and low scenarios), CBM production and, to a lesser extent, a pilot development, would be avoided.
- 5.55 The timeframe for the avoidance of these effects is effectively permanent. This is considered to be a **significant positive** effect.

¹⁰² Tyndall Manchester, 2014. *The Greenhouse Gas Emissions Profile of Coal Bed Methane (CBM) Production: A Review of Existing Research*. Available at:

https://www.research.manchester.ac.uk/portal/files/33717093/FULL_TEXT.PDF

¹⁰³ Health Protection Scotland (2016) A Health Impact Assessment of Unconventional Oil and Gas in Scotland. Available at: <http://www.hps.scot.nhs.uk/resourcedocument.aspx?resourceid=3102>

Construction and site traffic emissions

Business as usual – shale oil and gas extraction

- 5.56 Ricardo Energy and Environment¹⁰⁴ found that the range of unconventional oil and gas development scenarios considered could give rise to between 210 and 1,670 traffic movements per week on average across the country as a whole, with a further 99 movements associated with the coal bed methane scenario¹⁰⁵. The study concluded that additional traffic movements associated with unconventional oil and gas developments are unlikely to be significant at a regional or national scale, in view of the much greater number of traffic movements resulting from other activities. However, the potential for localised impacts would depend on the nature, scale and location of the proposed development. For instance, the proximity to a sensitive area, such as an Air Quality Management Area (AQMA) or near to sensitive receptors (e.g. schools, hospitals, residential properties etc.), would increase the scale of, and potential for, significant localised impacts.
- 5.57 The potential impacts caused by air pollution from traffic would occur with **immediate effect** during the exploration, appraisal and production stage. These stages combined could occur over a period of approximately **20 years**. The rate of vehicle movements fluctuates throughout the life of each well, with the full extent of these effects peaking during the production phase¹⁰⁶. For instance, it is estimated that the construction of each well pad would require between 7,000-11,000 truck visits¹⁰⁷.
- 5.58 Under the KPMG high scenario, the level of development has the greatest number of pads and wells, and therefore generates the highest level of traffic movements. This has the potential for cumulative effects on air quality for local communities where traffic from multiple pads uses the same routes. The location of pads under the central and low scenario could also result in this effect. The location of the pads is unknown, but if they are located within close proximity to sensitive receptors this could increase the local significance of effects. Reflecting the evidence base for air quality impacts from traffic, and the potential for locally significant effects, the impacts from unconventional oil and gas development for shale oil and gas are judged to be **significant negative** but **uncertain** depending on local circumstances.

Business as usual– CBM

- 5.59 CBM is characterised by a significantly reduced need for imported water, which is likely to require fewer traffic movements. As a result, CBM operations are expected

¹⁰⁴ Ricardo Energy & Environment, 2016. *Unconventional oil and gas development: Understanding and mitigating community impacts from transportation*. Available at: <http://www.gov.scot/Resource/0050/00509327.pdf>

¹⁰⁵ Ricardo Energy & Environment, 2016. *Unconventional oil and gas development: understanding and mitigating community impacts from transportation*. Available at: <http://www.gov.scot/Resource/0050/00509327.pdf>

¹⁰⁶ Ricardo Energy & Environment, 2016. *Unconventional oil and gas development: Understanding and mitigating community impacts from transportation*. Available at: <http://www.gov.scot/Resource/0050/00509327.pdf>

¹⁰⁷ Broderick et al., 2011. *Shale gas: an updated assessment of environmental and climate change impacts. A report commissioned by The Co-operative and undertaken by researchers at the Tyndall Centre, University of Manchester*. Available at: <http://www.mace.manchester.ac.uk/media/eps/schoolofmechanicalaerospaceandcivilengineering/newsandevents/news/research/pdfs2011/shale-gas-threat-report.pdf>

to generate fewer traffic movements per pad than for shale oil and gas, with lower impacts on air quality from traffic emissions. As noted in the above section on shale oil and gas extraction, the conclusion of Ricardo Energy and Environment are that additional traffic movements associated with unconventional oil and gas developments are unlikely to be significant at a regional or national scale. The location of the CBM pads is unknown, but if they are located within close proximity to sensitive receptors this could increase the local significance of effects. The impacts from the development of two CBM pads and associated wells are judged to be **minor negative** but **uncertain**.

Pilot project

- 5.60 The development of a pilot project is assumed to involve the development of a single pad and an unknown number of wells, although it is assumed that the overall scale of development would be less than for a pad at full production. If a pilot was located within the semi-urban location, it may have greater impacts on air quality than a rural or urban fringe pilot, due to the assumed proximity to areas of poorer air quality. This would increase the likelihood of cumulative effects on local air quality. Therefore, the scale and extent of emissions on local air quality from traffic associated with a single pilot is judged to be **minor negative** but **uncertain**.

Preferred policy position

- 5.61 The preferred policy position means that adverse impacts on air quality associated with emissions from traffic movements (greatest for the KPMG high production scenario, and less for the central and low scenarios), CBM production and, to a lesser extent, a pilot development, would be avoided.
- 5.62 This is considered to be a **significant positive** effect.

Cumulative, secondary and synergistic effects

Business as usual – shale oil and gas and CBM

- 5.63 The combined effect of air pollution from fugitive emissions and from transport is likely to be greatest under the KPMG high production scenario for shale oil and gas extraction which has the highest number of pads and greatest number of wells developed per pad.
- 5.64 The larger number of pads and wells increases the likely extent of adverse effects on air quality. It also increases the likelihood of development taking place within close proximity to an area with existing air quality issues, with potential greater significance of effect. However there is uncertainty over the location of pads under all three of the development scenarios. Conversely, positive synergy could also result from the high development scenario for shale oil and gas extraction which could facilitate sharing of pipelines, reducing overall impacts from individual pipeline construction or traffic impacts. The contribution of fugitive emissions in combination with transport emissions is however judged to be **significant negative** but **uncertain** for all three KPMG scenarios. The cumulative effects of CBM are based on lower levels of traffic pollution and the smaller scale of CBM development, however reflecting the potential for cumulative effects from fugitive emissions and transport to affect sensitive receptors, these effects are judged to be **minor negative** but **uncertain**.

Pilot project

- 5.65 An individual pilot project would result in cumulative effects from fugitive emissions and transport. This effect would be greater in combination with existing pressures on air quality from a site in close proximity to an AQMA. However the cumulative effects from a single pilot are judged to be **minor negative uncertain**.

Preferred policy position

- 5.66 The preferred policy position means that cumulative adverse impacts on air quality associated with fugitive and transport emissions from shale oil and gas production (greatest for the KPMG high production scenario, and less for the central and low scenarios), CBM production and, to a lesser extent, a pilot development, would be avoided.

The **timeframe** for the avoidance of these additional effects is approximately the next 40 years, although pressures from transport are focused within the exploration, appraisal and production stages of development. The avoidance of these effects is judged to be **permanent** within the context of the SEA. The **scale** of avoidance of effects reflects the geographic area identified as prospective for shale oil and gas, across the Central Belt of Scotland.

- 5.67 In summary, although the air quality of the Central Belt of Scotland will continue to face existing pressures, the preferred policy position means that additional pressures on air quality which could directly result from unconventional oil and gas development in Scotland would be avoided. This is considered to be a **minor positive** effect.

Scope for further mitigation

- 5.68 The assessment results are based on the application of existing regulatory controls. The evidence base includes information on a number of processes which could be implemented to reduce the scale of impact from fugitive and transport emissions. These could reduce the overall potential scale of effect from unconventional oil and gas development, and therefore the associated scale of effect avoided as a consequence of the preferred policy position.
- 5.69 The applicability and practicality of many of these additional measures would be determined at a site specific level so it is not possible to draw firm conclusions as to the extent to which they would mitigate predicted effects successfully.
- 5.70 Currently, there are technologies for limiting and monitoring fugitive methane emissions following shale gas extraction and CBM. Case studies from the US have demonstrated that these measures can be costly, lowering economic profitability. As a result, uptakes of measures for limiting emissions have been relatively low in the US due to the high costs of emission prevention and mitigation. Therefore, developments in the US unconventional oil and gas industry are currently focussed on reducing the cost of sensors and other related technologies¹⁰⁸. However, it is recognised that the regulatory situation relating to emission limitations is different in Scotland. Potential areas of additional mitigation include:

¹⁰⁸ TNO, 2015. *Inventory of technologies and developments for reducing (residual) risks in shale gas extraction*. Available at: <https://publications.tno.nl/publication/34618831/wHLFqd/TNO-2014-R10919-Ef.pdf>

- **Vented emissions** – gases that are being vented could be burnt rather than dispersed into the atmosphere. Combustion would partially reduce the environmental impacts, because the process serves to incinerate many of the volatile organic compounds (VOCs) and hazardous air pollutants (HAPs) that would otherwise be released directly into the atmosphere. It should be noted that the combustion process would still result in adverse environmental impacts so there is a limit to extent to which associated impacts could be reduced.
- **Super emitters** – A large proportion of the fugitive gas which is emitted has been found to come from a small group of ‘super emitters’. Although a complete avoidance of super-emitters may be unachievable, with suitable operational control and maintenance procedures these high emitters could largely be eliminated. The International Climate Fund (ICF) suggests that annual inspections and repair would reduce emissions by 40%, quarterly inspections by 60% and monthly inspections by 80%. If the super emitters could be brought in line with the average, then total supply chain emissions would be reduced by 65%-87%¹⁰⁹. Although the potential reduction in greenhouse gases achieved through mitigation measures is likely to be considerable, there is likely to be limited scope for further mitigation because super emitters comprise a relatively small proportion of unconventional oil and gas wells¹¹⁰. Further work is required to understand the characteristics that cause individual sites to be a ‘super-emitter’¹¹¹.
- **Leakage from decommissioned wells:** Ensuring well integrity is highly dependent upon the application of best practice standards for well design and construction. The risk of gas leakage (including methane) from abandoned unconventional oil and gas wells is expected to be very low if constructed and abandoned to comply with international standards and industry best practice. To further reduce potential impacts, monitoring technology can be used so that remedial measures can be taken at an early stage. Examples include fibre optic sensing techniques including Fibre Bragg gratings (FBGs), Distributed Temperature Sensing (DTS) and Distributed Acoustic Sensing (DAS). Recent evidence suggests that fibre optic sensing technology has existed for decades, but most techniques are not yet mature for commercial deployment in the unconventional oil and gas industry. DAS has matured most rapidly, as is currently deployed on a commercial basis for selected geophysical and flow applications following a recent trial¹¹².

¹⁰⁹ Committee on Climate Change, 2016. *Scottish unconventional oil and gas: Compatibility with Scottish greenhouse gas targets*. Available at: <https://www.theccc.org.uk/wp-content/uploads/2016/11/Scottish-Unconventional-Oil-and-Gas-Committee-on-Climate-Change-2016.pdf>

¹¹⁰ <https://www.theccc.org.uk/wp-content/uploads/2016/11/Scottish-Unconventional-Oil-and-Gas-Committee-on-Climate-Change-2016.pdf>

¹¹¹ Committee on Climate Change, 2016. *Scottish unconventional oil and gas: Compatibility with Scottish greenhouse gas targets*. Available at: <https://www.theccc.org.uk/wp-content/uploads/2016/11/Scottish-Unconventional-Oil-and-Gas-Committee-on-Climate-Change-2016.pdf>

¹¹² Lumens, 2014. *Fibre-optic sensing for application in oil and gas wells Eindhoven: Technische Universiteit Eindhoven*. Available at: <https://pure.tue.nl/ws/files/3823460/769555.pdf>

5.71 There are a number of ways to reduce the air quality impacts of increased vehicle movements associated with unconventional oil and gas developments. Firstly, transport capacity can be optimally deployed using supply chain management systems and ICT resources. These measures have the potential to reduce the impacts on local air quality associated with vehicle movements. Secondly, emissions can be reduced or avoided through the use of pipelines or the re-use of wastewater¹¹³.

¹¹³ Ricardo Energy & Environment, 2016. *Unconventional oil and gas development: Understanding and mitigating community impacts from transportation*. Available at: <http://www.gov.scot/Resource/0050/00509327.pdf>

Table 5.1: Summary of impacts on Air

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
Fugitive emissions to air	Business as usual – shale oil and gas extraction	Major	Short to long term	Temporary	A significant negative effect is identified reflecting the potential scale of emissions, the scale of development and the known issues with air quality in the Central Belt.	There is mixed evidence about the potential level of fugitive emissions and regulatory control of these emissions.
	Business as usual– coal bed methane	Minor	Short to long term	Temporary	A minor negative effect is identified reflecting that CBM typically have low fugitive emissions, and the more limited scale of development.	There is uncertainty around the potential scale of fugitive emissions for CBM and regulatory control of these emissions.
	Pilot project	Minor	Short to long term	Temporary	A negligible effect is identified reflecting the scale and extent of emissions on local air quality from a single pilot.	There is mixed evidence about the potential level of fugitive emissions and regulatory control of these emissions. The location of a pilot is uncertain, and therefore the sensitivity of the location and potential impact is uncertain.

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
	Preferred Policy Position	None	Short to long term	Permanent	A significant positive effect is identified reflecting the avoidance of significant negative effects.	
Construction and site traffic emissions	Business as usual– shale oil and gas extraction	Major	Short to long term	Temporary	A significant negative effect is identified reflecting the potential scale of air quality impacts from traffic, and the potential for locally significant effects.	The potential for localised impacts would depend on the nature, scale and location of the proposed development including the proximity to sensitive receptors/areas.
	Business as usual– coal bed methane	Minor	Short to long term	Temporary	A minor negative effect is identified reflecting that CBM results in fewer traffic movements than shale oil and gas extraction and has a lower level of potential overall development.	
	Pilot project	Minor	Short to long term	Temporary	A minor negative effect is identified reflecting the potential scale and extent of emissions on local air quality from traffic associated with a single pilot.	
	Preferred Policy Position	None	Short to long term	Permanent	A significant positive effect is identified reflecting the avoidance of significant negative effects.	

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
Cumulative	Business as usual – shale oil and gas extraction	Major	Short to long term	Temporary	A significant negative effect is identified from the combined effect of air pollution from fugitive emissions and from transport. This is likely to be greatest under the KPMG high production scenario for shale oil and gas extraction	The potential location of pads in proximity to sensitive receptors/areas is an area of uncertainty under all development scenarios.
	Business as usual– coal bed methane	Minor	Short to long term	Temporary	A minor negative effect is identified reflecting the potential for cumulative effects impacting on sensitive receptors.	
	Pilot project	Minor	Short to long term	Temporary	A minor negative effect is identified reflecting the potential for cumulative effects impacting on sensitive receptors.	
	Preferred Policy Position	None	Short to long term	Permanent	A significant positive effect is identified reflecting the avoidance of significant negative effects.	

6 Water

What are the environmental effects of unconventional oil and gas development on water?

- 6.1 Unconventional hydrocarbon extraction can both produce wastewater and consume water resources.
- 6.2 The wastewater produced by unconventional oil and gas developments is also referred to as 'flowback and produced' (FP) waters¹¹⁴. The difference between flowback water and produced water is the time spent in the well; flowback water usually refers to the return of injected fluids following hydraulic fracturing, while produced water is formation water that is high in gas and oil¹¹⁵ or water produced due to the pumped abstraction of water directly from coal beds. Coal bed methane (CBM) development generally does not require the injection of fluids or hydraulic fracturing^{116,117}.
- 6.3 Unconventional oil and gas development can also consume water. Shale gas and shale oil operations require water for the hydraulic fracturing process. In Scotland, the vast majority of water is sourced from surface water resources, although the industry may wish to abstract groundwater for logistical reasons.
- 6.4 Coal bed methane (CBM) operations involve a dewatering process. During this process, the coal bed methane is extracted by pumping out the water in the reservoir, which decreases the water pressure, allowing the gas to detach from the coal reservoir and well up to the surface¹¹⁸.
- 6.5 The potential environmental effects of unconventional oil and gas development on water arising from the different stages and activities associated with unconventional oil and gas development are identified as:
 - Direct water pollution arising from exploration, appraisal, production and decommissioning:
 - Water contamination caused by produced water during production;
 - Water pollution caused by flowback waters during production;

¹¹⁴ Kondash et al., 2017. *Quantity of flowback and produced waters from unconventional oil and gas exploration*. Available at: <https://www.sciencedirect.com/science/article/pii/S004896971631988X>

¹¹⁵ Blewett et al., 2017. *The effect of hydraulic flowback and produced water on gill morphology, oxidative stress and antioxidant response in rainbow trout (Oncorhynchus mykiss)*. Available at: <https://www.nature.com/articles/srep46582>

¹¹⁶ SEPA, undated. *Unconventional Gas Development: Monitoring of Produced Water*. Available at: <https://www.sepa.org.uk/media/59423/unconventional-gas-development-monitoring-of-produced-water.pdf>

¹¹⁷ Environment Agency, 2011. *Shale Gas North West – Monitoring of Flowback water*. Available at: [http://webarchive.nationalarchives.gov.uk/20140328145127/http://www.environment-agency.gov.uk/static/documents/Business/6th_Dec_-_Shale_gas_-_North_West_-_Monitoring_of_flowback_water_-_update_\(3\).pdf](http://webarchive.nationalarchives.gov.uk/20140328145127/http://www.environment-agency.gov.uk/static/documents/Business/6th_Dec_-_Shale_gas_-_North_West_-_Monitoring_of_flowback_water_-_update_(3).pdf)

¹¹⁸ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

- Gas and fluid leakage associated with poor well construction during exploration, appraisal and production;
 - Aquifer cross-contamination due to poor borehole construction during exploration, appraisal and production;
 - Accidental releases of hazardous materials;
 - Surface spills from storage tanks;
 - Contamination that could arise from the construction and removal of infrastructure;
 - Leaks along the casing of poorly constructed and decommissioned unconventional oil and gas wells.
- Abstraction of water for hydraulic fracturing during the exploration, appraisal and production stages with impacts on:
 - Water availability and supply.
 - Indirect water pollution arising from abstraction of water for hydraulic fracturing during the exploration, appraisal and production stages:
 - intrusion of saline water into waterbodies as a result of water extraction.

How do these effects relate to the current pressures and trends?

- 6.6 In recent decades, significant improvements in water quality have been observed in many rivers, canals and estuaries due to decreases in the releases of environmental pollutants. Recent data¹¹⁹ shows that 80% of groundwaters in Scotland were at good status in 2016. In addition, 62% of surface waters (rivers, lochs, and estuaries) were at good status or better in 2016¹²⁰. Rivers across Scotland's Central Belt and East Coast require further work in order to ensure that they achieve 'good or better' overall status under Scotland's overarching target framework for waterbodies¹²¹. Figure 2a and 2b, Appendix 1 illustrate the water quality across Scotland and the Central Belt, and illustrates that several areas of poor water quality coincide with the area prospective for unconventional oil and gas development.
- 6.7 Key pressures on water quality originate from human activity. Climate change could also affect water quality, it could extend the growing season, which could place additional pressures on water quality as agriculture is a key source of environmental pollutants¹²². Changes in water availability from warmer drier summers and warmer wetter winters could also impact on water quality.

¹¹⁹ SEPA, 2016. *Water Classification Hub – groundwaters*. Available at: <https://www.sepa.org.uk/data-visualisation/water-classification-hub/>

¹²⁰ SEPA, 2016. *Water Classification Hub – surface waters*. Available at: <https://www.sepa.org.uk/data-visualisation/water-classification-hub/>

¹²¹ SEPA, 2017. *River Basin Management Planning*. Available at: <https://www.sepa.org.uk/environment/water/river-basin-management-planning/>

¹²² DPMAG (undated). *Rural diffuse pollution plan for Scotland*. Available at: <https://www.sepa.org.uk/media/37557/rural-diffuse-pollution-plan-scotland.pdf>

What current regulatory processes control these effects?

- 6.8 There is legislation in place to control certain impacts of unconventional oil and gas developments on the wider water environment.
- 6.9 At the European level, the *REACH Enforcement Regulations 2008*¹²³ require that all additives in fracturing fluids that exceed the one metric tonne threshold and other requirements set by REACH Regulation must be registered at the European Chemicals Agency by the manufacturer or importer.
- 6.10 In Scotland, the *Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017*¹²⁴ relate to the assessment of the impact of certain public and private projects on the environment through the planning system.¹²⁵ This would require consideration of impacts on water quality and quantity where unconventional oil and gas developments are of a size and scale to require EIA.
- 6.11 In the UK, the *Borehole Sites and Operations Regulations 1995*¹²⁶ requires notifications to be made to HSE about the design, construction and operation of wells. In addition, well operators must provide HSE with regular reports of any activities on the well where there is a risk of an unplanned release of fluids from the well. In such circumstances, they must appoint an independent well examiner to undertake regular assessments of well integrity. Under the 1995 Regulations, the HSE also requires that wells are designed and construction with well abandonment in mind (DCR Regulation 15). During the decommissioning phase, operators must notify the HSE before wells are abandoned and show that the process complies with Oil and Gas UK guidelines and the requirements of the DCR.
- 6.12 Any unplanned release of fluids from an oil or gas well must also be reported to HSE under Schedule 2, Part 1, Section 20 of the *Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013*¹²⁷.
- 6.13 The *Control of Major Accident Hazards Regulations 2015* (COMAH)¹²⁸ seek to prevent major accidents involving dangerous substances and limit the consequences to the environment, including the water environment. If COMAH applies, the operator will be required to identify their major hazard scenarios and demonstrate to the Competent Authority that they have taken control measures to prevent major accidents and made arrangements for mitigatory action in the event of an accident occurring. The enforcement authority (HSE and SEPA) can prohibit operation where these measures are seriously deficient.

¹²³ European Commission, 2008. *Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006*. Available at: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32008R1272>

¹²⁴ The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017 (Scottish Statutory Instrument 2017 No. 102)

¹²⁵ Historic Environment Scotland, Assessing Impacts on the historic environment.

¹²⁶ The Borehole Sites and Operations Regulations 1995 (1995 No. 2038)

¹²⁷ The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013

¹²⁸ The Control of Major Accident Hazards Regulations 2015 (2015 No. 483)

- 6.14 If naturally occurring radioactive material (NORM) is above threshold levels set by the *Radioactive Substances Act 1993* (RSA 93)¹²⁹, contaminated vessels and pipework must be taken to specialist clean-up facilities, where the radioactive scale is removed before disposal in a UK landfill. The management of NORM containing wastes, including their disposal to the environment, is regulated by SEPA. The disposing of produced or 'flowback' waters is tightly regulated in Scotland. The production of „flow-back“ fluid from hydraulic fracturing is a mining waste activity, relevant to *The Management of Extractive Waste (Scotland) Regulations 2010*. Disposing of produce or flowback waters will be controlled through planning permission for the site through an agreed waste management plan. Operators will need to have a waste management plan in place, and be able to demonstrate to planning authorities how they will store and dispose of wastes safely without causing pollution to the environment.¹³⁰
- 6.15 Through the *Water Environment (Controlled Activities) (Scotland) Regulations 2011* (CAR)¹³¹, the operator requires an appropriate authorisation for specific activities with the aim of preventing significant adverse impacts on the water environment. The following activities all require CAR authorisation:
- the construction of the borehole;
 - the discharge of fracturing fluid to ground or surface water, including assessing hazards presented by fracturing fluids on a case-by-case basis;
 - ground or surface water abstractions.
- 6.16 Where the *Pollution Prevention and Control (Scotland) Regulations 2012*¹³² apply, SEPA will require the operator to effectively manage risks to ground water resources.
- 6.17 Scotland's regulatory framework comprises regulation to mitigate the risks of surface spills of fracturing fluid i.e. caused by accidental release. In the UK, there are systems in place to manage the impact of chemical spillage in the event of a traffic accident. These controls would reduce, but not fully eliminate, such risks.
- 6.18 Currently, there is no specific legislation for monitoring once a Petroleum Exploration and Development Licence (PEDL), Controlled Activities Regulations (CAR) licence or Pollution Prevention and Control (PPC) licence is surrendered. There is a need for improved baseline monitoring of environmental data to allow any environmental impacts to be effectively identified¹³³. A CAR license cannot be surrendered until SEPA is satisfied there is no risk to the environment.
- 6.19 Regulatory consents incorporate best practices in order to mitigate spills and leakages. These include using non-hazardous chemicals wherever possible, storing them away from surface waters and important aquifers, ensuring sites are protected with impermeable liners and ensuring all stores have double walls as a precaution

¹²⁹ Radioactive Substances Act 1993 (c.12)

¹³⁰SEPA (undated) Regulatory guidance: Coal bed methane and shale gas. Available at: https://www.sepa.org.uk/media/139706/unconventional_gas_guidance.pdf

¹³¹ Water Environment (Controlled Activities) (Scotland) Regulations 2011 (Scottish Statutory Instrument 2011 No. 209)

¹³² The Pollution Prevention and Control (Scotland) Regulations 2012 (Scottish Statutory Instrument 2012 No. 360)

¹³³ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

against leaks¹³⁴. In the event that surface spills or leakages occur, there is appropriate legislation already in place to ensure remediation¹³⁵.

- 6.20 An abstraction is the removal or diversion of water from the natural water environment, by a variety of means. Abstractions are regulated by the Water Environment (Controlled Activities) (Scotland) Regulations 2011– more commonly known as the Controlled Activity Regulations (CAR) and requires authorisation from SEPA, and ensures the responsible management of water resources.¹³⁶

What stages of unconventional oil and gas development result in these effects, what is the nature and significance of these effects?

Direct water pollution

Business as usual– shale oil and gas extraction

- 6.21 **Contamination caused by produced water** is a potential issue associated with unconventional oil and gas development. Research has shown that the chemistry of produced water is consistent with that of water contained in coal beds at depth with substances including: chloride, iron, aluminium, nickel, zinc, lead and a number of organic compounds (benzene, xylene, and naphthalene)¹³⁷. Produced water also contains high brine levels, with concentrations above that of seawater¹³⁸. In some instances, produced water may be contaminated with naturally occurring radioactive materials (NORM). NORM are present in a wide range of geological formations, including oil- and gas-bearing rock strata. Produced water abstracted from coal seams may contain NORM. In addition, NORM are likely to be present in unconventional oil and gas operations as insoluble sediments and scales that adhere to the surface of pipework (of both CBM developments and hydraulic fracturing operations)¹³⁹.
- 6.22 Contamination caused by produced water could occur during the exploration, appraisal and production stage, which together could occur over a period of approximately **20 years** for an individual development¹⁴⁰. Should these effects occur, it is judged that the duration of these impacts is **uncertain**, depending on the type(s) of naturally occurring radioactive material(s) present, the geochemistry of the reservoir, the volume of water circulating through the reservoir¹⁴¹ and the sensitivity of the receiving environment.

¹³⁴ Mair *et al.*, 2012. *Shale gas extraction in the UK: a review of hydraulic fracturing*. Available at:

https://royalsociety.org/~media/royal_society_content/policy/projects/shale-gas/2012-06-28-shale-gas.pdf

¹³⁵ Aecom, 2016. *Unconventional Oil and Gas Development in Scotland: Decommissioning, Site Restoration and Aftercare – Obligations and Treatment of Financial Liabilities*. Available at:

<http://www.gov.scot/Resource/0050/00509373.pdf>

¹³⁶ Scottish Environment Protection Agency website. Available at:

<https://www.sepa.org.uk/regulations/water/abstractions/>

¹³⁷ SEPA, undated. *Unconventional Gas Development: Monitoring of Produced Water*. Available at:

<https://www.sepa.org.uk/media/59423/unconventional-gas-development-monitoring-of-produced-water.pdf>

¹³⁸ TNO, 2015. *Inventory of technologies and developments for reducing (residual) risks in shale gas extraction*. Available at: <https://publications.tno.nl/publication/34618831/wHLFqd/TNO-2014-R10919-Ef.pdf>

¹³⁹ The Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

¹⁴⁰ The Scottish Government, 2017. *Talking 'Fracking' – A Consultation on Unconventional Oil and Gas*.

Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

¹⁴¹ The Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

- 6.23 Due to the existing regulatory regime, the environmental impacts of water contamination caused by the disposal of produced water should be **minimal**, unless there is illegal disposal of fluid.
- 6.24 **Water pollution caused by ‘flowback’ water** is a potential risk associated with hydraulic fracturing development. During the hydraulic fracturing process, water is injected into the shale at high pressure in order to create, or enlarge, tiny fractures in the rock. Some of the water that is injected into the shale rock returns to the surface as ‘flowback water’¹⁴². Typically around 25% of the water injected will return to the surface over a period of weeks, or potentially a few months. ‘Flowback’ water is very saline and has a high mineral content – notably high levels of sodium, chloride, bromide and iron, as well as higher values of lead, magnesium and zinc¹⁴³. It may also contain NORM, inorganic materials and organic matter¹⁴⁴.
- 6.25 Water pollution caused by ‘flowback’ water could occur during the exploration, appraisal and production stage, which together could occur over a period of approximately **20 years** for an individual development¹⁴⁵. Should water pollution caused by ‘flowback’ water occur, it is judged that the duration of these impacts is **uncertain**, depending on the type(s) of naturally occurring radioactive material(s) present, the chemical composition of the hydraulic fracturing fluid, the geochemistry of the reservoir, the volume of water circulating through the reservoir¹⁴⁶ and the sensitivity of the receiving environment.
- 6.26 There is the risk of surface water contamination if ‘flowback’ water is not treated properly before disposal¹⁴⁷. Due to the existing regulatory regime, the environmental impacts of water contamination caused by the disposal of ‘flowback’ water should be **minimal**, unless there is illegal disposal of fluid. It is important to note that the scale of these effects is likely to be greatest under the KPMG high production scenario, which has the highest number of pads and greatest number of wells developed per pad.
- 6.27 **Gas and fluid leakage associated with poor well construction** could have the potential to adversely impact local water quality. In certain circumstances, hydrocarbons and other well fluids can migrate out of the well and into the wider environment. It has been suggested that it may also be possible for gas in the shale formation to escape into ground water following fracking activities. However, the likelihood of widespread significant releases by this mechanism has been

¹⁴² Scotland, 2017. ‘Talking Fracking’ – A Consultation on Unconventional Oil and Gas. Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

¹⁴³ Environment Agency, 2011. *Shale Gas North West – Monitoring of Flowback water*. Available at: [http://webarchive.nationalarchives.gov.uk/20140328145127/http://www.environment-agency.gov.uk/static/documents/Business/6th_Dec_-_Shale_gas_-_North_West_-_Monitoring_of_flowback_water_-_update_\(3\).pdf](http://webarchive.nationalarchives.gov.uk/20140328145127/http://www.environment-agency.gov.uk/static/documents/Business/6th_Dec_-_Shale_gas_-_North_West_-_Monitoring_of_flowback_water_-_update_(3).pdf)

¹⁴⁴ Scotland, 2017. ‘Talking Fracking’ – A Consultation on Unconventional Oil and Gas. Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

¹⁴⁵ The Scottish Government, 2017. *Talking ‘Fracking’ – A Consultation on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

¹⁴⁶ The Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

¹⁴⁷ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

questioned in literature, as no such releases during the hydraulic fracturing process have been recorded^{148,149}.

- 6.28 Gas and fluid leakage caused by poor well construction can occur during the exploration, appraisal and production stages and following well decommissioning. These effects could therefore occur over a period well in **excess of 20 years**. Should gas and fluid leakage occur, the duration of these impacts is **uncertain**, depending on the construction of the well, the nature of the geological formation in question and the sensitivity of the receiving environment. The main waterbodies at risk from gas and fluid leakage from wells are¹⁵⁰:
- shallow groundwater;
 - groundwater bodies at greater depth;
 - drinking water.
- 6.29 Well integrity is important to ensure that no gas leakage occurs during the production stage or injected fluid leakage during the injection period of the hydraulic fracturing operation. Problems involving well construction, particularly well casing and cementing failures are the most common reported sources of water contamination¹⁵¹.
- 6.30 It is important to note that there are differences between the number of well casings, and the extent to which these are cemented in place. In the US, it is common to have two strings of casings. At a minimum, the cement should extend above any exposed water or hydrocarbon bearing zones. In some states, such as Pennsylvania and Texas, there is a requirement to cement casing to approximately 75ft below any aquifers. In the UK, standard practice is to have three strings of casing with at least two passing through (and thereby isolating) any freshwater zones. Best practice in the UK is to cement casings all the way back to the surface¹⁵². In addition, the details of local geology in Scotland remain unclear – making it difficult to draw any conclusions regarding the scale of any potential impacts¹⁵³. As a result, findings drawn from U.S. case studies cannot be assumed to represent the Scottish situation due to differences in regulatory regimes as well as

¹⁴⁸ Department of Energy & Climate Change, 2013. *Potential Greenhouse Gas Emissions Associated with Shale Gas Extraction and Use*. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/237330/Mackay_Stone_shale_study_report_09092013.pdf

¹⁴⁹ Aecom, 2016. *Unconventional Oil and Gas Development in Scotland: Decommissioning, Site Restoration and Aftercare – Obligations and Treatment of Financial Liabilities*. Available at: <http://www.gov.scot/Resource/0050/00509373.pdf>

¹⁵⁰ Aecom, 2016. *Unconventional Oil and Gas Development in Scotland: Decommissioning, Site Restoration and Aftercare – Obligations and Treatment of Financial Liabilities*. Available at: <http://www.gov.scot/Resource/0050/00509373.pdf>

¹⁵¹ Health Protection Scotland, 2016. *A Health Impact Assessment of Unconventional Oil and Gas in Scotland – Summary*. Available at: <http://www.hps.scot.nhs.uk/resourcedocument.aspx?resourceid=3101>

¹⁵² Royal Society/Royal Academy of Engineering, 2012. *Shale gas extraction in the UK: a review of hydraulic fracturing*. Available at: https://royalsociety.org/~media/royal_society_content/policy/projects/shale-gas/2012-06-28-shale-gas.pdf

¹⁵³ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

contrasts in geology. Therefore, there is uncertainty as to the extent to which result from US case studies could apply in Scotland¹⁵⁴.

- 6.31 Another key issue is **aquifer cross-contamination due to poor borehole construction**, particularly in the cased and cemented zone of a borehole. Movements of pollutants that depend on geological and hydrogeological conditions may result in the rise and the lateral spreading through geological strata via an aquifer¹⁵⁵. This is especially true in the shallower subsurface, where such leaks could potentially contaminate freshwater aquifers¹⁵⁶.
- 6.32 Aquifer cross-contamination due to poor borehole construction can occur during the exploration, appraisal and production stage. These stages together could occur over a period of approximately **20 years** for an individual development. Should aquifer cross-contamination occur, it is judged that these effects would be **effectively permanent**, although it is recognised that over a long timescale, these effects can be reversed. The duration of these impacts is **uncertain**, depending on the construction of the borehole and the nature of the geological formation in question, the nature of the hydrology near the cased and cemented zone of a borehole, the structure of the (sub)surface and the sensitivity of the receiving environment.
- 6.33 The risk of direct migration of methane or other components from the unconventional oil and gas well to aquifers is judged to be **minimal**, and only considered significant if fracking affects the insulating qualities of wells. Due to existing legislation for well construction and design, these risks are minimised but remain a point of **concern**¹⁵⁷.
- 6.34 Surface water contamination caused by **accidental releases of hazardous materials** and wastewater spills during transportation. Truck accidents could potentially lead to chemical or wastewater spills which could include fracturing fluid, additives, 'flowback' water and/or produced water¹⁵⁸. In the event of an accidental spill, fluids can run off into surface water and seep into groundwater¹⁵⁹.
- 6.35 Surface water contamination caused by accidental releases of hazardous materials and wastewater spills during transportation can occur during the production and decommissioning stage, which together could occur over a period of approximately **20 years**. Should surface water contamination occur, it is judged that the duration of these effects is **uncertain**, depending on the type of material spilled, the volume

¹⁵⁴ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

¹⁵⁵ Health Protection Scotland, 2016. *A Health Impact Assessment of Unconventional Oil and Gas in Scotland – Summary*. Available at: <http://www.hps.scot.nhs.uk/resourcedocument.aspx?resourceid=3101>

¹⁵⁶ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

¹⁵⁷ TNO, 2015. *Inventory of technologies and developments for reducing (residual) risks in shale gas extraction*. Available at: <https://publications.tno.nl/publication/34618831/wHLFqd/TNO-2014-R10919-Ef.pdf>

¹⁵⁸ Ricardo Energy & Environment, 2016. *Unconventional oil and gas development: understanding and mitigating community impacts from transportation*. Available at: <https://beta.gov.scot/publications/unconventional-oil-gas-understanding-mitigating-community-impacts-transportation/documents/00509327.pdf>

¹⁵⁹ Scotland, 2017. *'Talking Fracking' – A Consultation on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

of material spilled, and the proximity of the spill to surface waters and other sensitive systems¹⁶⁰.

- 6.36 There is regulation to mitigate the risk of accidental releases of hazardous materials, and therefore the environmental impacts of water contamination from these should be **minimal**. This risk increases under the higher production scenarios. The likelihood of pollution incidents that contaminate surface water increases as the number of drilling sites increases¹⁶¹. Therefore, the scale of these effects is likely to be greatest under the KPMG high production scenario and lower for the central and low scenarios.
- 6.37 **Surface water spills from storage tanks** could have the potential to adversely impact upon water quality. These spills include fluids and chemicals used in the unconventional oil and gas process, or produced water and ‘flowback’ water¹⁶². For instance, the water injected into the shale rock during the hydraulic fracturing process contains several substances. Typically, water injected into the shale rock during the hydraulic fracturing process contains proportions of sand (5%) and chemicals (1%)¹⁶³.
- 6.38 Surface spills from storage tanks can occur during the exploration, appraisal and production stage. These stages together could occur over a period of approximately **20 years** for an individual development. Should surface spills from storage tanks occur, it is judged that the duration of effects would be **temporary**, depending on the frequency of spills, the type of material spilled, the volume of material spilled, and the proximity of the spill to surface waters and other sensitive systems¹⁶⁴.
- 6.39 There is regulation to mitigate the risk of accidental releases of hazardous materials, and therefore the environmental impacts of water contamination from these should be **minimal**. This risk increases under the higher production scenarios. The likelihood of pollution incidents that contaminate surface water increases as the number of drilling sites increases¹⁶⁵. Therefore, the scale of these effects is likely to be greatest under the KPMG high production scenario and lower for the central and low KPMG scenarios.
- 6.40 Another risk is related to **contamination that could arise from the construction and removal of infrastructure** – particularly that which could link between different boreholes across the drilling area¹⁶⁶.

¹⁶⁰ Maloney et al., 2016. *Unconventional oil and gas spills: Materials, volumes and risks to surface waters in four states of the U.S.* Available at: <http://environment.law.harvard.edu/wp-content/uploads/2017/04/Science-of-the-Total-Environment-Spill-Paper.pdf>

¹⁶¹ Institution of Environmental Sciences, undated. *Fracking: the debate*. Available at: https://www.the-ies.org/sites/default/files/documents/fracking_the_debate.pdf

¹⁶² Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

¹⁶³ Scotland, 2017. *‘Talking Fracking’ – A Consultation on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

¹⁶⁴ Maloney et al., 2016. *Unconventional oil and gas spills: Materials, volumes and risks to surface waters in four states of the U.S.* Available at: <http://environment.law.harvard.edu/wp-content/uploads/2017/04/Science-of-the-Total-Environment-Spill-Paper.pdf>

¹⁶⁵ Institution of Environmental Sciences, undated. *Fracking: the debate*. Available at: https://www.the-ies.org/sites/default/files/documents/fracking_the_debate.pdf

¹⁶⁶ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

- 6.41 Boreholes are drilled for core sampling and for extracting oil, gas and water. The effects of borehole construction could occur during exploration, appraisal and production.
- 6.42 Poorly constructed and decommissioned oil and gas wells can develop **leaks along the casing** after production has ceased. Such leaks often take years to unfold after decommissioning, allowing hydrocarbons and other well fluids to eventually migrate out of the well and into the environment. During the decommissioning stage, there is also the risk of leaks in tanks and pipework which could potentially contaminate the ground¹⁶⁷.
- 6.43 Leaks from decommissioned wells can occur during the decommissioning stage, which usually occurs over a period of **2-5 years**, however, leaks often take years to unfold after decommissioning. Should leaks occur, it is judged that these effects would be **effectively permanent**, depending on the nature of the water environment and geological structures surrounding the well, and the construction of the well.
- 6.44 The scale of these effects on the water environment is likely to be greatest under the KPMG high production scenario, which has the highest number of pads and greatest number of wells developed per pad. These effects are likely to be lower for the central and low KPMG scenarios.
- 6.45 Taking account of the existing regulatory framework, it is judged that the potential impacts of direct water pollution occurring as a result of poor well construction and well leakage in decommissioned wells may result in **minor negative uncertain** effects.
- 6.46 It is judged that the potential impacts of direct water pollution from all of the above sources may result in a cumulative potential **significant negative** but uncertain effect.

Business as usual – CBM

- 6.47 The effects in terms of direct water pollution for shale oil and gas extraction are broadly similar for CBM. Based on this conclusion the potential effects on the water environment are also judged to be **significant negative**.

Pilot project

- 6.48 The effects of a pilot project on the water environment could vary significantly, depending on its location. Compared to the 'Business as usual' alternative, the development of a single pilot location would reduce the area over which the effects on the water environment may occur. The risk of direct impacts on the water environment is judged to be significant in areas of high sensitivity to water pollution. This includes resources which rely on high water quality such as biodiversity.
- 6.49 The rural pilot is assumed to be in an area of higher water quality, although its connectivity to sensitive areas is not specified. Therefore potentially **significant negative** effects on local water quality have been identified.
- 6.50 Compared to a rural pilot which is assumed to be in an area of higher water quality, the effect of water pollution may be greater in the semi urban pilot area which is

¹⁶⁷ Aecom, 2016. *Unconventional Oil and Gas Development in Scotland: Decommissioning, Site Restoration and Aftercare – Obligations and Treatment of Financial Liabilities*. Available at: <http://www.gov.scot/Resource/0050/00509373.pdf>

assumed to be in an area of moderate water quality and has direct pathways to an area of international biodiversity importance, and a secondary **significant negative** effect is identified, reflecting the impacts on the internationally important biodiversity site. The urban fringe pilot area is assumed to be in an area of poor water quality and the development will add to existing water quality issues, and a **minor negative** effect is identified.

Preferred policy position

- 6.51 The preferred policy position means that adverse impacts of direct water pollution on water quality from shale oil and gas production (greatest for the KPMG high production scenario, and less for the central and low scenarios), CBM production and a pilot development, would be avoided.
- 6.52 This is considered to be a **significant positive** effect.

Water abstraction and supply and indirect water pollution arising from abstraction

Business as usual– shale oil and gas

- 6.53 Water is typically the main component in hydraulic fracturing fluids. During large-scale shale gas extraction, large quantities of fracking fluids may be required. In some locations, this has been recorded as resulting in **shortages of local water supplies** e.g. for drinking water and agriculture¹⁶⁸. The impacts of climate change may further exacerbate this problem¹⁶⁹. Surface water and groundwater abstraction associated with unconventional oil and gas developments also has the potential to lead to the **intrusion of saline water** into non-saline groundwater¹⁷⁰.
- 6.54 Due to the regulatory control of water abstraction by SEPA, it is assumed that levels of abstraction would be controlled within environmental limits in order to maintain the quality of the local water environment. Should uncontrolled abstraction occur, this could result in significant negative effects on the local water environment¹⁷¹. Under the KPMG high scenario, the requirement for water would be greatest due to the high number of wells, and the cumulative effect of this could result in competing demand for water within a local area. This could impact on the local availability of water and the ecological status of waterbodies. Although there is potential risk of uncontrolled abstraction, this is viewed as low. Therefore, in light of the regulatory control provided by SEPA, adverse impacts from abstraction are judged to be **negligible**.

¹⁶⁸ TNO, 2015. *Inventory of technologies and developments for reducing (residual) risks in shale gas extraction*. Available at: <https://publications.tno.nl/publication/34618831/wHLFqd/TNO-2014-R10919-Ef.pdf>

¹⁶⁹ Broderick et al., 2011. *Shale gas: an updated assessment of environmental and climate change impacts. A report commissioned by The Co-operative and undertaken by researchers at the Tyndall Centre, University of Manchester*. Available at:

<http://www.mace.manchester.ac.uk/media/eps/schoolofmechanicalaerospaceandcivilengineering/newsandevents/news/research/pdfs2011/shale-gas-threat-report.pdf>

¹⁷⁰ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

¹⁷¹ SEPA (undated) Regulatory guidance: Coal bed methane and shale gas. Available at: https://www.sepa.org.uk/media/139706/unconventional_gas_guidance.pdf

Business as usual– CBM

- 6.55 CBM extraction uses a dewatering process, and where hydraulic fracturing is not required for extraction, does not require water. However, the CBM dewatering processes which remove groundwater can result in the intrusion of saline water into waterbodies. This can occur during the exploration, appraisal and production stage, which could occur over a period of approximately **20 years**. It is judged that the impacts would be **effectively permanent**, although it is recognised that over a long timescale, these effects can be reversed. However, this largely depends on the nature of the geological processes and interactions between rocks, the nature of the surrounding water environment and the sensitivity of the receiving environment. The areas at highest risk of saltwater intrusion include¹⁷²:
- close to the coast;
 - where there is a low to moderate slope;
 - on peninsulas or in areas with a limited source area for groundwater recharge;
 - where there is a high density of wells;
 - where there are high rates of pumping from a single well or from multiple wells in a coastal area;
 - where the static (non-pumping) groundwater level is at or below sea level.
- 6.56 The intrusion of saline water into waterbodies could impact on water quality with locally significant effects. **Secondary** effects from salinisation may occur in relation to soil quality, biodiversity and material assets. The regulatory control provided by SEPA should ensure that these impacts are **negligible**.

Pilot

- 6.57 Should uncontrolled abstraction take place, this could result in locally significant effects on water quality and availability. Compared to a rural pilot which is assumed to be in an area of higher water quality, the effect may be greater in a semi urban pilot area which is assumed to be in an area of moderate water quality and has direct pathways to an area of international biodiversity importance, and a secondary negative effect could occur, reflecting the impacts on the internationally important biodiversity site. The effect may also be greater in an urban fringe pilot area which is assumed to be in an area of poor water quality. Reflecting the regulatory control provided by SEPA a **negligible** effect is identified.

Preferred policy position

- 6.58 The environmental effects of the preferred policy position are the avoidance of the risk of effects resulting from water shortages caused by uncontrolled abstraction of water and impacts on water quality resulting from uncontrolled abstraction. This risk is however acknowledged as low, and the overall effect is judged to be **negligible**.

¹⁷² Government of British Columbia, 2016. *Best Practices for Prevention of Saltwater Intrusion*. Available at: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/water-wells/saltwaterintrusion_factsheet_flno_web.pdf

Cumulative, secondary and synergistic effects

Business as usual– shale oil and gas

- 6.59 The cumulative effects on the water environment from shale oil and gas extraction include the risk of direct water pollution, the risk of reduced water flow arising from water abstraction, and the secondary effect of indirect water pollution resulting from saline intrusion following water abstraction. Reflecting the potential scale of development under the KPMG scenarios, **significant negative** cumulative effects are identified for the water environment. The effects of reduced water levels as a result of abstraction could also result in negative synergy as a result of further exacerbation of the effects of direct water pollution as a result of reduced dilution of pollutants. **Secondary** effects from salinisation may occur in relation to soil quality, biodiversity and material assets. Impacts on soil quality and biodiversity could result in **significant negative** effects.

Business as usual- CBM

- 6.60 The impacts described above could also occur in relation to CBM, but over a smaller area, reflecting the development of two CBM pads. **Minor negative** effects are identified.

Pilot

- 6.61 Secondary effects from salinisation may result in effects with greater significance on resources such as soil, biodiversity and material assets, and potential locally significant effects could occur, with **minor negative** effects identified overall.

Preferred policy position

- 6.62 The timeframe for the avoidance of these additional effects is approximately the next 40 years reflecting the timescale of unconventional oil and gas development described in the KPMG scenarios. The avoidance of these effects is judged to be **permanent** within the context of the SEA. The **scale** of avoidance of effects reflects the geographic area identified as prospective for shale oil and gas, across the Central Belt of Scotland.
- 6.63 The preferred policy position means that adverse impacts on the water environment associated with shale oil and gas production (greatest for the KPMG high production scenario, and less for the central and low scenarios), CBM production and, to a lesser extent, a pilot development, would be avoided.

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| <p>6.64 In conclusion, although the water environment of the Central Belt of Scotland will continue to face existing pressures, the preferred policy position means that additional pressures on water which could directly result from unconventional oil and gas development in Scotland would be avoided. This is considered to be a significant positive effect.</p> |
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Scope for further mitigation

- 6.65 The assessment results are based on the application of existing regulatory controls. The evidence base includes information on a number of processes which could be implemented to reduce the scale of impact on the water environment. These could reduce the overall potential scale of effect from unconventional oil and gas development, and therefore the associated scale of effect avoided as a consequence of the preferred policy position.

- 6.66 The applicability and practicality of many of these additional measures will be determined at a site specific level so it is not possible to draw firm conclusions as to the extent to which they would mitigate predicted effects successfully.
- 6.67 The evidence base includes information on a number of processes which could be implemented to reduce the scale of impact on the water environment. The implementation of these measures would reduce the overall scale of adverse effects avoided.
- 6.68 Potential measures include:
- 6.69 **Contamination caused by produced water and flowback water** – there are a number of feasible ways to process flowback and produced (FP) water:
- Through the treatment of the wastewater so that it can be returned (back) to the environment. For instance, a crystallisation plant was recently commissioned in Pennsylvania (US) that is able to convert wastewater into water that meets current standards for water discharge in the US. The salt that is extracted during the process can also be used as road salt. The crystallisation plant in Pennsylvania is the first of its kind, and is more efficient economically and environmentally compared to more conventional wastewater treatment plants. Efforts are currently undertaken to further refine existing techniques or invent new approaches to fully or partially reuse wastewater.
 - Injection of the wastewater into an empty gas field.
 - Reuse of wastewater in subsequent fracking activities.
- 6.70 In addition, there are various substitutes that can be used to (partially) replace water in hydraulic fracturing fluids – carbon dioxide, LPG and/or propane being the most commonly used substances in the US and Canada. However, it is recognised that alternative substances have their respective disadvantages. For instance, they are often harmful or hazardous by nature (e.g. LPG) and their effect and risk is insufficiently known as nearly all alternative substances are hardly used or at the experimental stage.¹⁷³
- 6.71 **Gas and fluid leakage associated with poor well construction** – ensuring well integrity is highly dependent upon the application of best practice standards for well design and construction. In addition, a significant reduction in risks can be achieved by using monitoring technology so that remedial measures can be taken at an early stage. Examples include fibre optic sensing techniques including Fibre Bragg gratings (FBGs), Distributed Temperature Sensing (DTS) and Distributed Acoustic Sensing (DAS). Recent evidence suggests that fibre optic sensing technology has existed for decades, but most techniques are not yet mature for commercial deployment in the unconventional oil and gas industry. DAS has matured most rapidly, as is currently deployed on a commercial basis for selected geophysical and flow applications following a recent trial¹⁷⁴.
- 6.72 **Aquifer cross contamination** – further development of high resolution sensors for monitoring could be used to prevent or reduce methane migration to aquifers.

¹⁷³ TNO, 2015. *Inventory of technologies and developments for reducing (residual) risks in shale gas extraction*. Available at: <https://publications.tno.nl/publication/34618831/wHLFqd/TNO-2014-R10919-Ef.pdf>

¹⁷⁴ Lumens, 2014. *Fibre-optic sensing for application in oil and gas wells Eindhoven: Technische Universiteit Eindhoven*. Available at: <https://pure.tue.nl/ws/files/3823460/769555.pdf>

- 6.73 **Accidental releases of hazardous materials** – increased traffic safety measures could help to reduce the number of vehicles carrying hazardous substances getting involved in traffic accidents.
- 6.74 **Surface spills** – geotextiles and geo-synthetics can be used on surfaces to reduce the risk of surface water pollution. It is important to note that geotextiles and geo-synthetics are already available, but are not yet widely used.
- 6.75 **Borehole leaks** – there are other ways to mitigate or limit the effects caused by the contamination of fracking fluids; the advancement of alternative hydraulic fracturing and drilling techniques may increase the efficiency of the hydraulic fracturing process so that the use of hazardous chemicals can be reduced or avoided.

Table 6.1: Summary of effects on Water

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
Direct pollution	Business as usual– shale oil and gas extraction	Major	Short to long term	Permanent	A significant negative effect is identified reflecting the range of potential sources of direct water pollution.	Areas of uncertainty include the potential level of contamination by different pollutants, and the likelihood of contamination from different sources.
	Business as usual– coal bed methane extraction	Minor	Short to long term	Permanent	A significant negative effect is identified reflecting the range of potential sources of direct water pollution.	
	Pilot project	Low	Short to long term	Permanent	A significant negative effect is identified for rural and semi urban pilots, with a minor negative effect on the urban fringe pilot.	
	Preferred policy position	None	Short to long term	Permanent	A significant positive effect is identified reflecting the avoidance of significant negative effects.	
Water abstraction and supply, and indirect water pollution from	Business as usual– shale oil and gas	Major	Short to long term	Permanent	A negligible effect is identified reflecting the regulatory control provided	Occurrence of uncontrolled abstraction

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
abstraction	extraction				by SEPA.	
	Business as usual– coal bed methane extraction	Minor	Short to long term	Permanent	A negligible effect is identified reflecting the regulatory control provided by SEPA.	
	Pilot project	Minor	Short to long term	Permanent	A negligible effect is identified reflecting the regulatory control provided by SEPA.	
	Preferred policy position	None	Short to long term	Permanent	A negligible effect is identified reflecting the avoidance of negligible effects.	
Cumulative effects	Business as usual– shale oil and gas extraction	Major	Short to long term	Permanent	Significant negative cumulative effects are identified for the water environment reflecting the potential scale of development under the KPMG scenarios.	
	Business as usual– coal bed methane	Minor	Short to long term	Permanent	Minor negative effects are identified reflecting the scale of development over	

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
	extraction				a smaller area	
	Pilot project	Minor	Short to long term	Permanent	Minor negative effects are identified overall. Salinisation may result in effects with greater significance on resources such as soil, biodiversity and material assets, and potential locally significant effects could occur.	
	Preferred policy position	None	Short to long term	Permanent	A significant positive effect is identified reflecting the avoidance of significant negative effects.	

7 Soil

What are the environmental effects of unconventional oil and gas development on soil?

7.1 The environmental effects of unconventional oil and gas development on soil are identified as:

- Ground contamination caused by:
 - flowback fluids associated with hydraulic fracturing;
 - leaks from surface installations (e.g. tanks and pipework);
 - saline intrusion.
- Soil sealing resulting from construction of the well pad and access roads;
- Greenhouse gas emissions associated with land-use change (the greenhouse gas emissions are assessed under climatic factors).

How do these effects relate to the current pressures and trends?

7.2 The most important pressures affecting soil are climate change and changes in land use and land management practices.¹⁷⁵ According to the most recent State of Soil Report¹⁷⁶ it is acknowledged that there is a lack of systematic Scottish soil data and significant gaps remain in relation to the potential threats that unconventional oil and gas developments could impose on Scotland's soils. Gaps include:

- data on the extent and nature of soil contamination is limited;
- there is no systemic data collection to capture the extent and the quality of land being sealed;
- relatively little is known about the state and trend of Scotland's soil biodiversity except for a few protected soil-dwelling species.

7.3 There is some evidence that some contaminant inputs and their impacts are reducing, for example from atmospheric acid deposition. However, many other potential soil contaminants such as organic chemicals are not routinely measured. This, alongside changes in land management practices has the potential to impact on soil biodiversity.

7.4 The distribution of best and most versatile agricultural land is illustrated in Figure 7a and 7b, and the distribution of high carbon soils is illustrated in Figure 8a and 8b, Appendix 1. These show there are areas of both of these important soil types distributed across the Midland Valley, within the areas of potential unconventional oil

¹⁷⁵ Scottish Government (2011) The State of Scotland's soil report. Available at: <https://www.sepa.org.uk/media/138741/state-of-soil-report-final.pdf>

¹⁷⁶ Dobbie, K.E., Bruneau, P.M.C and Towers, W. (eds), 2011. *The State of Scotland's Soil – Natural Scotland*. Available at: <https://www.sepa.org.uk/media/138741/state-of-soil-report-final.pdf>

and gas development. Best and most versatile land is important in relation to agricultural production and high carbon soils are important carbon sinks and are also important for biodiversity.

What current regulatory processes control these effects?

- 7.5 There is legislation in place to control certain impacts of unconventional oil and gas developments on the wider water environment, which result in secondary effects on soil. These include the *Water Environment (Controlled Activities) (Scotland) Regulations 2011* and *Pollution Prevention, Control (Scotland) Regulations 2012*¹⁷⁷ and *Environmental Liability (Scotland) Regulations 2009*¹⁷⁸. Scotland's regulatory framework comprises regulation to mitigate the risks of surface spills of fracturing fluid i.e. caused by accidental release. It is important to note that these controls would reduce, but not fully eliminate, such risks.
- 7.6 Furthermore, the *Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017*¹⁷⁹ relate to the assessment of the impact of certain public and private projects on the environment through the planning system.¹⁸⁰ This would require consideration of impacts on soil quality where unconventional oil and gas developments are of a size and scale to require EIA.
- 7.7 The *Management of Extractive Waste (Scotland) Regulations 2010*¹⁸¹ requires that extractive waste will be managed without using processes or methods which could adversely impact upon soil quality.
- 7.8 Authorisation by SEPA under the *Radioactive Substances Act 1993*¹⁸² (RSA) is required if activities include the disposal of water, sediments or scales returning to the surface which contain naturally occurring radioactive materials and are above a certain threshold defined in the Act. If granted by SEPA, the RSA authorisation puts conditions and limitations on the accumulation and disposal of the produced and flowback waters and solids produced.
- 7.9 Workplace exposure to harmful substances is regulated under the *Control of Substances Hazardous to Health Regulations 2002* (COSHH)¹⁸³ by HSE. Under COSHH, assessment and control of the hazard posed by fluids containing chemicals that may be harmful to worker health is required, therefore it may also, indirectly, contribute to providing some protection measures against soil contamination.
- 7.10 In the event of land contamination, remediation can be required by SEPA under the environmental permitting system. If remediation does not otherwise occur it is

¹⁷⁷ The Pollution Prevention and Control (Scotland) Regulations 2012 (Scottish Statutory Instrument 2012 No. 360)

¹⁷⁸ The Environmental Liability (Scotland) Regulations 2009 (Scottish Statutory Instrument 2009 No. 266)

¹⁷⁹ The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017 (Scottish Statutory Instrument 2017 No. 102)

¹⁸⁰ Historic Environment Scotland, Assessing Impacts on the historic environment.

¹⁸¹ The Management of Extractive Waste (Scotland) Regulations 2010 (Scottish Statutory Instrument 2010 No. 60)

¹⁸² The Radioactive Substances Act 1993 (1993 c.12)

¹⁸³ The Control of Substances Hazardous to Health Regulations 2002 (2002 No. 2677)

regulated by the *Environmental Protection Act 1990*¹⁸⁴ Part IIA and the *Contaminated Land (Scotland) Regulations 2000*¹⁸⁵. Local authorities are responsible for identifying and securing remediation of contaminated land.

- 7.11 Due to the existing regulatory regime, the environmental impacts of ground contamination from flowback waters should be minimal, unless there is illegal disposal of fluid. There is regulation to mitigate the risk of surface spills of fracturing fluids, and therefore the environmental impacts of soil contamination from these should be minimal. However, the proximity of potential unconventional oil and gas development sites to sensitive receptors means that the potential impacts of these limited effects could be more significant.
- 7.12 The planning system controls development and the protection of soils and reduction in carbon emissions is embedded in the national policy framework. Nevertheless, were UOG to go ahead, negative effects could occur.

What stages of unconventional oil and gas development result in these effects, what is the nature and significance of these effects?

Ground contamination

Business as usual– shale oil and gas extraction

- 7.13 Ground contamination from flowback fluids can occur during the exploration, appraisal and production stages of unconventional oil and gas development, which together could occur over a period of approximately **20 - 30 years** for an individual development.
- 7.14 Surface leaks from decommissioned wells can occur during the decommissioning and abandonment stage of development, which may occur over a period of **2 – 5 years** for an individual development
- 7.15 Surface spills from surface installations can occur during the exploration, appraisal and production stages of development, which may only occur over a period of approximately **20 years** for an individual development.
- 7.16 Should ground contamination or surface spills occur, it is judged that the nature of these effects would be **temporary**, the scale and duration of these impacts is **uncertain**, depending on the nature of the contamination, the extent of contamination, and the sensitivity of the receiving environment. Contamination of soils which affects **water** supply for consumption or farmland soils could impact on **human health**, and all emissions into the wider environment could impact on **biodiversity, flora and fauna** (covered under the section on 'biodiversity, flora and fauna').
- 7.17 The scale of these effects is likely to be greatest under the KPMG high production scenario, which has the highest number of pads and greatest number of wells developed per pad. This larger number of developments increases the risk of ground contamination and surface spills. There is regulation to mitigate the risk of accidental release of hazardous materials and therefore a **minor negative** but

¹⁸⁴ Environmental Protection Act 1990 (1990 c. 43)

¹⁸⁵ The Contaminated Land (Scotland) Regulations 2000 (as amended) (Scottish Statutory Instrument 2000 No. 178)

uncertain effect is identified. These effects are likely to be lower for the central and low KPMG scenarios.

Business as usual- CBM

- 7.18 The nature and timescale of impacts on soil from ground contamination arising from CBM are similar to those described above. The scale of effect is limited to impacts arising from the development of two pads and 30 wells. Impacts on soil will reflect the sensitivity of the receiving environment, and in light of the regulatory controls the effects on soil quality are judged to be **negligible** but **uncertain**.

Pilot project

- 7.19 The significance of effects of ground contamination related to a pilot project will depend upon the sensitivity of the receiving environment. Impacts on soil quality for each the three potential pilot locations could impact on soil biodiversity and functionality. Similar to CBM, the scale of effects is limited to the area of a single pad and an unknown number of wells. Therefore the effects on soil quality of all three pilot locations are judged to be **negligible** but **uncertain**.

Preferred policy position

- 7.20 The preferred policy position means that potential soil contamination associated with unconventional oil and gas development in Scotland would be avoided.
- 7.21 This is considered to be a **minor positive** effect.

Soil sealing

Business as usual- shale oil and gas extraction

- 7.22 Soil sealing occurs during exploration, the development of the pad, and production, where further wells may be developed with additional surface infrastructure. The effect of soil sealing from an individual unconventional oil and gas development will be for the duration of approximately **20 - 30 years**, but will be **temporary**, as the majority of surface infrastructure is removed during decommissioning, and the site restored to original condition. However the extent to which the soil returns to its original function is uncertain. Soil sealing also impacts on flood risk, and this is covered under the section on '**Water**'.
- 7.23 For each of the KPMG shale oil and gas extraction scenarios the scale of effect from each scenario is greatest under the high production scenario, where the highest number of pads would be developed, leading to soil sealing over a larger area. This would result in the sealing of approximately 24ha¹⁸⁶ for the high scenario, 16ha for the central scenario and 8ha for the low scenario¹⁸⁷. All of the areas indicated are excluding any additional land area required for access roads, pipes etc. and are therefore presented as conservative estimates.
- 7.24 Even under the KPMG high scenario, the area of land lost to soil sealing is insignificant compared to the areas of land being brought forward for other types of

¹⁸⁶ For comparison the Alloa West Business Park allocated in the Clackmannanshire Local Plan (2015) p. 117 covers an area of 53.48ha, Sauchie West housing allocation p. 122 covers an area of 52.81ha. Available at: <http://gis.clacksweb.org.uk/dataset/e0a14ab6-c461-436a-a7e0-ec9ff4c899e9/resource/aaa5ccb2-136a-48e5-b349-848d2ca27abc/download/clackmannanshirelocaldevelopmentplanaugust2015.pdf>

¹⁸⁷ Based on the assumption that an average well pad is the area of a football pitch (8,000m²) each KPMG scenario is therefore the (number of pads x 8,000), plus the area of 2 CBM pads at 16,000m².

development within the relevant local plan areas. The potential location in areas of existing flood risk means that effects of soil sealing under all of the KPMG scenarios is judged to be **minor negative uncertain**.

Business as usual- CBM

- 7.25 The nature of the effect of soil sealing is similar for both shale oil and gas extraction and CBM. The scale of the effect for CBM reflects the potential development of two pads of a total area of approximately 1.6ha.
- 7.26 The overall scale of effect on soil sealing for CBM is identified as **negligible**.

Pilot project

- 7.27 Reflecting the above conclusions, the scale of soil sealing from an individual pad for a pilot project, in any of the three potential locations is judged to be **negligible**.

Preferred policy position

- 7.28 The preferred policy position means that potential soil sealing associated with unconventional oil and gas development in Scotland would be avoided.
- 7.29 This is considered to be a **minor positive** effect.

Cumulative, synergistic and secondary effects

Business as usual- shale oil and gas extraction

- 7.30 There is some degree of uncertainty over the extent of current threats to soil. The range of impacts on soil arising from shale oil and gas extraction includes minor negative effects from ground contamination and significant negative but uncertain effects of greenhouse gas emissions from land use change (assessed under climatic factors). These are not identified to have cumulative effects on the soil resource due to their different impact pathways in terms of soil quality and the contribution of soil to greenhouse gas emissions.

Business as usual- CBM

- 7.31 No cumulative effects are identified reflecting the negligible effects identified for all impacts on soil from the development of CBM.

Pilot project

- 7.32 No cumulative effects are identified reflecting the negligible effects identified for all impacts on soil from the development of a pilot in the three theoretical locations.

Preferred policy position

- 7.33 The environmental impact of the Scottish Government's preferred policy position on the development of unconventional oil and gas in Scotland is relative to the baseline which assumes the development of unconventional oil and gas. The **timeframe** for the avoidance of these additional effects is approximately the next 40 years. The avoidance of these effects is judged to be **permanent** within the context of the SEA. The **scale** of avoidance of effects reflects the geographic area identified as prospective for shale oil and gas, across the Central Belt of Scotland.
- 7.34 The effect is judged to be **minor positive** in relation to soil quality, reflecting the avoidance of any adverse effects on soil from unconventional oil and gas development.

7.35 In conclusion, although the soils of the Central Belt of Scotland will continue to face existing pressures, the preferred policy position means that additional pressures on the soil resource which would result from unconventional oil and gas development are avoided. This includes the potential impact on high carbon soils, soil sealing in flood risk areas and the proximity of the area of potential development to sensitive receptors (see Water, Population and Human Health, Biodiversity flora and fauna). The effect is judged to be **minor positive** in relation to soil quality, reflecting the avoidance of any adverse effects on soil from unconventional oil and gas development.

Scope for further mitigation

- 7.36 The assessment results are based on the application of existing regulatory controls. The evidence base includes information on a number of processes which could be implemented to reduce the scale of impact on soils. These could reduce the overall potential scale of effect from unconventional oil and gas development, and therefore the associated scale of effect avoided as a consequence of the preferred policy position.
- 7.37 The applicability and practicality of many of these additional measures will be determined at a site specific level so it is not possible to draw firm conclusions as to the extent to which they would mitigate predicted effects successfully.
- 7.38 Potential measures include:
- 7.39 **Ground contamination** – many of the water mitigation measures could help to protect soils, and reduce or avoid ground contamination. These include the use of geotextiles and geo-synthetics, the use of biodegradable fracking fluids, the (optimised) treatment of flowback and produced water through mobile units or at central facilities, and the use of advanced monitoring technologies (e.g. DTS and DAS). Other mitigatory measures include careful soil stripping, storage, and restoration in accordance with best practice. Furthermore, contingency planning to deal with accidental spillages and contamination of soil is likely to significantly reduce the potential impacts on soil quality and quantity associated with unconventional oil and gas developments.
- 7.40 **Greenhouse gas emissions associated with land use change** – avoiding development on high carbon soils is likely to have positive effects in terms of reducing greenhouse gas emissions associated with land use change.
- 7.41 **Soil sealing resulting from construction of the well pad and access road** – mitigating the effects of soil sealing can be achieved by using permeable materials that reduce water runoff and allow more rain water to infiltrate through the underlying soils. This could help to lower water treatment costs and reduces the risk of flooding and water erosion. Furthermore, impacts on soil quality could be reduced or potentially avoided if the works would be undertaken in suitable weather conditions to prevent soil damage i.e. avoiding periods of high rainfall.

Table 7.1: Summary of effects on soils

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
Ground contamination	Business as usual– shale oil and gas extraction	Major	Short to long term	Temporary	A minor negative effect is identified. These effects are likely to be lower for the central and low KPMG scenarios.	There is regulation to mitigate the risk of accidental release of hazardous materials, however there is a risk of ground contamination and surface spills. A larger number of developments increases the risk of ground contamination and surface spills.
	Business as usual– coal bed methane extraction	Minor	Short to long term	Temporary	A negligible effect is identified reflecting that the scale of effects is limited to the development of two pads and 30 wells.	There is regulation to mitigate the risk of accidental release of hazardous materials, however there is a risk of ground contamination and surface spills.
	Pilot project	Minor	Short to long term	Temporary	A negligible effect is identified reflecting that the scale of effects is limited to the area of a single pad and an unknown number of wells	
	Preferred policy position	None	Short to long term	Permanent	A minor positive effect is identified reflecting the avoidance of minor	

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
					negative effects.	
Soil sealing	Business as usual– shale oil and gas extraction	Major	Short to long term	Temporary	A minor negative effect is identified reflecting that the area of land lost to soil sealing is insignificant compared to the areas of land being brought forward for other types of development within the relevant local plan areas.	The potential location in areas of existing flood risk means there is uncertainty over impacts on soil sealing.
	Business as usual– coal bed methane extraction	Minor	Short to long term	Temporary	A negligible effect is identified reflecting the scale of development.	
	Pilot project	Minor	Short to long term	Temporary	A negligible effect is identified reflecting the scale of development.	
	Preferred policy position	None	Short to long term	Permanent	A minor positive effect is identified reflecting the avoidance of minor negative effects.	
Cumulative	Business as usual– shale oil and gas extraction	Major	Short to long term	Temporary	None due to the different impact pathways in terms of soil quality and the contribution of soil to greenhouse gas emissions.	There is uncertainty over the extent of current threats to soil.

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
	Business as usual– coal bed methane extraction	Minor	Short to long term	Temporary	None due to negligible effects identified for all impacts on soil from the development of CBM.	
	Pilot project	Minor	Short to long term	Temporary	None due to the negligible effects identified for all impacts on soil from the development of a pilot in the three theoretical locations.	
	Preferred policy position	None	Short to long term	Permanent	None reflecting the avoidance of no identified cumulative effects.	

8 Climatic factors

What are the environmental effects of the unconventional oil and gas development on climatic factors?

8.1 The environmental effects of unconventional oil and gas development on climatic factors are identified as:

- Direct greenhouse gas emissions associated with:
 - Direct release of produced gas to the atmosphere (from controlled venting during exploration, appraisal or production), or venting of fugitive emissions, i.e. leakage throughout the exploration, appraisal, production or decommissioning stages:
 - ‘Super-emitters’ have been identified as a key source of GHG emissions where a small number of installations have unchecked methane leaks for extended periods.
 - Sub-surface leakage from failure of decommissioned wells resulting in carbon dioxide and methane emissions.
 - The combustion of produced gas as part of controlled flaring or to power onsite machinery.
 - The combustion of other fuels to power onsite machinery or to transport equipment and materials to and from the site during exploration, appraisal and production.
- Indirect greenhouse gas emissions which arise as a consequence of exploration and production activities e.g. development on high carbon soils, emissions embedded in the sourcing of materials and fuels and waste treatment and disposal.
- The processing and use of unconventional oil and gas products¹⁸⁸.

How do these effects relate to the current pressures and trends?

8.2 Scotland is making good progress towards a low carbon society. Recent data¹⁸⁹ shows the following:

- The waste sector saw a 72.8% emissions reduction between 1990 and 2016.
- Scotland’s industrial sector saw emissions fall by 47.6% between 1990 and 2016.

¹⁸⁸ Also relevant to the Preferred Policy Position, if imported unconventional oil and gas continues to provide part of the energy mix in Scotland.

¹⁸⁹ The Scottish Government, 2016. *Alternative presentation using the categories used in the Climate Change Plan 2018*. Available at: <https://www.gov.scot/Resource/0053/00536547.docx>

- Energy efficiency in residential buildings has shown a 21.1% decrease in emissions from 1990 to 2016.
- Emissions in the agriculture sector have been reduced by 14.4% between 1990 and 2016.
- The size of the land use, land use change and forestry sector carbon sink has increased by 7.1 MtCO_{2e} between 1990 and 2016.

- 8.3 Unconventional oil and gas production is the development and use of a fossil fuel, which contributes to overall greenhouse gas emissions and climate change. The effects of climate change are inextricably linked to pressures on other SEA topic areas such as water, soils, air quality, landscape quality, as well as biodiversity and population and human health.
- 8.4 At a domestic level, the implications for greenhouse gas emissions from the development of unconventional oil and gas are subject to considerable uncertainties. This relates both to the size of any future industry and the emissions footprint of production. The Committee on Climate Change report¹⁹⁰ identified that any significant scale domestic production of unconventional oil and gas would not be compatible with Scottish Climate Change targets unless:
- Emissions are tightly regulated and closely monitored in order to ensure rapid action to address leaks;
 - Scottish UOG production displaces imported gas, rather than increasing domestic consumption; and
 - Additional production emissions from shale wells is offset through reductions elsewhere in the Scottish economy.
- 8.5 Shale gas is currently imported into Scotland and the processing and use of this gas within Scotland is assumed to be included within current greenhouse gas emissions inventory. The Committee on Climate Change (2016) identified that the overall emissions footprint of Scottish shale gas, if tightly regulated, is likely to be broadly similar to that of imported gas. Tightly regulated domestic production may provide an emissions saving when displacing imports of liquefied natural gas, and would provide greater control over the level of emissions associated with supply¹⁹¹.
- 8.6 The Committee on Climate Change report also notes that there is little data surrounding the sources and quantities of greenhouse gas emissions associated with CBM extraction. At the present time, the evidence is insufficient to estimate the GHG emissions from developing CBM wells in Scotland.
- 8.7 In addition, the recent UK Greenhouse Gas Inventory¹⁹² states that any fugitive emissions from existing non-productive ‘spudded’¹⁹³ sites are likely to fall below the

¹⁹⁰ Committee on Climate Change (2016) Scottish Unconventional oil and gas: Compatibility with Scottish greenhouse gas emissions targets Available at: <https://www.theccc.org.uk/wp-content/uploads/2016/11/Scottish-Unconventional-Oil-and-Gas-Committee-on-Climate-Change-2016.pdf>

¹⁹¹ Ibid.

¹⁹² UK Greenhouse Gas Inventory, 1990 to 2016 – Annual Report for Submission under the Framework Convention on Climate Change. Available at: https://uk-air.defra.gov.uk/assets/documents/reports/cat07/1804191054_ukghgi-90-16_Main_Issue1.1_UNFCCC.pdf

¹⁹³ Spudding is the process of beginning to drill a well. Initially, a larger drill bit is used to drill a surface hole, which is lined with casing and cement. After the surface whole is completed, the main drill bit is inserted to drill to total depth. This process is also known as ‘spudding in’.

reporting threshold of significance for UK reporting for sources that are 'not estimated'.

What current regulatory processes control these effects?

- 8.8 All of the previously listed sources of greenhouse gas emissions contribute to climate change, and Scotland's ability to meet statutory targets for reducing greenhouse gas emissions as set out in the Climate Change (Scotland) Act 2009. The Act sets statutory targets for the reduction of greenhouse gas emissions by setting an interim 42% reduction target by 2020 and an 80% reduction target from baseline levels (1990) for 2050. The Scottish Government has published a new Climate Change Bill with even more ambitious targets. Proposals include setting targets based on actual emissions, increasing the 2050 target to 90% emissions reduction, and making provisions for a net-zero greenhouse gas emissions target to be set when the evidence becomes available¹⁹⁴.
- 8.9 The Climate Change Plan¹⁹⁵ is the Scottish Government's report on proposals and policies for meeting its climate change targets. Scotland's actions are part of the international effort to reduce emissions and the effects of climate change.
- 8.10 The development of an unconventional oil and gas industry in Scotland would make achieving Scotland's ambitious energy and climate change commitments even more challenging. The Scottish Government acknowledges the important role of gas in the transition to a low carbon energy future. However, the addition of an onshore unconventional oil and gas industry would not promote Scotland's ability to meet the established greenhouse gas emissions targets and objectives in relation to protecting and enhancing the environment.
- 8.11 The *Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017*¹⁹⁶ relate to the assessment of the impact of certain public and private projects on the environment through the planning system.¹⁹⁷ This would require consideration of greenhouse gas emissions where unconventional oil and gas developments are of a size and scale to require EIA.
- 8.12 Under the *Pollution Prevention and Control (Scotland) Regulations 2012* (PPC)¹⁹⁸, certain activities (or part of these activities) require a permit from SEPA. Permits will control both point and fugitive sources of emissions to air, for certain substances and require monitoring. SEPA also assess compliance by the site with these control. Under PPC, controls may also be placed upon any 'directly associated activities' to the prescribed activity which can have an effect on pollution. Any PPC permit would cover aspects such as vehicle movements but do not cover vehicle emissions from exhausts.

¹⁹⁴ <https://www.gov.scot/Topics/Environment/climatechange/Newclimatechangebill>

¹⁹⁵ Scottish Government, 2018. *Climate Change Plan Third Report on Proposals and Policies 2018 - 2032*. Available at: <http://www.gov.scot/Resource/0053/00532096.pdf>

¹⁹⁶ The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017 (Scottish Statutory Instrument 2017 No. 102)

¹⁹⁷ Historic Environment Scotland, *Assessing Impacts on the historic environment*.

¹⁹⁸ The Pollution Prevention and Control (Scotland) Regulations 2012 (Scottish Statutory Instrument 2012 No. 360)

- 8.13 The *Management of Extractive Waste (Scotland) Regulations 2010*¹⁹⁹ requires that extractive waste will be managed without using processes or methods which could adversely impact upon air quality and harm the wider environment.

What stages of unconventional oil and gas development result in these effects, what is the nature and significance of these effects?

Controlled and uncontrolled release of produced gas

Business as usual– shale oil and gas extraction

- 8.14 Greenhouse gas emissions resulting from the extraction of unconventional oil and gas are likely to be greatest during the production phase of unconventional oil and gas development, which for an individual development is likely to occur over a period of approximately **15 years**²⁰⁰. Under all three scenarios peak production is assumed to be reached in **2036-2037**, and therefore the maximum contribution of unconventional oil and gas development to greenhouse gas emissions would be greatest at this time. These effects on greenhouse gas emissions will be **permanent**.
- 8.15 Fugitive air emissions and ‘super emitter’ leaks could occur during the exploration, appraisal and production stages of unconventional oil and gas development which together could take place over a period of approximately **20 years** for an individual development. There is **uncertainty** over the characteristics which cause some unconventional oil and gas developments to be super emitters, and therefore on the extent to which this effect would occur in Scotland, or the quantity of greenhouse gases emitted. These effects on greenhouse gas emissions will be **permanent**.
- 8.16 Early studies²⁰¹ have suggested that greenhouse gas (GHG) emissions associated with shale gas production could result in shale gas having a greater carbon footprint than coal, when used for electricity generation. These findings have been strongly criticised by other experts²⁰². Therefore, there is **uncertainty** as to the extent to which vented emissions differ, in terms of scale and carbon footprint.
- 8.17 Sub-surface leakage from decommissioned wells could occur at any point from the decommissioning stage of unconventional oil and gas development for an **uncertain** duration, however well leakage is most likely to happen within a few years of well abandonment and decommissioning. There is uncertainty around the level of specification for well decommissioning and aftercare if a company fails financial tests after consent to drill a well has been given. The occurrence of controlled and uncontrolled emissions is assumed to increase with the number of wells developed,

¹⁹⁹ The Management of Extractive Waste (Scotland) Regulations 2010 (Scottish Statutory Instrument 2010 No. 60)

²⁰⁰ Scottish Government, 2017. *Talking ‘Fracking’ – A Consultation on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

²⁰¹ Howarth r.w., Santoro, R. Ingraffea, A. (2011). Methane and the greenhouse gas footprint of natural gas from shale formations Available at: <http://www.eeb.cornell.edu/howarth/Howarth%20et%20al%20%202011.pdf>

²⁰² Department of Energy & Climate Change, 2013. *Potential Greenhouse Gas Emissions Associated with Shale Gas Extraction and Use*. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/237330/Mackay_Stone_shale_study_report_09092013.pdf

and therefore the high KPMG scenario is identified as having a greater effect on national greenhouse gas emissions, although a potential **significant negative** but **uncertain** effect is identified for all three KPMG scenarios.

Business as usual- CBM

- 8.18 It is **uncertain** whether the occurrence of controlled and uncontrolled release of produced gas varies for the processes involved in shale oil and gas extraction and CBM. However, coal bed methane typically contains a higher proportion of methane than shale gas/oil²⁰³. The scale of anticipated development of CBM involving a total of 30 wells is lower than that for shale oil and gas for the KPMG production scenarios, and a **minor negative** uncertain effect on national greenhouse gas emissions is identified.

Pilot project

- 8.19 The development of a pilot project will involve the development of a single pad and an unknown number of wells. The location of a pilot within a rural, semi-urban or urban fringe location is not anticipated to have any effect on the levels of controlled or uncontrolled emissions of greenhouse gases. Within the context of the development of a single pad, the overall impact on greenhouse gas emissions is identified as **negligible**.

Preferred policy position

- 8.20 The preferred policy position means that Scottish unconventional oil and gas development would not contribute to greenhouse gas emissions from controlled and uncontrolled release of produced gas. The effect is judged to be **significant positive** in relation to greenhouse gas emissions, reflecting the avoidance of any adverse effects on climate change from unconventional oil and gas development..

Combustion of gas or fossil fuels for on-site power and for transportation

Business as usual– shale oil and gas extraction

- 8.21 Emissions associated with on-site power use and transportation can occur during the exploration, appraisal and production stage which together occur over a period of approximately 20 years, although it is acknowledged that the greatest number of vehicle movements will occur during well pad construction and hydraulic fracturing. These effects are not anticipated to be significant at a regional or national scale in relation to greenhouse gas emissions for any of the three KPMG scenarios, and a **negligible effect** is identified.

Business as usual– CBM

- 8.22 Where hydraulic fracturing is not required for CBM extraction a lower level of vehicle movements are generated than for shale oil and gas extraction. The overall impacts from on-site power and transportation from the development of two pads for CBM extraction are judged to be **negligible**.

Pilot project

- 8.23 The development of a pilot project will involve the development of a single pad and an unknown number of wells. The development of a pilot will use gas or fossil fuels for on-site power and transportation. Based on the assumptions set out, locating a

²⁰³ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

pilot within a rural, semi-urban or peri-urban location is not anticipated to have any impact on the level of effect. The overall level of effect is anticipated to be **negligible** for a single pilot in any location.

Preferred policy position

- 8.24 The preferred policy position means that Scottish unconventional oil and gas development would not contribute to greenhouse gas emissions from combustion of gas or fossil fuels for on-site power and transportation. This effect is judged to be negligible, reflecting the avoidance of negligible effects..

Greenhouse gas emissions associated with land use change

Business as usual– shale oil and gas extraction

- 8.25 The distribution of high carbon soils across the Midland Valley includes several areas of high carbon soil. Greenhouse gas emissions associated with land use change can occur during the exploration, appraisal and production stages (up to well completion). Carbon emissions from land use change could be significant should production occur in an area with deep peat soil, where estimated emissions of carbon dioxide are ten times higher than for grassland. The effect of carbon emissions from soil will occur in the early years of exploration, appraisal and production, and be **permanent** depending on the type of land-use changes and the sensitivity of the affected land. For instance, emissions could be significant and long-lasting if development occurs on carbon-rich soils such as peatlands²⁰⁴.
- 8.26 It has been found that overall greenhouse gas (GHG) emissions are small at the stages up to well completion. However, a lifecycle analysis for the Scottish Government suggests that land-use change emissions could be significant if development occurs on carbon-rich land. For grassland, land-use change emissions are estimated to be in the region of 920 tCO₂ per well or 1,800 tCO₂ for Tera Watt hours (TWh). Should production instead occur in an area with deep peat soil, estimated emissions are around 10 times higher, at around 10,000 tCO₂ per well or 20,000 tCO₂ per TWh. Land-use change emissions may also be significant for other types of land²⁰⁵.
- 8.27 The scale of all of the above effects is likely to be greatest under the KPMG high production scenario, which has the highest number of pads and greatest number of wells developed per pad. This larger number of developments increases the likely extent of impacts and the location on high carbon soils, with the greatest impact under the KPMG high production scenario. A potential **uncertain significant negative** effect on national emissions is identified, with lesser effects for the central and low KPMG scenarios. The level of uncertainty reflects the unknown location of development in relation to areas of high carbon soils.

Business as usual- CBM

- 8.28 The nature and timescale of impacts on greenhouse gas emissions arising from land use change for CBM development are similar to those described for shale oil

²⁰⁴ Committee on Climate Change, 2016. *Scottish unconventional oil and gas: Compatibility with Scottish greenhouse gas targets*. Available at: <https://www.theccc.org.uk/wp-content/uploads/2016/11/Scottish-Unconventional-Oil-and-Gas-Committee-on-Climate-Change-2016.pdf>

²⁰⁵ Committee on Climate Change, 2016. *Scottish unconventional oil and gas: Compatibility with Scottish greenhouse gas targets*. Available at: <https://www.theccc.org.uk/wp-content/uploads/2016/11/Scottish-Unconventional-Oil-and-Gas-Committee-on-Climate-Change-2016.pdf>

and gas extraction. The scale of effect is limited to impacts arising from the development of two pads and a total of 30 wells. The significance of the effects of greenhouse gas emissions associated with land use change depends on the carbon content of the soil on which the CBM extraction takes place. However the location of the pads is unknown and the potential for these to be located on areas of high carbon soils remains and potential **uncertain minor negative** effects on national emissions are identified.

Pilot project

- 8.29 The development of a pilot project will involve the development of a single pad and an unknown number of wells. The location of a pilot is unknown, however it is assumed that a rural pilot could be located on an area of high carbon soil and the semi-urban and peri-urban pilots are assumed to be located on soils of moderate carbon content. Based on these assumptions, the overall scale of emissions from land use change from a rural pilot project on an area of high carbon and although contributing to national carbon emissions, is judged to be **minor negative**. The impacts on the semi-urban and urban fringe pilot locations are judged to be **negligible**.

Preferred policy position

- 8.30 The preferred policy position means that Scottish unconventional oil and gas development would not contribute to national greenhouse gas emissions from development on high carbon soils.
- 8.31 This is considered to be a **significant positive** effect.

Greenhouse gas emissions from processing and use of unconventional oil and gas products

Business as usual– shale oil and gas extraction

- 8.32 Greenhouse gas emissions resulting from the domestic processing and use of unconventional oil and gas are likely to be greatest during the production phase of development, which for an individual development is likely to occur over a period of approximately **15 years**²⁰⁶. Under all three scenarios peak production is assumed to be reached in **2036-2037**, and therefore the maximum contribution of unconventional oil and gas development to greenhouse gas emissions is assumed to be greatest at this time. These effects on greenhouse gas emissions will be **permanent**.
- 8.33 For shale oil and gas extraction the lifetime production per pad under the central scenario is 47.3 billion cubic feet (bcf), with 1.2 million barrels of oil equivalent (MMBOE) associated liquids, for the high scenario is 94.7 bcf, with 2.4 MMBOE, and for the low scenario 31.6 bcf with 0.1 MMBOE. Although it is recognised that the scale of emissions is significantly higher for the high KPMG scenario, the effect of all three scenarios on national emissions is judged to be **significant negative**.
- 8.34 Reflecting the constraints associated with domestic unconventional oil and gas production and meeting Scotland's climate change targets, there is considerable

²⁰⁶ Scottish Government, 2017. Talking 'Fracking' – A Consultation on Unconventional Oil and Gas. Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

uncertainty applied to the conclusion. This uncertainty relates to the net effect of domestic unconventional oil and gas production on greenhouse gas emissions elsewhere, and indirect effects on energy production and demand.

Business as usual- CBM

- 8.35 The scale of development of CBM is anticipated to involve two pads each with 15 wells with an output of 13.1 billion cubic feet (bcf) for each pad.
- 8.36 Therefore the total volume of gas available for processing and use is significantly lower for CBM, than for shale oil and gas extraction. The effects on national greenhouse gas emissions are therefore judged to be **minor negative**.

Pilot project

- 8.37 The scale of production from a pilot project is unknown, however it is anticipated to be below that of an individual pad under the development scenarios as outlined previously. Therefore the greenhouse gas emissions from a pilot project in any location are anticipated to be **negligible**. This is however **uncertain**, reflecting the unknown scale of production.

Preferred policy position

- 8.38 The preferred policy position means that adverse climatic effects associated with the use of Scottish shale oil and gas production (greatest for the KPMG high production scenario, and less for the central and low scenarios), CBM production and, to a lesser extent, a pilot development, would be avoided.
- 8.39 This is considered to be a **significant positive** effect, though there is considerable **uncertainty** reflecting a lack of accurate information on the scale of development that would have taken place in the absence of the preferred policy position and the indirect changes in greenhouse gas emissions associated with wider changes in the supply and use of oil and gas.

Cumulative, synergistic and secondary effects

Business as usual– shale oil and gas extraction and CBM

- 8.40 The cumulative effects of all sources of greenhouse gases on climate change are greatest for shale oil and gas extraction under the KPMG high scenario. This generates the highest level of production of gas and associated liquids, results in the greatest number of pads and wells with impacts on land use, and generates the greatest impacts from transport and construction. The cumulative effects of greenhouse gas emissions for shale oil and gas extraction in Scotland are identified as **significant negative**. These effects are likely to be lower for the central and low KPMG scenarios.

Business as usual–CBM

- 8.41 The cumulative effects of greenhouse gas emissions from all sources from CBM development alone are identified as **minor negative**, reflecting the scale of development.

Pilot project

The cumulative effects of sources of greenhouse gas emissions from a single pilot project are judged to be **negligible**, reflecting the scale of development.

Preferred policy position

- 8.42 The preferred policy position means that adverse climatic effects associated with the development and use of Scottish shale oil and gas (greatest for the KPMG high production scenario, and less for the central and low scenarios), CBM production and, to a lesser extent, a pilot development, would be avoided.
- 8.43 This is considered to be a **significant positive** effect, though there is considerable **uncertainty** reflecting a lack of accurate information on the scale of development that would have taken place in the absence of the preferred policy position and the indirect changes in the wider supply and use of oil and gas.

Scope for further mitigation

- 8.44 The assessment results are based on the application of existing regulatory controls. The evidence base includes information on a number of processes which could be implemented to reduce the scale of impact on the climate. These could reduce the overall potential scale of effect from unconventional oil and gas development, and therefore the associated scale of effect avoided as a consequence of the preferred policy position.
- 8.45 The applicability and practicality of many of these additional measures will be determined at a site specific level so it is not possible to draw firm conclusions as to the extent to which they would mitigate predicted effects successfully. Potential measures include:
- 8.46 **Direct greenhouse gas emissions** – many of the air mitigation measures are relevant to mitigating greenhouse gas emissions, particularly direct greenhouse gas emissions including: controlled and uncontrolled releases of produced gas; and, the combustion of fossil fuels for on-site power and transportation. These include annual inspections and repair, the use of advanced monitoring technologies (e.g. DTS and DAS), the use of supply chain management and ICT resources, the use of pipelines to replace transport, and the re-use of wastewater.
- 8.47 **Greenhouse gas emissions associated with land use change** – avoiding development on high carbon soils is likely to have positive effects in terms of reducing greenhouse gas emissions associated with land use change.
- 8.48 Furthermore, greenhouse gas emissions could also be reduced through carbon offsetting. Carbon offsets are typically achieved through financial support for projects that aim to reduce the emission of greenhouse gases, which, in turn, compensate for emissions made elsewhere. Examples of such projects include forestry projects (e.g. wood planting), energy efficiency projects, and renewable energy projects such as wind farms, biomass energy, or hydroelectric dams. As such, carbon offsets could be achieved through investment in renewable energy sector or woodland planting.

Table 8.1: Summary of effects on climate

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
Controlled and uncontrolled release of produced gas	Business as usual– shale oil and gas extraction	Major	Short to long term	Permanent	A potential significant negative but uncertain effect is identified for all three KPMG scenarios. The occurrence of controlled and uncontrolled emissions is assumed to increase with the number of wells developed, and therefore the high KPMG scenario is identified as having a greater effect on national greenhouse gas emissions.	There is uncertainty over the characteristics which cause some unconventional oil and gas developments to be super emitters, and therefore on the extent to which this effect would occur in Scotland, or the quantity of greenhouse gases emitted. There is also uncertainty as to the extent to which vented emissions differ, in terms of scale and carbon footprint.

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
	Business as usual– coal bed methane extraction	Minor	Short to long term	Permanent	A minor negative uncertain effect on national greenhouse gas emissions is identified. This reflects the scale of anticipated development of CBM involving a total of 30 wells which is lower than that for shale oil and gas for the KPMG production scenarios.	It is uncertain whether the occurrence of controlled and uncontrolled release of produced gas varies for the processes involved in shale oil and gas extraction and CBM.
	Pilot project	Minor	Short to long term	Permanent	A negligible effect is identified reflecting the scale of effects from a single pad.	
	Preferred policy position	None	Short to long term	Permanent	A significant positive effect is identified in relation to greenhouse gas emissions, reflecting the avoidance of any adverse effects on climate change from unconventional oil and gas development	
Combustion of gas or fossil fuels	Business as usual– shale	Major	Short to long term	Permanent	A negligible effect is identified as these effects	

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
for on-site power and for transportation	oil and gas extraction				are not anticipated to be significant at a regional or national scale in relation to greenhouse gas emissions for any of the three KPMG scenarios.	
	Business as usual– coal bed methane extraction	Minor	Short to long term	Permanent	A negligible effect is identified reflecting the overall impacts from on-site power and transportation from the development of two pads for CBM extraction.	
	Pilot project	Minor	Short to long term	Permanent	A negligible effect is identified reflecting that the development of a pilot project will involve the development of a single pad and an unknown number of wells.	
	Preferred policy position	None	Short to long term	Permanent	This effect is judged to be negligible , reflecting the avoidance of negligible effects.	
Greenhouse gas emissions	Business as usual– shale	Major	Short to	Permanent	A significant negative effect on national	Uncertainty relates to the unknown location of

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
associated with land use change	oil and gas extraction		long term		emissions is identified for the KPMG high scenario, with lesser effects for the central and low scenarios. A larger number of pad and well developments increases the likely extent of impacts and the location on high carbon soils.	development in relation to areas of high carbon soils.
	Business as usual– coal bed methane extraction	Minor	Short to long term	Permanent	A minor negative effect is identified, reflecting the scale of development of two pads and 30 wells.	
	Pilot project	Minor	Short to long term	Permanent	A minor negative effect is identified, reflecting the scale of development of a single pilot.	
	Preferred policy position	None	Short to long term	Permanent	A significant positive effect is identified reflecting the avoidance of significant adverse effects on soil.	
Greenhouse gas emissions from processing and	Business as usual– shale oil and gas	Major	Short to long term	Permanent	A significant negative effect is identified reflecting the scale of	Uncertainty relates to the net effect of domestic

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
use of unconventional oil and gas products	extraction				emissions from the three KPMG production scenarios, and commitments to Scotland's climate change targets.	unconventional oil and gas production on greenhouse gas emissions elsewhere, and indirect effects on energy production and demand.
	Business as usual– coal bed methane extraction	Minor	Short to long term	Permanent	A minor negative effect is identified as the total volume of gas available for processing and use is significantly lower for CBM, than for shale oil and gas extraction	
	Pilot project	Minor	Short to long term	Permanent	A negligible effect is identified as production is anticipated to be below that of an individual pad under the development scenarios.	The scale of production from a single pilot is unknown.
	Preferred policy position	None	Short to long term	Permanent	A significant positive effect is identified reflecting the avoidance of significant negative effects.	

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
Cumulative	Business as usual– shale oil and gas extraction	Major	Short to long term	Permanent	A significant negative effect is identified under the KPMG high scenario. This generates the highest level of production of gas and associated liquids, results in the greatest number of pads and wells with impacts on land use, and generates the greatest impacts from transport and construction. These effects are likely to be lower for the central and low KPMG scenarios.	
	Business as usual– coal bed methane extraction	Minor	Short to long term	Permanent	A minor negative effect is identified reflecting the scale of development.	
	Pilot project	Minor	Short to long term	Permanent	A negligible effect is identified reflecting the scale of the development.	
	Preferred policy	None	Short to long term	Permanent	A significant positive effect is identified reflecting the avoidance of	There is a lack of accurate information on the scale of

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
	position				significant negative effects.	development that would have taken place in the absence of the preferred policy position and the indirect changes in the wider supply and use of oil and gas.

9 Biodiversity, flora and fauna

What are the environmental effects of unconventional oil and gas development on biodiversity, flora and fauna?

9.1 The potential environmental effects of unconventional oil and gas development on biodiversity, flora and fauna arising from the different stages and activities associated with unconventional oil and gas development are identified as:

- Construction and development of the pad and associated infrastructure. This may include perimeter fencing, internal and access road construction for pad development. Pipes may also be laid to transport extractive products to a processing plant or to carry water to or from the site. This may result in:
 - loss of habitat and habitat fragmentation from site infrastructure and fencing.
 - introduction of invasive species e.g. as a result of fencing, road construction.
- Unconventional oil and gas development requires a water supply to support the extraction process. The water may be delivered and removed from site by vehicle, or by surface lain or buried pipe. Laying of pipes and water extraction may result in:
 - impacts on hydro-ecological functioning.
- Site construction and activity during production which could include construction disturbance, flaring (noise and light pollution), site lighting (light pollution) may result in:
 - disturbance to species.
- Accidental release of hazardous material to air, soil or water during production, storage or transportation (see Air and Water sections) could result in:
 - direct impacts on habitat and species quality and functionality.
- Greenhouse gas emissions from production and use of unconventional oil and gas, including fugitive air emissions during production could result in:
 - indirect effects on biodiversity, primarily through increased emissions of greenhouse gases, and impacts on climate change;

How do these effects relate to the current pressures and trends?

9.2 Direct loss of habitat and habitat fragmentation from unconventional oil and gas development would add to the existing pressures from land use change. However based on the area of land lost to development under the KPMG high scenario (estimated at approximately 26ha) this would not lead to the loss of large scale areas of habitat, even including potential additional habitat loss from ancillary development. This habitat loss could occur in locations where existing habitat is more important to local habitat networks or for supporting habitat connectivity to designated biodiversity sites. Figures 3a and 3b, Appendix 1, show the distribution

of national and international biodiversity designations and areas, which illustrates in particular the importance of the coastal areas of the Firth of Forth, and the wider distribution of smaller sites across the area prospective for unconventional oil and gas development.

- 9.3 The UK National Ecosystem Assessment²⁰⁷ reported that habitats have declined both in area and condition over the last 70 years as a consequence of increased exploitation of ecosystem outputs for provisioning services (ecosystem provisioning services include food, water, raw materials and medicinal resources), especially from agriculture. The extent and condition of habitats will affect their ability to cope with pressures, including climate change.²⁰⁸ There has also been a decrease in the extent and condition of hedgerows between 1998 - 2007²⁰⁹.
- 9.4 Climate change poses a very significant threat to Scotland's natural environment. In addition to direct impacts on habitats (e.g. sea-level rise), climate change will alter the complex ecological balances that allow the plants and animals to grow and thrive.²¹⁰
- 9.5 Over the last 10 years there has been an increase in the number of notified features (habitats and species) to be classified as favourable. Currently, 73.4% of habitat features and 71.9% of species features are in positive condition.²¹¹

What current regulatory processes control these effects?

- 9.6 Loss of habitat and habitat fragmentation that could affect a Natura²¹² site should be subject to Habitats Regulations Appraisal. Under the Habitats Regulations, all competent authorities must consider whether any plan or project will have a 'likely significant effect' on a Natura site. If so, they must carry out an 'appropriate assessment'. This is known as Habitats Regulations Appraisal (HRA). The competent authority must decide whether there's enough evidence to conclude that the proposals won't have adverse effects on a Natura site's integrity.²¹³
- 9.7 Site of Special Scientific Interest is a statutory designation made by Scottish Natural Heritage under the Nature Conservation (Scotland) Act 2004. It is an offence for anyone to intentionally or recklessly damage the protected natural features of an SSSI.²¹⁴ Owners and occupiers of land within an SSSI must apply to SNH for consent to carry out certain operations, which are specified for individual SSSI.
- 9.8 European Protected Species (EPS) are animals and plants (species listed in Annex IV of the Habitats Directive) that are afforded protection under the *Conservation*

²⁰⁷ UK National Ecosystem Assessment (2011) The UK National Ecosystem Assessment: Synthesis of the Key Findings. UNEP-WCMC, Cambridge.

²⁰⁸ https://www.climatexchange.org.uk/media/2501/nb10a_key_semi-natural_habitats.pdf

²⁰⁹

https://www.climatexchange.org.uk/media/2475/nb3_extent_and_condition_of_hedgerows_and_ponds_2103_16_branded_template.pdf

²¹⁰ https://www.climatexchange.org.uk/media/2521/nb19_positive_condition.pdf

²¹¹ Ibid.

²¹² Natura sites are internationally important for threatened habitats and species.

²¹³ <https://www.nature.scot/professional-advice/planning-and-development/environmental-assessment/habitats-regulations-appraisal-hra>

²¹⁴ <https://www.nature.scot/professional-advice/safeguarding-protected-areas-and-species/protected-areas/national-designations/sites-special-scientific-interest>

(*Natural Habitats, &c.*) Regulations 1994²¹⁵ (as amended). If any activity is likely to cause disturbance or injury to a European Protected Species a licence is required to undertake the activity legally. Where unconventional oil and gas development requires Environmental Impact Assessment (EIA) an EIA report would describe the likely significant effects on the environment, including on biodiversity. This is likely to include information on European Protected Species.

- 9.9 Habitat loss and fragmentation affecting other habitats and species arising from development is controlled through the planning system, however impacts may still occur. Development consisting of well pads, potential access roads and / or pipelines could further contribute to habitat loss and fragmentation.
- 9.10 Excessive water extraction has potential significant ecological impacts. The abstraction of water is tightly regulated in Scotland to prevent or minimise unacceptable impacts to the wider water environment. Water abstraction which affected a Natura site should be subject to HRA, requiring that impacts are identified, assessed and mitigated.
- 9.11 Disturbance to species may result from site construction and maintenance activity, flaring (noise and light pollution), and site lighting (light pollution). This could include impacts on mobile species from designated sites.
- 9.12 Direct impacts on habitat and species quality and functionality resulting from accidental release of hazardous material during transportation and hydro-ecological functioning should be assessed and mitigated through the risk assessment undertaken for the planning application (as set out in Scottish Planning Policy). However the risk of negative effects remains, particularly in relation to the potential connectivity of the areas subject to unconventional oil and gas development and designations such as Natura sites.
- 9.13 Introduction of invasive species e.g. as a result of fencing and road construction could result in significant negative effects on biodiversity. Under the Wildlife and Countryside Act 1981 it is an offence to plant or otherwise cause to grow in the wild any non-native plant, or release any non-native animal²¹⁶. Where required, the EIA process (see below) should require ecological survey which would identify non-native species on site and recommend construction activities follow best practice to avoid spread.
- 9.14 The *Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017*²¹⁷ relate to the assessment of the impact of certain public and private projects on the environment through the planning system.²¹⁸ This would require consideration of impacts on biodiversity where unconventional oil and gas developments are of a size and scale to require EIA.

²¹⁵ The Conservation (Natural Habitats, &c.) Regulations 1994 (1994 No. 2716)

²¹⁶ <https://www.sepa.org.uk/media/163480/biosecurity-and-management-of-invasive-non-native-species-construction-sites.pdf>

²¹⁷ The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017 (Scottish Statutory Instrument 2017 No. 102)

²¹⁸ Historic Environment Scotland, Assessing Impacts on the historic environment.

- 9.15 Furthermore, the *Management of Extractive Waste (Scotland) Regulations 2010*²¹⁹ requires that extractive waste will be managed without using processes or methods which could adversely impact upon local flora and fauna, and harm the wider environment.
- 9.16 The regulation of effects on the water environment, with associated impacts on biodiversity is discussed under 'Water'. In addition impacts on biodiversity which affect a Natura site should be subject to HRA, requiring that impacts are identified, assessed and mitigated. However, the risk of effects remains, particularly through accidental contamination.
- 9.17 Unconventional oil and gas development contributes to greenhouse gas emissions and climate change from the extraction, processing and use of unconventional oil and gas, alongside fugitive air emissions. These could indirectly affect international, national and local biodiversity, through the resulting effect on climate change and negative impacts on biodiversity. Scotland has national and international statutory commitments to reduce greenhouse gas emissions produced within its territory. However these effects are uncertain given conclusions regarding fugitive emissions (which are themselves uncertain) and the net impact of producing and using Scottish sources of unconventional oil and gas on global carbon emissions and thus climate change.

What stages of unconventional oil and gas development result in these effects, and what is the nature and significance of these effects?

Habitat loss and fragmentation

Business as usual– shale oil and gas extraction

- 9.18 Loss of habitat and habitat fragmentation would occur with **immediate effect** during the exploration, appraisal and production stages of unconventional oil and gas development, which together could take place over a period of approximately **20 years** for an individual development. The full extent of these effects would peak during the production phase of unconventional oil and gas development. These effects may be **temporary** and **reversible** or **permanent**, depending on the sensitivity of the receiving environment, and the approach to restoration of the site. Loss of habitat and habitat fragmentation would occur both at the site of the pad, and along the route of any access road or pipeline construction.
- 9.19 Under each of the KPMG scenarios the effects of habitat loss are greatest under the high scenario, reflecting the greater number of pads, wells and associated infrastructure. However the area of land impacted is not identified as significant within the wider context of development within the Central Belt. The location of development could be in close proximity to sites designated for their nature conservation importance, and therefore **significant negative** but **uncertain** effects are identified. These effects are likely to be lower for the central and low KPMG scenarios.

²¹⁹ The Management of Extractive Waste (Scotland) Regulations 2010 (Scottish Statutory Instrument 2010 No. 60)

Business as usual- CBM

- 9.20 The nature of the effects described above is similar for both shale oil and gas extraction under the three KPMG scenarios, and CBM. The scale of effects for CBM is related to the development of two pads. Reflecting the limited extent of these impacts **minor negative** effects are identified. These effects are **uncertain** due to the potential that these locations are within close proximity to sites important for nature conservation.

Pilot project

- 9.21 The development of a pilot project will have local effects on habitat loss and fragmentation and will extend to a limited local area, reflecting the development footprint of a single pad. All of the theoretical pilots could result in the loss of habitat which is important for habitat connectivity overall or which is important for nearby designated sites. The timescale of effects from development of a pilot would be related to the lifetime of an individual pad from exploration and appraisal to decommissioning, which could be approximately 30 years.
- 9.22 A rural pilot is assumed to be in close proximity to an SSSI, however a rural location may provide greater opportunities for flexibility in micro siting of the pad, compensatory planting or mitigation of effects of habitat fragmentation. Although the potential importance of the surrounding habitat network of the pad site to the nearby nature conservation designations is unknown, the effects of habitat loss are judged to be **minor negative**.
- 9.23 A semi-urban pilot could have pathways to a nearby Natura site. Such a location may be more limited in opportunities for mitigation of the effects of habitat loss and fragmentation due to constraints of infrastructure and other built development. Potential effects on the Natura site would be addressed through the requirement for a Habitats Regulations Assessment (HRA) so it is assumed that development would have no 'adverse effect on site integrity'. As for a rural pilot location, the potential importance of the surrounding habitat network of a pad site to the nearby nature conservation designations is unknown, however due to the relatively small area of habitat affected the effects of habitat loss are judged to be **minor negative**.
- 9.24 Within a peri-urban area the impacts on the habitat network may be locally more significant due to fewer opportunities for compensatory habitat creation or mitigation through site layout due to the constraints of other infrastructure and built development. A site is assumed not to have direct connectivity to any designated nature conservation sites, however its role within the urban habitat network may be locally significant, therefore **minor negative** effects are identified.

Preferred policy position

- 9.25 The preferred policy position means that habitat loss and fragmentation from shale oil and gas production (greatest for the KPMG high production scenario, and less for the central and low scenarios), CBM production and, to a lesser extent, a pilot development, would be avoided.
- 9.26 This is considered to be a **significant positive** effect.

Disturbance

Business as usual– shale oil and gas extraction

- 9.27 Disturbance to species as a result of noise, lighting, vibration and vehicle movement from construction and operation would occur with **immediate effect** during the exploration, appraisal and production stages of unconventional oil and gas development, which together could take place over a period of approximately **20 years** for an individual development. The greatest levels of disturbance would occur during exploration and appraisal and in the **initial two years** of production, with potential subsequent increases in activity if more wells are drilled during the production phase. The effects of disturbance are anticipated to be **temporary** but longer term effects could occur depending on the nature of the species affected, and their vulnerability. Disturbance could occur both at the site of the pad, and along the route of any pipeline construction. The extent of disturbance is greatest under the KPMG high scenario, reflecting the greater number of pads and wells developed. Disturbance to species resulting from site construction and maintenance activity, flaring (noise and light pollution), site lighting (light pollution) will be temporary in nature, however **minor negative** impacts may still occur. This could include impacts on mobile species from designated sites. These effects are likely to be lower for the central and low KPMG scenarios.

Business as usual- CBM

- 9.28 The nature of the effects described above is similar for both shale oil and gas extraction and CBM. The scale of effect is lower for CBM, reflecting the anticipated development of two pads of 15 wells each, and **negligible** effects are identified.

Pilot project

- 9.29 The development of a pilot project could have local effects of disturbance to species, which may be more significant where a development is located close to sensitive species.
- 9.30 A rural pilot location could result in increased levels of disturbance in an area which is currently in a more tranquil location with lower existing levels of noise and light pollution. However a single pad development would have a local impact and the effects are judged to be **negligible**.
- 9.31 A semi-urban pilot location may already experience some level of disturbance due to proximity to urban areas and is assumed to have connectivity to a Natura site. The HRA process is assumed to address direct impacts on the Natura site and therefore the effects are judged to be **negligible**.
- 9.32 An urban fringe pilot location could result in increased disturbance within an area already subject to a high level of noise, lighting and activity. This may mean that species within the area are habituated to higher levels of disturbance, or lead to increases in disturbance which, combined with effects such as habitat loss make the area unviable for some species. Reflecting the limited scale and extent of disturbance from a single pilot, and the assumed relevant site surveys and mitigation would have been undertaken, the effects of an urban fringe pilot location is judged to be **negligible**.

Preferred policy position

- 9.33 The preferred policy position means that disturbance to species as a result of noise, lighting, vibration and vehicle movement from construction and production of shale

oil and gas (greatest for the KPMG high production scenario, and less for the central and low scenarios), CBM production and, to a lesser extent, a pilot development, would be avoided.

9.34 This is considered to be a **minor positive** effect.

Direct impacts on habitats and species: release of hazardous material, introduction of non-native species, impacts on hydro-ecological functioning
Business as usual– shale oil and gas extraction

- 9.35 Direct impacts on habitat and species quality, health, distribution and functionality resulting from accidental release of hazardous material to air or water could occur with **immediate effect** during the exploration, appraisal and production stages of unconventional oil and gas development, which together could take place over a period of approximately **20 years** for an individual development. The effect could occur both at the site of the pad, and along the route of any pipeline construction, or vehicle routes. The greatest risk of accidental spillage is within the exploration and appraisal phase (approximately 2 – 6 years), and in the **initial two years** of production, with potential subsequent increases in activity if more wells are drilled during the production phase. The effects of accidental spillage of hazardous material are anticipated to be **temporary**, but could persist in the long term, depending on the nature of the species affected and their vulnerability.
- 9.36 Construction work could result in the introduction of non-native species, particularly where pipeline construction provides a potential pathway for species movement. This could occur with **immediate effect** during the exploration, appraisal stages and early years of production. The effects of the introduction of non-native species may be **temporary**, but could persist in the long term, or be **permanent**, depending on the nature of the species introduced.
- 9.37 Impacts on hydro-ecological functioning could result from water extraction and from buried linking infrastructure used in unconventional oil and gas developments (e.g. pipes to transport extractive products to a processing plant). If the buried linking infrastructure is protected by material of different hydraulic conductivity, it could have adverse impacts on hydro-ecological functioning²²⁰.. Pipework may be laid during the exploration and appraisal phase to support production, and could be required for a period of approximately **20 years**, therefore the nature of the effect is anticipated to be **temporary**.
- 9.38 Under the KPMG high scenario, the scale of shale oil and gas development is larger with a greater number of pads, wells and vehicle movements and the risk of direct effects on habitats and species is increased. The risk of **significant negative** effects remains under all three KPMG scenarios, particularly in relation to the potential connectivity of the areas subject to unconventional oil and gas development and nationally important sites.
- 9.39 The regulation of effects on the water environment, with associated impacts on biodiversity is discussed under Water. In addition impacts on biodiversity which affect a Natura site should be subject to HRA, requiring that impacts are identified, assessed and mitigated. However, the risk of **significant negative** impacts remains particularly through accidental contamination.

²²⁰ Scottish Government (2014) Independent Expert Scientific Panel – Report on Unconventional Oil and Gas. P. 36. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

- 9.40 Introduction of invasive species e.g. as a result of fencing and road construction could result in locally significant negative effects on biodiversity. The impact of the effects on biodiversity from non-native species is judged to be **minor negative**.

Business as usual- CBM

- 9.41 The nature of the effects described above is similar for both shale oil and gas extraction and CBM. The location of the CBM pads is unknown, and potential connectivity to sites with higher biodiversity value is unknown. The scale of effect on habitat and species, the water environment and introduction of non-native species for CBM is identified as **minor negative**, reflecting the lower level of development of two pads.

Pilot project

- 9.42 Compared to the 'business as usual' alternative, the development of a single pilot limits the area over which these effects may occur. The effects of accidental release of hazardous material, introduction of non-native species and impacts on hydro-ecological functioning on biodiversity, and introduction of non-native species are judged to be more significant in locations which are closer to sites designated for their nature conservation value. Where a site supports species which are already experiencing other pressures, the effects may be more significant.
- 9.43 For the purposes of the assessment it is assumed that a rural pilot location is located within close proximity to a SSSI, therefore the impacts described under the 'business as usual' alternative could impact directly on the overall quality and functionality of a site of national importance, with a potentially significant negative effect. However, it is assumed the existing regulatory framework would ensure that impacts on nationally important habitats and species were minimised, resulting in **minor negative** effects.
- 9.44 A semi-urban pilot location is assumed to have direct connectivity to a Natura site and therefore the impacts of accidental release of hazardous material would result in potentially significant negative effects. However, it is assumed the existing regulatory framework would ensure that potential impacts on internationally important habitats and species were avoided, resulting in **minor negative** effects.
- 9.45 An urban fringe pilot is assumed to be located in an area with no direct connectivity to sites with nature conservation designations. Therefore the sensitivity of the receiving environment to these potential effects is judged to be lower, and **minor negative** effects are identified.

Preferred policy position

- 9.46 The preferred policy position would mean the avoidance of adverse impacts on habitats and species associated with:
- accidental release of hazardous material during transportation associated with unconventional oil and gas development;
 - impacts on hydro-ecological functioning from unconventional oil and gas development;

These effects are likely to be greatest for the KPMG high production scenario, less for the central and low scenarios and CBM production and least for a pilot development.

- 9.47 The preferred policy position would also avoid minor negative effects on habitat and species quality and functionality resulting from introduction of invasive species e.g. as a result of fencing, road construction associated with unconventional oil and gas development.
- 9.48 Overall, this is considered to be a **significant positive** effect.

Indirect impacts on habitats and species as a result of greenhouse gas emissions and climate change

Business as usual– shale oil and gas extraction

- 9.49 Unconventional oil and gas is a fossil fuel and its extraction and use could result in increased emissions of greenhouse gases. The exploration and appraisal stages of development, along with the early years of production are likely to result in greenhouse gas emissions from the development of the pad over a period of approximately eight years. Fugitive emissions may occur during the same stages of development, but could continue throughout the production and decommissioning stages.
- 9.50 The use of unconventional oil and gas also contributes to emissions of greenhouse gases and climate change which is a significant threat to biodiversity. These effects are further discussed under ‘climatic factors’.
- 9.51 The scale of the effect is greater for shale oil and gas extraction under the KPMG high scenario, reflecting the anticipated greater quantity extracted. Impacts on climate change are further assessed under the climatic factors, and impacts on biodiversity from shale oil and gas extraction are judged to be **minor negative**. These effects are likely to be lower for the central and low KPMG scenarios.

Business as usual - CBM

- 9.52 The nature of the effects described above is similar for both shale oil and gas extraction and CBM. Due to the anticipated scale of CBM extraction of two pads, the effects on emissions on biodiversity are judged to be **negligible**.

Pilot project

- 9.53 The effects on climate change and therefore on biodiversity as a result of the pilot project are judged to be **negligible** at a local, national and global scale.

Preferred policy position

- 9.54 The preferred policy position means that adverse climate impacts of greenhouse gas emissions from Scottish shale oil and gas production (greatest for the KPMG high production scenario, and less for the central and low scenarios), CBM production and, to a lesser extent, a pilot development, would be avoided.
- 9.55 This is considered to be a **minor positive** effect, though there is considerable uncertainty reflecting a lack of accurate information on the scale of development that would have taken place in the absence of the preferred policy position and on the indirect effects on wider energy use.

Cumulative, synergistic and secondary effects

Shale oil and gas extraction and CBM

- 9.56 The scale of all of the effects of habitat loss and fragmentation, disturbance, direct impacts on habitats and species and greenhouse gas emissions is likely to be greatest under the KPMG high production scenario for shale oil and gas extraction,

which has the highest number of pads and greatest number of wells developed per pad. This larger number of developments increases the likely extent of impacts. This could result in potential **significant negative cumulative** effects on biodiversity where pad developments take place within close proximity to each other. It also increases the likelihood of development taking place within close proximity to a designated biodiversity site. These effects are therefore likely to be lower for the central and low KPMG scenarios.

- 9.57 Pads for shale oil or gas extraction or CBM in closer proximity to designated wildlife sites could result in a greater scale of impact arising from any of the above effects identified, with locally minor negative effects, although there is **uncertainty** over the location of pads. Conversely, positive synergy could also result from the high development scenario for shale oil and gas extraction which could facilitate sharing of pipelines, reducing overall impacts from individual pipeline construction or traffic impacts. However there is **uncertainty** over the likely distribution of pads, and sharing of infrastructure.

Pilot

- 9.58 The scale of an individual pilot project would result in site specific cumulative effects on biodiversity from habitat loss and fragmentation, disturbance, direct impacts on habitats and species and greenhouse gas emissions in addition to the existing pressures on biodiversity in any of the three theoretical locations. However as the existing pressures are unknown, the cumulative nature of these effects is **minor negative uncertain**.

Preferred policy position

- 9.59 The **timeframe** for the avoidance of these additional effects is approximately the next 40 years. The avoidance of these effects is judged to be **permanent** within the context of the SEA. The **scale** of avoidance of effects reflects the geographic area identified as prospective for shale oil and gas, across the Central Belt of Scotland.

9.60 In conclusion, although the biodiversity, flora and fauna of the Central Belt of Scotland will continue to face existing pressures, the preferred policy position means that additional pressures on biodiversity, flora and fauna which could directly result from unconventional oil and gas development in Scotland, are avoided.

9.61 This is considered to be a **significant positive** effect.

Scope for further mitigation

- 9.62 The assessment results are based on the application of existing regulatory controls. The evidence base includes information on a number of processes which could be implemented to reduce the scale of impact on the biodiversity, flora and fauna. These could reduce the overall potential scale of effect from unconventional oil and gas development, and therefore the associated scale of effect avoided as a consequence of the preferred policy position.

- 9.63 The applicability and practicality of many of these additional measures will be determined at a site specific level so it is not possible to draw firm conclusions as to the extent to which they would mitigate predicted effects successfully. Potential measures include:

- 9.64 **Loss of habitat, habitat fragmentation and impacts on hydro-ecological functioning** – potential impacts could be reduced if site selection and the laying of pipes associated with that development would avoid sites of high biodiversity value, particularly areas characterised by sensitive hydro-ecological regimes. Surveys, such as bats and birds surveys, could help to identify potential ecological constraints and provide initial recommendations for avoidance of impacts and mitigation measures, as well as further ecological investigations and ongoing monitoring during construction, operation and decommissioning where necessary.
- 9.65 **Disturbance of species** – disturbance to species is highly dependent on the timing of works. To minimise potential impacts on breeding birds, for instance, the construction works that effect nesting habitat should be carried out during winter to avoid the bird breeding season (March-August). Furthermore, disturbance to local fauna could be reduced if lighting would avoid illuminating habitats such as woodland and hedgerows. Other mitigation measures include covering up any excavated holes/trenches overnight to prevent mammals from becoming trapped.
- 9.66 **Accidental release of hazardous material to air, soil, or water** – many of the water, soil and air mitigation measures could help to protect or reduce potential impacts on local biodiversity. These include careful soil stripping and restoration, use of permeable materials during soil sealing, the use of geotextiles and geo-synthetics, the use of biodegradable fracking fluids, the (optimised) treatment of flowback and produced water through mobile units or at central facilities, the use of advanced monitoring technologies (e.g. DTS and DAS), annual inspections and repair, the use of supply chain management and ICT resources, and the re-use of wastewater.
- 9.67 **Introduction of non-native species** – contingency planning to deal with accidental releases and spread of invasive species is likely to reduce the potential impacts on biodiversity, flora and fauna.

Table 9.1: Summary of effects on biodiversity, flora and fauna

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
Habitat loss and fragmentation	Business as usual– shale oil and gas extraction	Major	Short to long term	Permanent	A significant negative effect is identified for the loss of habitat in areas of habitat importance.	The location of development in proximity to sites of nature conservation importance, and the sensitivity of the habitat loss.
	Business as usual– coal bed methane extraction	Minor	Short to long term	Temporary or permanent	A minor negative effect is identified reflecting the scale of effects for the development of two pads.	
	Pilot project	Minor	Short to long term	Permanent	A minor negative effect is identified reflecting the locally important potential loss of habitat.	
	Preferred policy position	None	Short to long term	Permanent	A significant positive effect is identified reflecting the avoidance of the loss of habitat loss and fragmentation.	
Disturbance	Business as usual– shale oil and gas extraction	Major	Short to long term	Temporary	A minor negative effect is identified reflecting the temporary duration of the effect. These effects are likely to be lower for the central and low KPMG scenarios reflecting the lower level of development.	Proximity to sites designated for their nature conservation importance or sensitive species.

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
	Business as usual– coal bed methane extraction	Minor	Short to long term	Temporary	A negligible effect is identified reflecting the lower level of development.	
	Pilot project	Minor	Short to long term	Temporary	A negligible effect is identified reflecting the lower level of development.	
	Preferred policy position	None	Short to long term	Permanent	A minor positive effect is identified reflecting the avoidance of minor negative effects.	
Hazardous materials, introduction of non-native species, hydrology impacts	Business as usual– shale oil and gas extraction	Major	Short to long term	Temporary or permanent	A significant negative effect is identified, reflecting the risk of accidental contamination.	Risk of accidental contamination
	Business as usual– coal bed methane extraction	Minor	Short to long term	Temporary or permanent	A minor negative effect is identified reflecting the lower level of development and lower risk.	
	Pilot project	Minor	Short to long term	Temporary or permanent	A minor negative effect is identified reflecting the lower level of development and lower risk.	
	Preferred policy position	None	Short to long term	Permanent	A significant positive effect is identified reflecting the avoidance of significant negative	

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
					effects.	
Climate change impacts on habitats and species	Business as usual– shale oil and gas extraction	Major	Short to long term	Permanent	A minor negative effect is identified. These effects are likely to be lower for the central and low KPMG scenarios	
	Business as usual– coal bed methane extraction	Minor	Short to long term	Permanent	A negligible effect is identified reflecting the scale of development.	
	Pilot project	Minor	Short to long term	Permanent	A negligible effect is identified reflecting the scale of development.	
	Preferred policy position	None	Short to long term	Permanent	A minor positive effect is identified reflecting the avoidance of minor negative effects.	A lack of accurate information on the scale of development that would have taken place in the absence of the preferred policy position and on the indirect effects on wider energy use.
Cumulative	Business as usual– shale oil and gas extraction	Major	Short to long term	Permanent	A significant negative effect is identified reflecting that pad developments could take place within close proximity to each other.	The distribution and location of pads and sharing of infrastructure.

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
	Business as usual– coal bed methane extraction	Minor	Short to long term	Permanent	A minor negative effect is identified reflecting potential proximity to sensitive wildlife sites.	
	Pilot project	Minor	Short to long term	Permanent	A minor negative effect is identified reflecting the potential sensitivities of the pilot locations.	
	Preferred policy position	None	Short to long term	Permanent	A significant positive effect is identified, reflecting the avoidance of significant negative effects.	

10 Cultural and archaeological heritage

What are the environmental effects of the reasonable alternative on cultural and archaeological heritage?

- 10.1 The potential environmental effects of unconventional oil and gas development on historic environment features are identified²²¹ as:
- Construction of the well pad, access roads and any ancillary development leading to:
 - Loss and or damage of known and unknown surface and subsurface archaeology and other designated and undesignated historic assets;
 - Indirect impacts arising from changes to surface drainage patterns or removal of peat, increased erosion or changes in the water table.
 - Presence of access roads, perimeter fencing and ancillary development and drilling rigs²²² resulting in:
 - Impacts on the setting of cultural heritage assets.

How do these effects relate to the current pressures and trends?

- 10.2 As outlined in the Environmental Baseline chapter there are a number of important historic assets located in the Midland Valley. This includes the Antonine Wall and the Forth Bridge, Conservation Areas and battlefields, such as Stirling Old Bridge. Historic structures also include features such as Blackness and Stirling Castles, and Clackmannan Tower and Alloa Tower. Designed landscapes include Dunimarle Castle, Culross Abbey House and High Valleyfield. As illustrated on Figure 9a and 9b, Appendix 1, the importance and distribution of these heritage assets across the Central Belt means that unconventional oil and gas development could result in potential impacts on historic environment assets.
- 10.3 Key threats to the historic environment include development and land use change, and climate change poses a further threat to the structure of historic environment assets.
- 10.4 Figure 8a, Appendix 1, illustrates the distribution of high carbon soils in Scotland and Figure 8b, Appendix 1, illustrates the distribution within the Central Belt. This shows that unconventional oil and gas development within this area could potentially affect high carbon soils.

What current regulatory processes control these effects?

- 10.5 Nationally significant historic environment assets are protected through legislation. In addition, the Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017 relate to the assessment of the impact of certain public and private projects on the environment – including the historic environment – through the planning system. This would require consideration of impacts on known historic environment assets and unknown archaeological potential where unconventional oil and gas developments are of a size and scale to require EIA.
- 10.6 Designated historic environment assets are also protected through the statutory consents i.e. Listed Building Consent, Conservation Area Consent and Scheduled Monument Consent:
- Listed Building Consent – is the mechanism by which planning authorities ensure that any changes to listed buildings are appropriate and sympathetic to their character. It is a criminal offence to demolish, alter or extend a Listed Building without Listed Building consent.²²³
 - Conservation Area Consent – controls the demolition of unlisted buildings in Conservation Areas. The consent process is similar to the Listed Building consent process.²²⁴
 - Scheduled Monument Consent – is the mechanism by which HES ensures that any changes to monuments of national importance are appropriate and sympathetic to their character²²⁵. Under the *Ancient Monuments and Archaeological Areas Act 1979*²²⁶, it is a criminal offence to carry out unauthorised works, or to allow unauthorised work to be carried out, on a Scheduled Monument.
- 10.7 The Hydrocarbon Licensing Directive 1994 allows for licences to impose terms and conditions that concern protection of national treasures possessing artistic, historic or archaeological value. The Town and Country Planning (Scotland) Act 1997 requires planning applications to be determined in accordance with the development plan unless material considerations indicate otherwise. The content of the Scottish Planning Policy, which is a material consideration, sets out that the planning system should ‘promote the care and protection of the designated and non-designated historic environment’.²²⁷

²²² The presence of the drilling rig (height approximately 38m) when on site, has the potential to impact on the setting of historic environment features at greater distance from the well pad.

²²³ <https://www.historicenvironment.scot/advice-and-support/applying-for-consents/listed-building-consent-and-conservation-area-consent/listed-building-consent/>

²²⁴ <https://www.historicenvironment.scot/advice-and-support/applying-for-consents/listed-building-consent-and-conservation-area-consent/listed-building-consent-process/>

²²⁵ <https://www.historicenvironment.scot/advice-and-support/applying-for-consents/scheduled-monument-consent/what-is-scheduled-monument-consent/>

²²⁶ Ancient Monuments and Archaeological Areas Act 1979. Available at: <https://www.legislation.gov.uk/ukpga/1979/46>

²²⁷ Scottish Government (2014) Scottish Planning Policy. Available at: <https://beta.gov.scot/binaries/content/documents/govscot/publications/publication/2014/06/scottish-planning-policy/documents/00453827-pdf/00453827-pdf/govscot:document/>

What stages of unconventional oil and gas result in these effects, what is the nature and significance of these effects?

Loss and or damage of known and unknown archaeology and other designated and undesignated historic assets including indirect effects

Business as usual– shale oil and gas extraction

- 10.8 Direct and indirect impacts resulting in loss or damage of known and unknown archaeology and other designated and undesignated historic assets could occur during the stages of exploration, appraisal, production and decommissioning, at stages throughout the **30 year** lifespan of the pad. The effect could occur both at the site of the pad, and along the route of any pipeline construction, or vehicle access routes. These effects are most likely during the initial development of the pad during the exploration and appraisal stage, however further effects could occur as new infrastructure is constructed to support the development of the pad. The effects could be **permanent**.
- 10.9 There is **uncertainty** over the scale of effect of loss or damage to known and unknown archaeology and other designated and undesignated historic assets, which would depend on the sensitivity of the cultural heritage asset affected and the extent of the impact.
- 10.10 Under the KPMG high scenario a larger number of pads and wells are developed and there is greater potential risk of impacts to known and unknown archaeology and other designated and undesignated historic assets. The existing regulatory processes are assumed to limit effects on significant assets. Therefore the potential impact of pads could result in **minor negative** but **uncertain** effects if pads are located in or close to an area with important cultural heritage assets. These effects are likely to be lower for the central and low KPMG scenarios.

Business as usual – CBM

- 10.11 The nature of the effects described above is similar for both shale oil and gas extraction under the three KPMG scenarios, and CBM. The scale of effect remains the same for CBM for each scenario. Although CBM is only anticipated to involve the development of two pads, the existing regulatory processes would limit effects and the potential impact of an individual pad could result in **minor negative** effects, if the pad is located in or close to an area with important cultural heritage assets, although this effect is **uncertain**.

Pilot project

- 10.12 The development of a pilot project has the potential for loss or damage to known or unknown archaeology and other designated and undesignated historic assets. Compared to the 'business as usual' alternative, the development of a single pilot location reduces the area over which these effects may occur, and the overall risk to the historic environment. The regulatory processes are assumed to limit effects; however, the location of a pilot project is unknown and therefore the potential direct impacts on known or unknown archaeology may be greater. This is a **minor negative** but **uncertain** effect depending on the location of the pilot, and cannot be distinguished for each theoretical pilot location.

Preferred policy position

- 10.13 The preferred policy position means that adverse impacts resulting from the loss or damage to culture heritage assets resulting from shale oil and gas development

(greatest for the KPMG high production scenario, and less for the central and low scenarios), CBM production and, to a lesser extent, a pilot development, would be avoided.

10.14 This is considered to be a **minor positive** effect.

Impacts on setting of cultural heritage

Business as usual– shale oil and gas extraction

10.15 Impacts on setting of historic environment features could occur during exploration, appraisal and production, with the greatest scale of effect during exploration, appraisal and the first two years of production (giving a total of approximately **eight years**²²⁸) when the presence of a drilling rig would increase the visual extent of impacts on setting. Impacts on setting may also occur from floodlighting at the rig to support safe working at night. These impacts would be **temporary** and related to the timescale when drilling is required. During the production phase, the generators, container units for chemicals, waste materials and fluids, portable offices and work amenities could also impact on the setting of cultural heritage features. These effects would occur during exploration, appraisal and production stages which take place over a period of approximately **20 years** for an individual development, and would be **temporary**.

10.16 There is **uncertainty** over the impacts on setting of historic environment features which would depend on the proximity of the development to a historic environment feature and the sensitivity of the historic environment asset affected and the number of pads and wells.

10.17 For each of the KPMG scenarios the scale of effect from each scenario is likely to be greatest under the high production scenario, where the highest number of pads and wells would be developed. In particular cumulative effects from pads which are developed in proximity to each other could increase the scale of effect on the setting of an historic environment asset, although these effects are recognised as temporary. However, there is **uncertainty** over the likely location of pads under all three scenarios.

10.18 The effect of the high KPMG scenario on the historic environment is judged to be **significant negative**. Effects from the central and low KPMG scenarios are also judged to be significant negative, although this is **uncertain**, reflecting the potential for their distribution to result in cumulative effects.

Business as usual- CBM

10.19 The development of CBM is anticipated to involve the development of two pads, and therefore the potential extent of impacts on the historic environment is lower than for the scenarios for shale oil and gas extraction. However the location of individual pads is unknown and proximity to historic environment assets could result in **minor negative** effects.

Pilot project

10.20 The development of a pilot project has the potential for impacts on the setting of historic environment features. Compared to the 'business as usual' alternative, the

²²⁸ Based on longest timescale for exploration and appraisal, plus two years of production as outlined in Scottish Government (2017) Talking Fracking, p.21

development of a single pilot location relates to a limited the area over which these effects may occur, and results in a lower overall risk to the historic environment. The location of a pilot project is unknown and therefore negative effects could occur on the setting of a nationally or internationally significant historic environment feature. These effects would be temporary and relate to the development of a single pad and therefore **minor negative** effects are identified. The potential impacts on the setting of historic environment features are not distinguished for each theoretical pilot location.

Preferred policy position

- 10.21 The preferred policy position means that adverse impacts on the setting of cultural heritage assets resulting from shale oil and gas development (greatest for the KPMG high production scenario, and less for the central and low scenarios), CBM production and, to a lesser extent, a pilot development, would be avoided.
- 10.22 This is considered to be a **significant positive** effect.

Cumulative, secondary and synergistic effects

- 10.23 The cumulative effects on the historic environment could arise from impacts on loss or damage to known or unknown archaeology and from direct impacts on the setting of cultural heritage resources leading to overall loss or damage to these resources. This could occur under the low, central or high KPMG scenarios.
- 10.24 The development of CBM alone or a single pilot project would not result in significant cumulative effects.
- 10.25 The preferred policy position means that existing pressures on cultural heritage assets resulting from unconventional oil and gas development, in addition to the existing pressures on cultural heritage assets arising from development and land use change and climate change would be avoided.
- 10.26 The **timeframe** for the avoidance of these additional effects is approximately the next 30 years²²⁹. The avoidance of these effects is judged to be **permanent** within the context of the SEA. The **scale** of avoidance of effects reflects the geographic area identified as prospective for shale oil and gas, across the Central Belt of Scotland.
- 10.27 No secondary or synergistic effects are identified.

Therefore, although the cultural heritage resource of Central Scotland will continue to face existing pressures, the preferred policy position means that additional pressures which would result from unconventional oil and gas development are avoided.

- 10.28 The preferred policy position means that cumulative adverse impacts resulting from shale oil and gas development (greatest for the KPMG high production scenario, and less for the central and low scenarios), CBM production and, to a lesser extent, a pilot development, would be avoided. This is considered to be a **minor positive** effect.

²²⁹ Total cumulative output for shale gas and associated liquids is assumed to be in the late 2040s based on KPMG (2016) Economic Impact Assessment and Scenario development of Unconventional Oil and Gas in Scotland p. 25 Available at: <http://www.gov.scot/Resource/0050/00509321.pdf>

Scope for further mitigation

- 10.29 The assessment results are based on the application of existing regulatory controls. The evidence base includes information on a number of processes which could be implemented to reduce the scale of impact on cultural heritage. These could reduce the overall potential scale of effect from unconventional oil and gas development, and therefore the associated scale of effect avoided as a consequence of the preferred policy position.
- 10.30 The applicability and practicality of many of these additional measures will be determined at a site specific level so it is not possible to draw firm conclusions as to the extent to which they would mitigate predicted effects successfully. Potential measures include:
- 10.31 **Loss and/or damage of known and unknown archaeology, and other designated and undesignated heritage assets** – potential impacts could be reduced or avoided if the siting of development avoids sites of cultural heritage significance. Site survey to identify previously unknown cultural heritage assets and monitoring during site construction and decommissioning phases will also help minimise impacts.
- 10.32 **Direct and indirect impacts on the setting of cultural and archaeological heritage** –screening (e.g. planting hedges) and landscape treatment could minimise potential impacts on the setting of cultural heritage sites.

Table 10.1: Summary of effects on cultural heritage

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
Loss and or damage of known and unknown archaeology, and other designated and undesignated historic assets	Business as usual – shale oil and gas extraction	Major	Short to long term	Permanent	A minor negative effect is identified reflecting the potential to impact on designated and undesignated heritage assets. These effects are likely to be lower for the central and low KPMG scenarios.	Scale of effect of loss or damage to known and unknown archaeology and other designated and undesignated historic assets, which would depend on the sensitivity of the historic environment asset affected and the extent of the impact on the resource.
	Business as usual – coal bed methane extraction	Minor	Short to long term	Permanent	A minor negative effect is identified, if the pad is located in or close to an area with important heritage assets.	
	Pilot project	Minor	Short to long term	Permanent	A minor negative effect is identified, if the pad is located in or close to an area with important heritage assets.	
	Preferred	None	Short to	Permanent	A minor positive effect	

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
	policy position		long term		is identified reflecting the avoidance of minor negative effects.	
Impacts on setting of cultural heritage	Business as usual – shale oil and gas extraction	Major	Short to long term	Temporary	A significant negative effect is identified, reflecting potential cumulative effects from pads developed in close proximity to each other. Effects from the central and low KPMG scenarios are likely to be lower but are still identified as significant negative.	The likely location of pads under all three scenarios and proximity to historic environment features.
	Business as usual – coal bed methane extraction	Minor	Short to long term	Temporary	A minor negative effect is identified reflecting the development of two pads, and therefore the potential extent of impacts on the historic environment is lower than for the scenarios for shale oil and gas extraction.	Proximity to historic environment assets is unknown.
	Pilot project	Minor	Short to long term	Temporary	A minor negative effect is identified reflecting the potential for impacts on	

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
					the setting of historic environment features.	
	Preferred policy position	None	Short to long term	Permanent	A significant positive effect is identified reflecting the avoidance of significant negative effects on cultural heritage.	
Cumulative effects	Business as usual – shale oil and gas extraction	Major	Short to long term	Permanent	A minor negative cumulative effect is identified from impacts on loss or damage to known or unknown archaeology and from direct impacts on the setting of cultural heritage resources leading to overall loss or damage to these resources. This could occur under the low, central or high KPMG scenarios.	
	Business as usual – coal bed methane	Minor	Short to long term	Permanent	A negligible effect is identified.	

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
	extraction					
	Pilot project	Minor	Short to long term	Permanent	A negligible effect is identified.	
	Preferred policy position	None	Short to long term	Permanent	A minor positive effect is identified reflecting the avoidance of cumulative minor negative effects.	

11 Landscapes and geodiversity

What are the environmental effects of the reasonable alternative on landscapes and geodiversity?

11.1 The potential environmental effects of unconventional oil and gas development on landscape and geodiversity are identified as:

- Direct impacts on landscape resulting from drilling rigs, lighting, flaring, access roads, pipelines, perimeter fencing, generators, sealed container units for chemicals and waste materials and fluids, portable offices and work amenities.²³⁰

How do these effects relate to the current pressures and trends?

11.2 The upland landscapes of Scotland include the main areas of national landscape significance (see Figure 10, Appendix 1), and within the Central Belt a number of local landscape designations recognise areas of local landscape importance. Furthermore landscape character assessment has identified the key qualities of local landscapes. Scotland's landscape is under pressure from new development, and this is an issue around the settlements of the Central Belt.

11.3 Trends in the visual influence of built development on the landscape show an increase in the area of influence of built development. The area of Scotland from which one or more types of built development can be seen increased to 73% in 2013, an 11.6% increase from 2008²³¹, with the largest visual influence from wind turbines.

11.4 Furthermore, 2014 data on the perceived naturalness of habitat across the CSGN²³² (which covers a similar area to the Midland Valley) classified the landscape using a five point scale from least natural to most natural. Only 25% of the land area was classed in the most natural categories.

What current regulatory processes control these effects?

11.5 Nationally significant landscapes are protected through legislation and Scottish Natural Heritage has statutory functions within the planning system as part of the

²³⁰ Scottish Government (2017) Talking Fracking, p. 22

²³¹ SNH. 2014. Visual influence of built development indicator – 2013 data update - Technical note. Scottish Natural Heritage, Inverness. Available at: <https://www.nature.scot/sites/default/files/2017-06/Natural%20Heritage%20Indicator%20-%20N3%20-%20Visual%20Influence%20of%20Built%20Development%20and%20Land%20Use%20Change%20-%202014%20update.pdf>

²³² Scottish Natural Heritage (2016) Landscape Indicator LLQ2 Perceived Naturalness of land cover in the Central Scotland Green Network Area (CSGN) <https://www.nature.scot/sites/default/files/2018-02/Landscape%20Indicator%20-%20LLQ2%20-%20Naturalness%20of%20land%20cover%20in%20CSGN.pdf>

wide range of responsibilities for the natural environment. In addition the *Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017*²³³ relate to the assessment of the impact of certain public and private projects on the environment – including landscape– through the planning system.

- 11.6 The Town and Country Planning (Scotland) Act 1997 requires planning applications to be determined in accordance with the development plan unless material considerations indicate otherwise. Scottish Planning Policy is a material consideration, and states that the planning system should ‘facilitate positive change while maintaining and enhancing distinctive landscape character’.
- 11.7 Furthermore, the *Management of Extractive Waste (Scotland) Regulations 2010*²³⁴ requires that extractive waste will be managed without using processes or methods which could cause unacceptable effects to the landscape or places of special interest.

What stages of unconventional oil and gas developments result in these effects, what is the nature and significance of these effects?

Business as usual – shale oil and gas

- 11.8 Direct impacts on landscape could result from the presence of surface equipment of drilling rigs, lighting, flaring, access roads, pipelines, perimeter fencing, generators, sealed container units for chemicals and waste materials and fluids, portable offices and work amenities. The initial drilling requires a rig with a mast typically 30m – 38m²³⁵ in height which will be replaced with a work-over rig (typically with a mast 22m) one the initial drilling is complete. These rigs are temporary structures and the drill-hole is then capped with an extraction point and protective cage (typically 3m high)²³⁶.
- 11.9 The landscape impacts of surface infrastructure are greatest during exploration, appraisal and the early years of production when there will be the presence of the drilling rig in addition to the other surface infrastructure. The surface infrastructure will introduce built features into the landscape. The landscape impact of the drilling rig and surface infrastructure is **temporary**. The drilling rig is likely to be present on site over a period of approximately 4 – 8 years²³⁷, although other surface infrastructure will remain throughout the production period of the pad, with **minimal** surface infrastructure remaining following decommissioning.
- 11.10 **Cumulative** landscape impacts could arise under all of levels of development under the three KPMG scenarios, should unconventional oil and gas developments take place in close proximity to each other. The likelihood of **cumulative** effects occurring is greatest during the exploration, appraisal and early years of production

²³³ The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017 (Scottish Statutory Instrument 2017 No. 102)

²³⁴ The Management of Extractive Waste (Scotland) Regulations 2010 (Scottish Statutory Instrument 2010 No. 60)

²³⁵ 38m is referenced in Scottish Government (2017) Talking Fracking, 30m is referenced in Scottish Government (2014) Independent Expert Scientific Panel – Report on Unconventional Oil and Gas

²³⁶ Scottish Government (2014) Independent Expert Scientific Panel – Report on Unconventional Oil and Gas. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

²³⁷ Based on 2-6 years for exploration and appraisal and drilling rig being on site during first two years of production as outlined in Scottish Government (2016) Talking Fracking. p23.

and is likely to be **temporary** in nature. The effect is likely to be greatest under the KPMG high scenario as this includes the highest number of pads and wells which therefore has the greatest chance of developments taking place where intervisibility between pad sites could occur. However, the distribution of pads under the central or low scenario could also result in cumulative effects, and **significant negative** effects are identified for the KPMG high scenario, and minor negative effects for the central and low scenarios.

Business as usual - CBM

11.11 The nature of landscape impacts of shale oil and gas extraction and CBM are similar, although the technical approach to extraction is recognised as different. The extent of landscape impacts for CBM extraction is significantly lower than for shale oil and gas extraction reflecting the anticipated development of two pads of 15 wells each. The location of developments for shale oil and gas extraction or CBM could be within or in close proximity to a locally designated landscape. However, reflecting the development of two wells, the scale of infrastructure and the temporary nature of the landscape impacts described above, these effects are judged to be **negligible**.

Pilot project

11.12 The development of a pilot project will have local landscape effects including industrialisation of the landscape. These effects may be more significant where a development is located within or close to sensitive landscapes.

11.13 A rural pilot location is assumed to be in close proximity to a local landscape designation. However, reflecting the temporary nature of the landscape impacts, the effect of a single pilot pad and associated wells is judged to be **negligible**.

11.14 A semi-urban pilot could result in increased urbanisation, impacting on the character and integrity of the landscape at the urban edge. However the landscape effects are judged to be **negligible**.

11.15 An urban pilot could result in further industrialisation of an already fragmented urban fringe landscape. However the landscape effects are judged to be **negligible**.

Preferred policy position

11.16 The preferred policy position would result in the **avoidance** of the following effects resulting from unconventional oil and gas development:

- Direct impacts on landscape resulting from drilling rigs, lighting, flaring, access roads, pipelines, perimeter fencing, generators, sealed container units for chemicals and waste materials and fluids, portable offices and work amenities.

11.17 The preferred policy position would mean that pressures on landscape and geodiversity resulting from unconventional oil and gas development, in addition to the existing pressures on landscape and geodiversity arising from development, land use change and climate change would be avoided.

11.18 The **timeframe** for the avoidance of the most significant additional effects associated with the cumulative landscape impacts of exploration, appraisal and the early years of production is approximately the next 15 years²³⁸. The avoidance of

²³⁸ Total cumulative output for shale gas and associated liquids is assumed to be in the late 2040s based on KPMG (2016) Economic Impact Assessment and Scenario development of Unconventional Oil and Gas in Scotland p. 25 Available at: <http://www.gov.scot/Resource/0050/00509321.pdf>

these effects is judged to be **permanent** within the context of the SEA. The **scale** of avoidance of effects reflects the level of development under the KPMG scenarios for shale oil and gas, across the Central Belt of Scotland.

11.19 Therefore, although the landscape of Central Scotland will continue to face existing pressures, the preferred policy position means that additional pressures that would result from unconventional oil and gas development would be avoided.

11.20 This is considered to be a **significant positive** effect.

Cumulative, synergistic and secondary effects

Business as usual – shale oil and gas extraction

11.21 The cumulative landscape impacts of all aspects of unconventional oil and gas development are covered together within the assessment of each alternative.

11.22 Positive synergy could occur from developments in close proximity to each other sharing water disposal infrastructure, thereby reducing the amount of on-site storage and transport and associated landscape impact. However this will result in the development of separate facilities at an additional location, and extent to which this might occur is **uncertain**.

Business as usual - CBM

11.23 The cumulative effects from CBM development alone are identified as **negligible**, reflecting the scale of development.

Pilot project

11.24 Reflecting the above conclusions, the landscape impacts from an individual pad for a pilot project, in any of the three locations are judged to be **negligible**.

Preferred policy position

11.25 No additional negative cumulative, synergistic or secondary effects are identified for the alternatives, therefore no cumulative, synergistic or secondary effects are avoided.

Scope for further mitigation

11.26 The assessment results are based on the application of existing regulatory controls. The evidence base includes information on a number of processes which could be implemented to reduce the scale of impact on landscape and geodiversity. These could reduce the overall potential scale of effect from unconventional oil and gas development, and therefore the associated scale of effect avoided as a consequence of the preferred policy position.

11.27 The applicability and practicality of many of these additional measures will be determined at a site specific level so it is not possible to draw firm conclusions as to the extent to which they would mitigate predicted effects successfully. Potential measures include:

- Site selection to avoid sensitive, locally important sites and visually prominent locations.
- Mitigation measures such as screening, landscape treatment and landscape restoration after decommissioning could further reduce landscape and visual impacts that may arise from unconventional oil and gas developments.

- Sharing of infrastructure could reduce the number of traffic movements over the lifetime of an unconventional oil and gas site, with associated positive effects by reducing impacts on landscape quality and local amenity.

Table 11.1: Summary of effects on landscapes and geodiversity

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
Landscape and visual effects (including cumulative effects)	Business as usual – shale oil and gas extraction	Major	Short to long term	Temporary	A significant negative effect is identified for the KPMG high scenario, and minor negative effects for the central and low scenarios.	The likely location of pads under all three scenarios and potential for cumulative effects and the likelihood of infrastructure sharing.
	Business as usual – coal bed methane extraction	Minor	Short to long term	Temporary	A negligible effect is identified reflecting the development of two wells, the scale of infrastructure and the temporary nature of the landscape impacts	
	Pilot project	Minor	Short to long term	Temporary	A negligible effect is identified reflecting the scale of development, the scale of infrastructure and the temporary nature of the landscape impacts.	
	Preferred policy position	None	Short to long term	Permanent	A significant positive effect is identified reflecting the avoidance of significant negative effects.	

12 Material assets

What are the sources of impacts of the reasonable alternative on material assets?

12.1 The potential environmental effects of unconventional oil and gas development on material assets are identified as:

- development of pads impacting on:
 - land use change:
 - mineral resources, forestry and woodland, agricultural land.
 - infrastructure:
 - roads
 - water supply, treatment of waste products and environmental pollution.

How do these effects relate to the current pressures and trends?

12.2 Development pressure impacts on existing mineral resources, forestry and woodland and agricultural land, and unconventional oil and gas development provides a further contributory factor. Between 1947 and 1988, the total area of built land increased by an estimated 46% and the land used for infrastructure increased by around 22%. Most of these changes involved agricultural land, and the remainder was largely on upland or woodland habitats²³⁹. Land use change associated with unconventional oil and gas development would result in the development of approximately 24ha²⁴⁰ for the high scenario, 16ha for the central scenario and 8ha for the low scenario²⁴¹. All of the areas indicated are excluding any additional land area required for access roads, pipes etc. and are therefore presented as conservative estimates.²⁴²

12.3 The distribution of higher quality agricultural land including land of Grade 2 and 3.1 is found particularly in the East, including coastal areas of Fife, Edinburgh, West

²³⁹ SNH, 2003. *Trend note – Land Cover Change 1940s – 1980s: Built land*. Available at: <https://www.nature.scot/sites/default/files/2017-09/B1009926%20-%20Trend%20note%20-%20Land%20Cover%20Change%201940s%20-%20E2%80%93%201980s%20-%20Built%20land.pdf>

²⁴⁰ For comparison the Alloa West Business Park allocated in the Clackmannanshire Local Plan (2015) p. 117 covers an area of 53.48ha, Sauchie West housing allocation p. 122 covers an area of 52.81ha.

Available at: <http://gis.clacksweb.org.uk/dataset/e0a14ab6-c461-436a-a7e0-ec9ff4c899e9/resource/aaa5ccb2-136a-48e5-b349-848d2ca27abc/download/clackmannanshirelocaldevelopmentplanaugust2015.pdf>

²⁴¹ Based on the assumption that an average well pad is the area of a football pitch (8,000m²) each KPMG scenario is therefore the (number of pads x 8,000), plus the area of 2 CBM pads at 16,000m².

²⁴² This compares to the allocations in Clackmannanshire Local Development Plan (2015) of approximately 351ha business land and 363ha housing land. These total figures are based on the figures provided in the area statements for Forth, West Ochils and East Ochils

Lothian and Falkirk²⁴³. Climate change is also anticipated to result in changes to the agricultural productivity of land.

- 12.4 The Scottish Forestry Strategy sets out an ambition to increase Scotland's woodland cover. At the beginning of the last century woodland cover in Scotland had declined to about 5%, and today Scotland's woodland cover is about 17% of the land area. Expansion of woodland brings a range of benefits, and the expectation is to increase woodland cover to around 25% in the second half of the century.²⁴⁴
- 12.5 Trends in traffic movements show an overall growing trend in vehicle km travelled on Scotland's roads. 46.4 billion vehicle kilometres were travelled on Scotland's roads in 2016– an increase of 2% over the year, 5% more than in 2006 and the highest recorded level. Long-term, the volume of car traffic on major roads (Motorways and A roads) has more than doubled, from an estimated 9,300 million vehicle kilometres in 1975 to between 28,000 and 30,000 million vehicle kilometres for the last ten years.²⁴⁵
- 12.6 The Central Belt of Scotland contains a wide range of minerals including a highly productive coalfield, extensive igneous rock aggregate quarries and significant deposits of sand, gravel and clay. Unconventional oil and gas is itself a mineral resource, and these mineral resources are identified and protected through planning policies. Furthermore, the area of land that would be potentially utilised for unconventional oil and gas development is low compared to the area of land being brought forward for development within local plans²⁴⁶.
- 12.7 Waste water produced from unconventional oil and gas development will be stored, treated and disposed of at a suitable waste treatment facility²⁴⁷. It is anticipated that the treatment of waste may take place using purpose built facilities and would not impact on the existing waste water infrastructure. Direct impacts on water supply, treatment of waste water and environmental pollution are addressed under the relevant SEA topics of water and soil.

What current regulatory processes control these effects?

- 12.8 The planning system controls planning for minerals, and minerals safeguarding is the mechanism by which mineral resources are managed to ensure supplies for the future. Shale oil and gas and CBM resources are mineral resources relevant to development plan mineral policies.
- 12.9 Transport Scotland is consulted on planning applications for developments affecting the trunk road network. Scottish Planning Policy states that where a new

²⁴³ Grade 2 is land capable of producing a wide range of crops. Grade 3.1 is land capable of producing consistently high yields of a narrow range of crops and/or moderate yields of a wider range. Short grass leys are common. http://map.environment.gov.scot/Soil_maps/?layer=5#

²⁴⁴ Forestry Commission Scotland (2009) The Scottish Government's Rationale for Woodland Expansion. Available at: <https://scotland.forestry.gov.uk/images/corporate/pdf/ForestExpansion.pdf>

²⁴⁵ Transport Scotland Scottish Transport Statistics no 36 2017 Edition. A National Statistics publication for Scotland. Available at: <https://www.transport.gov.scot/media/41863/scottish-transport-statistics-2017-with-correction-to-table-214.pdf>

²⁴⁶ See reference to footnote in paragraph 12.2 to the area of land allocated for development in the Clackmannanshire Local Development Plan.

²⁴⁷ Scottish Government (2017) Talking 'Fracking' A consultation on Unconventional Oil and Gas. Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

development or a change of use is likely to generate a significant increase in the number of trips, a transport assessment should be carried out. The assessment should set out how the development will affect the performance and safety of the trunk road network, including any potential cumulative effects, and what, if any, mitigation measures are required.²⁴⁸

- 12.10 The *Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017*²⁴⁹ relate to the assessment of the impact of certain public and private projects on the environment through the planning system.²⁵⁰ This would require consideration of impacts on mineral resources where unconventional oil and gas developments are of a size and scale to require EIA.
- 12.11 Furthermore, the *Management of Extractive Waste (Scotland) Regulations 2010*²⁵¹ requires that extractive waste will be managed without using processes or methods which could result in the abandonment, dumping or uncontrolled depositing of extractive waste.

What stages of unconventional oil and gas development result in these effects, what is the nature and significance of these effects?

Impacts on land use change

Business as usual – shale oil and gas

- 12.12 The development of a pad is assumed to exclude the use of land for other purposes such as agriculture, forestry and woodland or other mineral extraction. This extends over the operational period of the pad through to the completion of decommissioning, a period of approximately **30 years**. This effect would be **temporary**, reflecting the restoration of the site following decommissioning. Although some loss or damage to soil may reduce the overall area of land suitable for agriculture or forestry and woodland, it is assumed that following restoration of the site these land uses could take place although this is considered to be a long-term process.
- 12.13 For each of the KPMG scenarios the scale of effect on land use change from each scenario is likely to be greatest under the high production scenario, where the largest number of pads would be developed. However, there is **uncertainty** over the likely location of pads under all three scenarios and impacts on land with greatest suitability for agriculture or forestry and woodland production, or with high carbon content.
- 12.14 The impacts on land use change from all of the KPMG scenarios are therefore identified as **minor negative**.

²⁴⁸ Transport Scotland (2016) Development and the Trunk Road Network. Available at:

<https://www.transport.gov.scot/media/1414/trbo-development-and-the-trunk-road-network-march-2016.pdf>

²⁴⁹ The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017 (Scottish Statutory Instrument 2017 No. 102)

²⁵⁰ Historic Environment Scotland, Assessing Impacts on the historic environment.

²⁵¹ The Management of Extractive Waste (Scotland) Regulations 2010 (Scottish Statutory Instrument 2010 No. 60)

Business as usual - CBM

- 12.15 The nature of the effects described above is similar for both shale oil and gas extraction and CBM. The scale of development of CBM is anticipated to involve two pads and is therefore lower in terms of impacts on land use change, a **minor negative** effect is identified for CBM, because there remains uncertainty about the likely locations of these developments and impacts on land with greatest suitability for agriculture, forestry or with a high carbon content..

Pilot project

- 12.16 The development of a pilot project is assumed to involve the development of a single pad and an unknown number of wells. The location of a pilot is unknown, however it is assumed that a rural pilot would be on an area of high carbon soil and the location of a semi-urban and peri-urban pilot would be on soils of moderate carbon content. The overall scale of impact on land use change is therefore identified as **minor negative**.

Preferred policy position

- 12.17 The preferred policy position means that adverse impacts associated with land use change to accommodate shale oil and gas production (greatest for the KPMG high production scenario, and less for the central and low scenarios), CBM production and, to a lesser extent, a pilot development, would be avoided.
- 12.18 This is considered to be a **minor positive** effect.

Impacts on infrastructure

Business as usual – shale oil and gas

- 12.19 Unconventional oil and gas development results in increased traffic movements which would contribute to the growing trend in vehicle kilometres travelled on Scotland's roads. The use of pipelines to transport water or gas would reduce the overall number of vehicle movements generated. However the extent or likelihood of the use of pipelines across all three development scenarios is **uncertain**. Assuming that no pipelines are used, and that wastewater is not reused, the KPMG high scenario would generate the greatest number of traffic movements, with lower levels generated for the central and low scenarios. The overall impact of the increased traffic movements is likely to depend on the nature of the local road network, and local congestions issues or if there are settlements which the vehicles would travel through. A **minor negative** uncertain effect on road infrastructure is identified for all three of the KPMG scenarios.
- 12.20 In relation to water supply, it is assumed that the regulation of water abstraction by SEPA would ensure the avoidance of locally significant negative effects on the water environment, with **negligible** effects for the three KPMG scenarios.
- 12.21 The three KPMG scenarios for shale oil and gas extraction generate waste water which requires treatment. It is assumed that the waste water is either treated on the site of the pad, or is transported by vehicle or pipeline to a purpose built waste water treatment plant. The KPMG high scenario is estimated to produce twice as much shale gas as the central scenario and will potentially generate the greatest volume of waste water for treatment reflecting the higher number of pads and wells. **Minor negative** effects on waste water generation and disposal are identified for the KPMG scenarios for shale oil and gas.

12.22 The specific impacts of environmental pollution are covered under the relevant topic areas of air, water and soil. The issue of environmental pollution in relation to material assets is the overall degradation of the quality of the environment. A high quality environment contributes to a high quality of life, and degraded environmental surroundings could have negative effects on health and wellbeing. The high KPMG scenario has the potential for greater impacts in terms of environmental pollution and impacts on environmental quality from the greater number of pads and wells, and overall impacts on environmental quality are judged to be **minor negative**. These effects are likely to be lower for the central and low KPMG scenarios.

Business as usual - CBM

12.23 Ricardo Energy and Environment (2016) found that the range of unconventional oil and gas development scenarios considered could give rise to between 210 and 1,670 traffic movements per week on average across the country as a whole, with a further 99 movements associated with the coal bed methane scenario²⁵². However reflecting the scale of CBM development, and the potential for lower water requirements and vehicle movements, **negligible** effects are identified for impacts on road infrastructure.

12.24 In relation to the use of water, normal CBM extraction methods do not require significant volumes of water during drilling or extraction. In contrast, hydraulic fracturing requires large volumes of water. CBM extraction can require use of hydraulic fracturing, depending on local geological conditions, though currently it is usually extracted without the use of hydraulic fracturing. Should hydraulic fracturing be required water requirements for CBM may increase, along with potential vehicle movements, however based on the overall low scale of development, and lower water requirements **negligible** effects are identified in relation to water supply.

12.25 With regard to the generation of waste, the water produced during CBM extraction was originally present in fractures and pores prior to drilling. There are typically much more saline than fracking fluids²⁵³. Similar to the processing of waste for shale oil and gas the waste water requires treatment and disposal. Reflecting the scale of CBM development, **negligible** effects are identified.

12.26 Overall impacts on environmental quality are lower for CBM extraction reflecting the more limited impacts of the development of two pads of 15 wells, and **negligible** effects are identified.

Pilot project

12.27 The development of a pilot project is assumed to involve the development of a single pad and an unknown number of wells. The location of a pilot is unknown, however the development of any of the three theoretical pilot locations on infrastructure is judged to be **negligible**.

²⁵² Ricardo Energy & Environment, 2016. *Unconventional oil and gas development: understanding and mitigating community impacts from transportation*. Available at: <http://www.gov.scot/Resource/0050/00509327.pdf>

²⁵³ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

Preferred policy position

12.28 The preferred policy position means that adverse impacts on infrastructure resulting from shale oil and gas production (greatest for the KPMG high production scenario, and less for the central and low scenarios), CBM production and, to a lesser extent, a pilot development, would be avoided.

12.29 This is considered to be a **minor positive** effect.

Cumulative, synergistic and secondary effects

Business as usual - Shale oil and gas extraction

12.30 Cumulatively the impacts on land use change as a result of development and infrastructure, including increased traffic levels could result in urbanisation of the countryside, with overall **minor negative** effects on environmental quality. Secondary effects could also arise as a result of the construction of waste treatment facilities. No synergistic effects are identified.

Business as usual - CBM

12.31 The environmental effects of the development of CBM will contribute to combined effects on land use change, roads, water abstraction and waste treatment, however the scale of these effects is judged to be **negligible** reflecting the scale of CBM development.

Pilot project

12.32 The environmental effects of the development of a pilot project will contribute to combined effects on land use change, roads, water abstraction and waste treatment. However the scale of these effects is judged to be **negligible**.

Preferred policy position

The preferred policy position means that adverse cumulative impacts on material assets (land use change and infrastructure) resulting from shale oil and gas production (greatest for the KPMG high production scenario, and less for the central and low scenarios), CBM production and, to a lesser extent, a pilot development, would be avoided.

12.33 In conclusion, although the material assets within the Central Belt of Scotland will continue to face existing pressures, the preferred policy position ensures that additional pressures on material assets, which would result from unconventional oil and gas development will not take place. This is considered to be a **minor positive** effect.

Scope for further mitigation

12.34 The assessment results are based on the application of existing regulatory controls. The evidence base includes information on a number of processes which could be implemented to reduce the scale of impact on material assets. These could reduce the overall potential scale of effect from unconventional oil and gas development, and therefore the associated scale of effect avoided as a consequence of the preferred policy position.

12.35 The applicability and practicality of many of these additional measures will be determined at a site specific level so it is not possible to draw firm conclusions as to

the extent to which they would mitigate predicted effects successfully. Potential measures include:

- 12.36 **Land use change** – potential impacts in relation to land use change could be reduced if brownfield sites are promoted for re-development, rather than greenfield land. This would ensure the prudent use of resources.
- 12.37 **Impacts on infrastructure** – many of the water, soil and air mitigation measures could help to reduce impacts on infrastructure and the wider environment. These include careful soil stripping and restoration, the use of advanced monitoring technologies (e.g. DTS and DAS), annual inspections and repair, the use of supply chain management and ICT resources, and the re-use of wastewater.

Table 12.1: Summary of effects on material assets

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
Land use change	Business as usual – shale oil and gas extraction	Major	Short to long term	Temporary	A minor negative effect is identified as the scale of effect on land use change from each scenario is likely to be greatest under the high production scenario, where the largest number of pads would be developed.	The likely location of pads and impacts on land with greatest suitability for agriculture or forestry and woodland production.
	Business as usual – coal bed methane extraction	Minor	Short to long term	Temporary	A minor negative effect is identified reflecting the scale of development of two pads.	
	Pilot project	Minor	Short to long term	Temporary	A minor negative effect is identified due to the potential location of the pilot on high carbon soils.	
	Preferred policy position	None	Short to long term	Permanent	A minor positive effect is identified reflecting the avoidance of minor negative effects associated with land use change.	
Impacts on infrastructure	Business as usual – shale oil and gas extraction	Major	Short to long term	Temporary	A minor negative effect is identified reflecting impacts on road infrastructure, wastewater generation and disposal, and is identified for all three of the KPMG scenarios. A negligible effect is identified in relation to water	The use of pipelines to transport water or gas would reduce the overall number of vehicle movements generated, however this is uncertain.

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
					supply reflecting the effect of regulation.	
	Business as usual – coal bed methane extraction	Minor	Short to long term	Temporary	A negligible effect is identified in relation to infrastructure reflecting the scale of development of two pads.	
	Pilot project	Minor	Short to long term	Temporary	A negligible effect is identified in relation to infrastructure reflecting the scale of development of a single pad.	
	Preferred policy position	None	Short to long term	Permanent	A minor positive effect is identified reflecting the avoidance of minor negative effects.	
Cumulative	Business as usual – shale oil and gas extraction	Major	Short to long term	Temporary	A minor negative effect is identified on environmental quality resulting from land use change as a result of development and infrastructure, including increased traffic levels and resulting urbanisation.	
	Business as usual – coal bed methane extraction	Minor	Short to long term	Temporary	A negligible effect is identified reflecting the scale of development of two pads.	
	Pilot project	Minor	Short to long term	Temporary	A negligible effect is identified reflecting the scale of development of a single	

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
					pad.	
	Preferred policy position	None	Short to long term	Permanent	A minor positive effect is identified reflecting the avoidance of minor negative cumulative effects.	

13 Population and human health

What are the environmental effects of the reasonable alternative on population and human health?

13.1 Unconventional shale gas/oil development and CBM development could result in the following effects on population and human health:

- Health impacts associated with air pollution from direct and indirect sources associated with exploration, appraisal, production and decommissioning.
- Health impacts associated with water pollution from direct and indirect sources associated with exploration, appraisal, production and decommissioning.
- Noise, light, and odour issues from exploration, appraisal and production:
 - Noise impacts (from site activities and traffic associated with unconventional oil and gas developments).
 - Light pollution from site activities including floodlighting and flaring.
 - Odour nuisance.
- Health issues associated with induced seismic activity during exploration, appraisal and production.
- Impacts on local amenity and mental well-being, and access to opportunities for recreation and physical activity.
- Physical health and safety risks:
 - Increased risk of road accidents.
 - Accidental releases of hazardous materials.
 - Explosive risk (including waterborne methane)
 - Occupational risks associated with respirable crystalline silica.

13.2 The health impacts of air pollution are described in detail in the section on Air which explains the different air pollutants released by unconventional oil and gas development and their health impacts. Pollutants include methane (CH₄), carbon dioxide (CO₂), volatile organic compounds (VOCs), non-methane volatile organic compounds (NMVOC), nitrogen oxides (NO_x), carbon monoxide (CO), sulphur dioxide (SO₂), particulate matter (PM), and black carbon.

13.3 Air pollution due to gaseous and particulate hazards linked to unconventional oil and gas activities is a potential source of both short- and long-term adverse effects on human health. Evidence is well established that the main toxic pollutants can cause a variety of health effects including irritation of the respiratory system and exacerbate existing health conditions, especially heart disease and respiratory illnesses, in vulnerable individuals.²⁵⁴

²⁵⁴ Health Protection Scotland (2016) A Health Impact Assessment of Unconventional Oil and Gas in Scotland. P.61 Available at: <http://www.hps.scot.nhs.uk/resourcedocument.aspx?resourceid=3102>

- 13.4 The health impacts of water pollution are explained in detail in the section on Water which explains the different sources of water pollution. Health impacts include carcinogens used in fracturing fluid, and naturally occurring radioactive material within flowback water.
- 13.5 Unconventional oil and gas developments have the potential to increase **noise impacts** on nearby residents. Site activities associated with unconventional oil and gas development that could increase noise impacts include drilling, completion operations, flaring and traffic movements to and from unconventional oil and gas facilities²⁵⁵.
- 13.6 **Light pollution** may be caused by lighting for safe working or flaring, particularly during the drilling phase which occurs 24 hours a day until complete. Truck movements may comprise another source of light pollution²⁵⁶.
- 13.7 Odours associated with unconventional oil and gas could potentially result in **odour nuisance**, particularly in neighbouring areas²⁵⁷.
- 13.8 It is documented that unconventional oil and gas developments can lead to **induced seismic activity**. When unconventional oil and gas wells are fractured, the rock breaks and causes locally detectable seismic events. Induced seismicity is often the result of long-term unconventional oil and gas production^{258,259}. Seismicity is associated with hydraulic fracturing, which is generally not required with the extraction of CBM²⁶⁰, although it can take place.
- 13.9 The risk of fracking-induced felt seismicity causing damage to properties or people at the surface is considered to be very low: very few earthquakes have been triggered by fracking for shale gas (3-5 documented cases of felt seismicity over millions of frack jobs, Davies et al 2013), and the hazard they pose is very small since the few incidences of felt seismicity were at such small magnitudes that they caused little or no environmental effect or damage to the built environment.²⁶¹ However Health Protection Scotland²⁶² concluded that there was 'inadequate' evidence that seismicity linked to unconventional oil and gas activity was associated with any actual physical risk to health. Furthermore natural seismicity is low in the

²⁵⁵ Ricardo Energy & Environment, 2016. *Unconventional oil and gas development: understanding and mitigating community impacts from transportation*. Available at:

<http://www.gov.scot/Resource/0050/00509327.pdf>

²⁵⁶ Health Protection Scotland, 2016. *A Health Impact Assessment of Unconventional Oil and Gas in Scotland. Volume 1 Report*. Available at:

<http://www.hps.scot.nhs.uk/resourcedocument.aspx?resourceid=3102>

²⁵⁷ Health Protection Scotland, 2016. *A Health Impact Assessment of Unconventional Oil and Gas in Scotland – Summary*. Available at: <http://www.hps.scot.nhs.uk/resourcedocument.aspx?resourceid=3101>

²⁵⁸ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

²⁵⁹ British Geological Society, 2016. *Unconventional Oil and Gas Development: Understanding and Monitoring Induced Seismic Activity*. Available at: <http://www.gov.scot/Resource/0050/00509318.pdf>

²⁶⁰ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. P. 39 Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

²⁶¹ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. P. 49 Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

²⁶² Health Protection Scotland (2016) *A Health Impact Assessment of Unconventional Oil and Gas in Scotland Volume 1 Report* available at:

<http://www.hps.scot.nhs.uk/resourcedocument.aspx?resourceid=3102>

Central Belt of Scotland, where natural (background) earthquake activity almost all occurs north of the Central Belt, or south of the Southern Uplands²⁶³.

- 13.10 **Impacts on local amenity and well-being** relate to wider environmental quality, such as landscape, amenity and access to recreational resources, and the associated direct and indirect effects on health and well-being.
- 13.11 **Physical health and safety risks** are associated with unconventional oil and gas development, such as the physical risks associated with respirable crystalline silica²⁶⁴ and the immediate physical risks caused by potentially explosive mixtures of methane and air. Such risks particularly apply to unconventional oil and gas industry workers²⁶⁵.
- 13.12 There is the risk of **accidental releases of hazardous materials** (e.g. wastewater spills) during transportation, particularly if a collision involves a vehicle carrying dangerous substances. The release of hazardous materials could have the potential to adversely impact upon public health²⁶⁶.
- 13.13 Unconventional oil and gas development would lead to increased traffic movements and heavy vehicle movements. These additional vehicle movements could potentially result in an **increased risk of road accidents**²⁶⁷.

How do these effects relate to the current pressures and trends?

Deprivation and health

- 13.14 There are established links between deprivation and health and this is further contributed by links between environmental quality and deprivation. Air pollution is often worst in urban deprived areas, worsening existing inequalities in local environmental quality and human health.²⁶⁸ The areas of Scotland experiencing the highest levels of multiple deprivation are illustrated on Figure 4a and 4b, Appendix 1, and this shows a correlation between the prospective areas for unconventional oil and gas development and a number of areas within the 20% most deprived areas. Similarly, those parts of Scotland in the 20% most deprived areas for health deprivation include areas of Fife, Edinburgh, Falkirk, North Lanarkshire and Glasgow which lie within the prospective area for unconventional oil and gas development.
- 13.15 In relation to cardiovascular conditions and diabetes, those in the most deprived areas are more likely to have such a condition than those in the least deprived areas (18% and 12% respectively). The same pattern applies to the percentage of adults reported having Chronic Obstructive Pulmonary Disease (COPD), and was recorded for only 2% of adults in the two least deprived quintiles, compared with 7% of those in the most deprived areas. The prevalence of ever experiencing wheezing was also linked to deprivation, with prevalence higher in the most deprived areas (36%)

²⁶³ Ibid.

²⁶⁴ Health Protection Scotland, 2016. *A Health Impact Assessment of Unconventional Oil and Gas in Scotland – Summary*. Available at: <http://www.hps.scot.nhs.uk/resourcedocument.aspx?resourceid=3101>

²⁶⁵ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

²⁶⁶ Ibid.

²⁶⁷ Ibid.

²⁶⁸ <https://www.environment.gov.scot/our-environment/air/air-quality-and-health/>

than the least deprived areas (25%)²⁶⁹. Existing health conditions can be exacerbated by poor air quality.

Air quality

13.16 Scotland has seen strong declines in emissions of most pollutants between 1990 and 2013: SO₂ by 87%, NO_x by 67%, PM₁₀ by 53% and PM_{2.5} by 56% (UK)²⁷⁰.

Water quality

13.17 In recent decades, significant improvements in water quality have been observed in many rivers, canals and estuaries due to decreases in the releases of environmental pollutants. Recent data²⁷¹ shows that 80% of groundwaters in Scotland were at good status in 2016. In addition, 62% of surface waters (rivers, lochs, and estuaries) were at good status or better in 2016²⁷². There has been a steady improvement in the water quality of Scotland's designated bathing sites since 1988. In 2016, about 80% of Scotland's designated bathing waters met the sufficient or better classification²⁷³.

Noise, light, odour

13.18 The Scottish Government has produced noise maps for major roads, rail airports and industry. This data only relates to the four main cities, and for Edinburgh this shows higher noise levels in relation to the main roads and airport²⁷⁴. The pattern of concentration of noise pollution around main roads and areas of industry is likely to be replicated across the central belt. In relation to light pollution, the Central Belt is one the most densely populated parts of Scotland, and again light pollution is higher in towns, cities and along main transport routes.

Seismic activity

- 13.19 An analysis of recent instrumental recordings of earthquakes and older historical data shows that earthquake activity in Scotland is low. On average there are eight earthquakes with a magnitude of 2.0 M_L or above in Scotland every year. In the last 400 years, only two earthquakes with a magnitude greater than 5.0 M_L have been observed. The largest recorded earthquake in Scotland had a magnitude of 5.2 M_L. Therefore, the risk of damaging earthquakes is low.
- 13.20 Most of Scotland's seismic activity is on the west side of mainland Scotland, north of the Highland Boundary Fault. Earthquake activity in the Midland Valley of Scotland is lower, and most of the recorded earthquakes in this area were induced by coal

²⁶⁹ The Scottish Health Survey 2016 (2016) <http://www.gov.scot/Resource/0052/00525366.pdf>

²⁷⁰ The Scottish Government, 2016. *SPICe Briefing – Air Quality in Scotland*. Available at: http://www.parliament.scot/ResearchBriefingsAndFactsheets/S5/SB_16-35_Air_Quality_in_Scotland.pdf

²⁷¹ SEPA, 2016. *Water Classification Hub – groundwaters*. Available at: <https://www.sepa.org.uk/data-visualisation/water-classification-hub/>

²⁷² SEPA, 2016. *Water Classification Hub – surface waters*. Available at: <https://www.sepa.org.uk/data-visualisation/water-classification-hub/>

²⁷³ SEPA, 2016. *Scottish bathing waters*. Available at: https://www.sepa.org.uk/media/219168/1282_sepa_bathing_waters_2016_web.pdf

²⁷⁴ <https://noise.environment.gov.scot/noisemap/>

mining. Since the decline of the coal-mining industry in the 1990's, very few induced earthquakes have been recorded²⁷⁵.

Local amenity, mental well-being, access and recreation

13.21 Local environmental quality, access to greenspace and opportunities for access and recreation have been found to contribute widely to public health and wellbeing by promoting physical activity and reducing health inequalities while also promoting mental and social health²⁷⁶. Participation in all physical activity and sport has risen between 2011 and 2016, and is driven by the rise in recreational walking. Around half of adults (48 %) visited the outdoors at least once a week in the last year, however adults living in the most deprived areas were more likely not to have made any visits to the outdoors in the past twelve months (19%) compared to those in the least deprived areas (7%). Most adults (7%) are satisfied or very satisfied with their nearest area of greenspace, a similar proportion to 2015.²⁷⁷

Physical health and safety risks

13.22 Scotland has shown decreasing trends in the number of people killed or seriously injured in road accidents. The total numbers of casualties on Scottish roads has fallen by 1% between 2015 and 2016 and are at their lowest level since records began over 50 years ago. Serious injury casualties fell in every year in the last ten apart from small rises in 2008, 2012 and 2014, while there have been no increases in slight injury casualties.²⁷⁸

13.23 Statistics on work related fatal injuries in Scotland show that after standardising for industry composition, fatality rates in Scotland are not significantly higher than the rate for Great Britain as a whole. Non-fatal injury rates in Scotland are also not statistically significantly different from Great Britain²⁷⁹.

What current regulatory processes control these effects?

13.24 *The regulatory processes for air and water which also apply to population and human health are set out under the respective topics, and are not replicated in this section.*

13.25 At the European level, the *REACH Enforcement Regulations 2008*²⁸⁰ require that all additives in fracturing fluids that exceed the one metric tonne threshold and other

²⁷⁵ Baptie et al., 2016. *Unconventional Oil and Gas Development: Understanding and Monitoring Induced Seismic Activity*. Available at: <http://www.gov.scot/Resource/0050/00509318.pdf>

²⁷⁶ James Hutton Institute, OPENSspace Edinburgh University, University of Glasgow, Heriot-Watt University, Biomathematics and Statistics Scotland (2014) Contribution of green and open space to public health and wellbeing. For Rural and Environmental Science and Analytical Services Division Scottish Government. Available at: <http://www.hutton.ac.uk/sites/default/files/files/projects/GreenHealth-Final-Report.pdf>

²⁷⁷ Scottish Household Survey, 2016. *Scotland's People Annual Report 2016*. Available at: <http://www.gov.scot/Resource/0052/00525075.pdf>

²⁷⁸ Transport Scotland Scottish Transport Statistics no 36 2017 Edition. A National Statistics publication for Scotland. Available at: <https://www.transport.gov.scot/media/41863/scottish-transport-statistics-2017-with-correction-to-table-214.pdf>

²⁷⁹ Available from: <http://www.hse.gov.uk/statistics/regions/index.htm>

²⁸⁰ European Commission, 2008. *Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006*. Available at: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32008R1272>

requirements set by REACH Regulation must be registered at the European Chemicals Agency by the manufacturer or importer.

- 13.26 In the UK, there are systems in place to manage the impact of chemical spillage in the event of a traffic accident. These controls would reduce, but not fully eliminate, such risks.
- 13.27 Any unplanned release of fluids (liquid or gas) from an oil or gas well must be reported to HSE under Schedule 2, Part 1, Section 20 of the *Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013*²⁸¹.
- 13.28 The *Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017*²⁸² relate to the assessment of the impact of certain public and private projects on the environment through the planning system. This would require an assessment of the potential risks to human health. For instance, any planning application for unconventional oil and gas development with the potential for generating significant traffic movements could be made subject to an Environmental Impact Assessment (EIA). Traffic modelling studies are likely to be needed in support for an EIA for unconventional oil and gas development. The exception would be cases where the potential traffic impact is too low to warrant such a study²⁸³.
- 13.29 The *Management of Extractive Waste (Scotland) Regulations 2010*²⁸⁴ requires that extractive waste will be managed without using processes or methods which could cause a nuisance through noise or odours.
- 13.30 The *Control of Major Accident Hazards Regulations 2015* (COMAH)²⁸⁵ seek to prevent major accidents involving dangerous substances and limit the consequences to people and the environment of any accidents which do occur. If COMAH applies, the operator will be required to identify their major hazard scenarios and demonstrate to the Competent Authority that they have taken control measures to prevent major accidents and made arrangements for mitigatory action in the event of an accident occurring. The enforcement authority (HSE and SEPA) can prohibit operation where these measures are seriously deficient.
- 13.31 Workplace exposure to harmful substances is regulated under the *Control of Substances Hazardous to Health Regulations 2002* (COSHH)²⁸⁶ by HSE. Under COSHH, assessment and control of the hazard posed by fluids containing chemicals that may be harmful to worker health is required.
- 13.32 The *Ionising Radiations Regulations 1999*²⁸⁷ may apply to employers working with materials containing NORM depending on if they are used above the specified level.
- 13.33 The *Workplace (Health, Safety and Welfare) Regulations 1992*²⁸⁸ require every workplace to have suitable and sufficient lighting, ensuring that lighting or lack of it

²⁸¹ The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013

²⁸² The Town and Country Planning (Environmental Impact Assessment) Regulations 2017 (Scottish Statutory Instrument 2017 No. 571)

²⁸³ Ricardo Energy & Environment, 2016. *Unconventional oil and gas development: Understanding and mitigating community impacts from transportation*. Available at: <http://www.gov.scot/Resource/0050/00509327.pdf>

²⁸⁴ The Management of Extractive Waste (Scotland) Regulations 2010 (Scottish Statutory Instrument 2010 No. 60)

²⁸⁵ The Control of Major Accident Hazards Regulations 2015 (2015 No. 483)

²⁸⁶ The Control of Substances Hazardous to Health Regulations 2002 (2002 No. 2677)

²⁸⁷ The Ionising Radiations Regulations 1999 (1999 No. 3232)

does not present a risk to health and safety. The 1992 Regulations also set out requirements for onsite traffic management to manage the risks from workplace transport effectively. The operator will need to consider three key areas: safe site, safe vehicle, and safe driver.

- 13.34 The *Control of Noise at Work Regulations 2005*²⁸⁹ set out legislation to control noise exposure and, where necessary, provide hearing protection.
- 13.35 In the UK, there is also legislation to regulate the noise impacts from industrial activity such as *BS 4142: 2014 'Methods for Rating and Assessing Industrial and Commercial sound'*²⁹⁰. BS 4142 provides a method for rating sound from industrial and commercial sources affecting people inside or outside dwellings or premises used for residential purposes.
- 13.36 Various phases of unconventional oil and gas development are associated with the use of a large number of chemicals and with the release of a range of environmental emissions. Some of these are known to be hazardous to human health and therefore subject to regulatory health limits for short-term or chronic exposures. These regulations are set by regulatory and other expert bodies such as the World Health Organization (WHO).²⁹¹
- 13.37 Effects which can be defined as a statutory nuisance are primarily contained within Part III of the Environmental Protection Act 1990, as amended. This includes issues such as odour, artificial light, and noise²⁹².

What stages of unconventional oil and gas development result in these effects, and what is the nature of these effects?

- 13.38 Impacts on air and water are addressed under these topic areas.

Noise impacts

Business as usual – shale oil and gas

- 13.39 The potential noise impacts associated with unconventional oil and gas site activity and transport flows would occur with **immediate effect** during the exploration, appraisal and production stage. These stages combined could occur over a period of approximately **30 years** for an individual development. The scale of these impacts is likely to be greatest during the production phase. The duration of these effects are **temporary**, as site activity and transport flows would come to a halt when unconventional oil and gas operations eventually cease. Furthermore, a single passing of a heavy goods vehicle (HGV) is a short duration event.
- 13.40 A study by Ricardo Energy & Environment²⁹³ concludes that additional traffic movements associated with unconventional oil and gas developments are unlikely

²⁸⁸ The Workplace (Health, Safety and Welfare) Regulations 1992 (1992 No. 3004)

²⁸⁹ The Control of Noise at Work Regulations 2005

²⁹⁰ UK Government, 2016. *Noise impact assessment: information requirements*. Available at:

<https://www.gov.uk/government/publications/noise-impact-assessment-information-requirements>

²⁹¹ Health Protection Scotland, 2016. *A Health Impact Assessment of Unconventional Oil and Gas in Scotland. Volume 1 Report*. Available at:

<http://www.hps.scot.nhs.uk/resourcedocument.aspx?resourceid=3102>

²⁹² <https://www.gov.scot/Topics/Environment/waste-and-pollution/Pollution-1/Noise-Nuisance/17661>

to be significant at a regional or national scale, in view of the much greater number of traffic movements resulting from other activities.

- 13.41 The noise impacts of drilling associated with hydraulic fracturing are expected to be minimal.
- 13.42 As mentioned previously, flaring may also be a source of noise. However, evidence suggests that the disruption caused by flaring is minimal – particularly compared to refinery activity or gas compression facility vent relief valves²⁹⁴.
- 13.43 Based on this information, noise impacts associated with unconventional oil and gas operations (caused by traffic and site activities) are expected to be **minimal**. However, there is inadequate evidence to determine whether unconventional oil and gas-associated noise impacts would occur at levels that could pose a risk to physical health²⁹⁵. The potential noise impacts depend on a number of local factors including existing background noise, proximity to sensitive receptors and potential mitigation measures proposed (e.g. use of acoustically insulated boxes)²⁹⁶. As a result, there is uncertainty whether noise pollution associated with unconventional oil and gas could have significant impacts on human health. Under the KPMG high scenario, cumulative effects from the noise associated with the higher number of pads and wells could have significant negative local effects. Although this is likely to occur within areas with existing higher levels of background noise, and taking the regulatory controls into account, this effect is judged to be **minor negative** but **uncertain**. These effects are likely to be lower for the central and low KPMG scenarios.

Business as usual - CBM

- 13.44 It is important to note that the potential noise impacts associated with CBM are expected to be lower than those associated with hydraulic fracturing. Coal bed methane requires shallower drilling depths and CBM is characterised by a significantly reduced need for imported water, which is likely to require less traffic movements. As a result, CBM operations are expected to generate less noise and/or operate for a shorter period²⁹⁷. Taking these factors and the regulatory controls into account, the effects of CBM on noise are judged to be **negligible**.

Pilot

- 13.45 The development of a pilot relates to a single pad and an unknown number of wells. The impacts of noise from traffic and onsite activity such as flaring will be local in their effect and controlled by the regulatory framework. An urban fringe and semi-urban pilot are assumed to be closer to areas of population and any impacts could affect these populations. A rural pilot is assumed not to be located within close proximity to large areas of population and any effect would be further limited by the

²⁹³ Ricardo Energy & Environment, 2016. *Unconventional oil and gas development: Understanding and mitigating community impacts from transportation*. Available at: <http://www.gov.scot/Resource/0050/00509327.pdf>

²⁹⁴ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

²⁹⁵ Health Protection Scotland, 2016. *A Health Impact Assessment of Unconventional Oil and Gas in Scotland – Summary*. Available at: <http://www.hps.scot.nhs.uk/resourcedocument.aspx?resourceid=3101>

²⁹⁶ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

²⁹⁷ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

lower potential number of receptors. The overall impact on noise from a single pilot is judged to be **negligible**.

Preferred policy position

13.46 The preferred policy position means that adverse noise impacts resulting from shale oil and gas production (greatest for the KPMG high production scenario, and less for the central and low scenarios), CBM production and, to a lesser extent, a pilot development, would be avoided.

13.47 This is considered to be a **minor positive** effect.

Light pollution

Business as usual – shale oil and gas

13.48 Light pollution associated with unconventional oil and gas site activity would occur with **immediate** effect during the exploration, appraisal and production stage. These stages combined could occur over a period of approximately **30 years** for an individual development. The scale of these impacts is likely to be greatest during the production phase. The duration of these effects are **temporary**, as the impacts of light pollution decrease as unconventional oil and gas site activity declines towards the end of the production phase.

13.49 The impacts of light pollution can be reduced by scheduling flaring and truck movements to take place during daylight hours, as well as using spotlights that shed light only on the working area²⁹⁸.

13.50 According to a recent study by Health Protection Scotland (HPS)²⁹⁹, there is inadequate evidence to determine whether unconventional oil and gas-associated light pollution would occur at levels that could pose a risk to physical health. As a result, there is **uncertainty** regarding whether light pollution with unconventional oil and gas could have significant impacts on human health.

13.51 Under the KPMG high scenario, the scale of shale oil and gas development is larger with a greater number of pads, wells and vehicle movements and higher levels of potential light pollution, although these effects would be temporary. In particular cumulative effects from pads which are developed in proximity to each other could increase the scale of effect. Taking these effects, and the regulatory controls into account, **minor negative** but **uncertain** effects are identified for all of KPMG scenarios, reflecting the potential for the distribution to result in cumulative effects.

Business as usual – CBM

13.52 The nature of the light pollution effects described above is similar for both shale oil and gas extraction and CBM, although the effects from transport for an individual pad may be lower where hydraulic fracturing vehicle movements are not required. The development of two pads also limits the overall scale of effect of light pollution, and taking regulatory controls into account, **negligible** effects are identified.

²⁹⁸ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

²⁹⁹ Health Protection Scotland, 2016. *A Health Impact Assessment of Unconventional Oil and Gas in Scotland – Summary*. Available at: <http://www.hps.scot.nhs.uk/resourcedocument.aspx?resourceid=3101>

Pilot project

13.53 Compared to the 'business as usual' alternative, the development of a single pilot location limits the area over which these effects may occur. A rural pilot location is likely to have greater local impacts in terms of light pollution due to the rural character of the area, although however the number of potential receptors would be lower. Semi-urban and urban fringe locations would be located closer to larger numbers of receptors, but are also located within locations which are already subject to higher levels of light pollution. The effects of all three pilots are therefore judged to be **negligible**.

Preferred policy position

13.54 The preferred policy position means that light pollution impacts resulting from shale oil and gas production (greatest for the KPMG high production scenario, and less for the central and low scenarios), CBM production and, to a lesser extent, a pilot development, would be avoided.

13.55 This is considered to be a **minor positive** effect.

Odour nuisance

Business as usual – shale oil and gas

13.56 Odour nuisance associated with unconventional oil and gas site activity would occur with **immediate** effect during the exploration, appraisal and production stage. These stages combined could occur over a period of approximately **30 years** for an individual development. The scale of these impacts is likely to be greatest during the production phase. The duration of these effects are **temporary**, as the impacts of odour nuisance decrease as unconventional oil and gas site activity declines towards the end of the production phase.

13.57 A recent report by Health Protection Scotland³⁰⁰ states that there is inadequate evidence to suggest that odour nuisance associated with unconventional oil and gas developments could pose a risk to human health. There is also regulatory control of odour nuisance, however odour nuisance associated with unconventional oil and gas developments are **uncertain**.

Business as usual – CBM

13.58 It is uncertain if odour issues associated with CBM differ from odour issues associated with shale oil and gas extraction. Therefore the effects of odour are **uncertain**.

Pilot project

13.59 The development of a pilot project would have local impacts from any resulting odour issues. Semi-urban and urban fringe pilots would be located closer to larger numbers of receptors than a rural pilot location.

³⁰⁰ Health Protection Scotland, 2016. *A Health Impact Assessment of Unconventional Oil and Gas in Scotland – Summary*. Available at: <http://www.hps.scot.nhs.uk/resourcedocument.aspx?resourceid=3101>

13.60 As noted above odour nuisance is uncertain, however based on the limited scale of any potential effect **uncertain negligible** effects for all three pilot locations are identified.

Preferred policy position

13.61 The preferred policy position would result in the avoidance of **uncertain** effects associated with odour on human health.

Felt seismic activity

Business as usual – shale oil and gas

13.62 Induced seismic activity resulting from unconventional oil and gas developments are likely to be greatest during the production phase, which for an individual development is likely to occur over a period of approximately **15 years**. In the early stages of exploration and appraisal, there may not be enough data to carry out efficient fracturing operations – increasing the risk of felt seismic activity occurring in subsequent stages³⁰¹. The effects of disturbance are judged to be **temporary** due to the instantaneous nature of seismic events. However, it is recognised that induced seismicity is often the result of long-term unconventional oil and gas production.

13.63 It is judged that unconventional oil and gas induced seismicity would be more likely to occur in major faults of the Midland Valley, given their geological sensitivity. It is important to note that the BGS regional data cannot provide an accurate representation of the complexity of structures within the subsurface due to their large scale³⁰², and there is uncertainty associated with the location or potential occurrence of seismic events.

13.64 A study by the Royal Society and Royal Academy of Engineering (2012)³⁰³ concluded that health, safety and environmental risks associated with hydraulic fracturing, including impacts on aquifers and seismicity, can be managed effectively in the UK– provided best practices are implemented and enforced through regulation.

13.65 Taking the evidence above into account, it is judged that disturbance caused by induced seismic activity would be **minimal**. Under the KPMG scenarios the high scenario involves 31 pads with 30 wells per pad, which would result in hydraulic fracturing across a wider area. Based on the evidence outlined above it is judged that impacts on human health from seismic activity are **minor negative uncertain**. These effects are likely to be lower for the central and low KPMG scenarios.

Business as usual – CBM

13.66 CBM may be extracted through dewatering, with or without hydraulic fracturing, depending on local geological conditions (though currently it is usually extracted without the use of hydraulic fracturing). Assuming that hydraulic fracturing is the

³⁰¹ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

³⁰² Baptie et al., 2016. *Unconventional Oil and Gas Development: Understanding and Monitoring Induced Seismic Activity*. Available at: <http://www.gov.scot/Resource/0050/00509318.pdf>

³⁰³ Royal Society/Royal Academy of Engineering, 2012. *Shale gas extraction in the UK: a review of hydraulic fracturing*. Available at: https://royalsociety.org/~media/royal_society_content/policy/projects/shale-gas/2012-06-28-shale-gas.pdf

main cause of seismic activity, the impacts from CBM development are judged to be **negligible**.

Pilot project

13.67 Any seismic activity associated with the development of a single pilot with an unknown number of wells is anticipated to have a local effect. Urban fringe and semi-urban pilots would be closer to areas of population and any impacts could affect these populations. A rural pilot would not be located within close proximity to large areas of population and any effect would be further limited by the lower potential number of receptors. For all three hypothetical pilot location effects on human health are judged to be **negligible**.

Preferred policy position

13.68 The preferred policy position means that adverse impacts on human health from induced seismic activity associated with shale oil and gas production (greatest for the KPMG high production scenario, and less for the central and low scenarios), CBM production and, to a lesser extent, a pilot development, would be avoided.

13.69 This is considered to be a **minor positive** effect.

Impacts on local amenity and mental well-being, and access to opportunities for recreation and physical activity.

Business as usual – shale oil and gas

13.70 The development of a pad is assumed to exclude the use of land for other purposes such access and recreation. Therefore if land was currently used for access or recreation the development of unconventional oil and gas could preclude this use. It is assumed that alternative route creation or access provision would be required through the planning process, however the size of the pad development and impact on local access networks could reduce connectivity between communities, with adverse effects on population and human health. This extends over the operational period of the pad through to the completion of decommissioning, a period of approximately **30 years**. This effect would be **temporary**, reflecting the restoration of the site following decommissioning.

13.71 Under the KPMG high scenario, the scale of development would result in the largest area of land affected by unconventional oil and gas development with potential negative effects on local access and recreation. A secondary effect would be the adverse effects on environmental quality and industrialisation of the landscape reducing the quality of recreational experience. The potential cumulative effects of pads within the same area could increase the scale of effects on local access and recreation opportunities, however this effect is uncertain as the location of pads is unknown. Due to the uncertainty over the location of pads, and the potential for cumulative effects, the scale of effect under all of the KPMG scenarios is judged to be **minor negative**, but **uncertain**.

Business as usual – CBM

13.72 The nature of the effects described above is similar for both shale oil and gas extraction and CBM. The scale of development of CBM is anticipated to involve two pads and is therefore lower in terms of cumulative impacts on access and

recreation. Impacts could be locally significant, a **minor negative** but **uncertain** effect is identified.

Pilot

13.73 The development of a pilot project is assumed to involve the development of a single pad and an unknown number of wells. The location of a pilot is unknown, however it is assumed that a rural pilot would be located in an area with lower population, and there could be greater opportunities for mitigation of these environmental effects, and a **negligible** effect is identified. A semi urban pilot and urban fringe pilot area may have greater importance for recreation, opportunities for mitigation may be more limited due to built development and effects could be locally significant. A **minor negative** but **uncertain** effect is identified.

Preferred policy position

13.74 The preferred policy position means that adverse impacts on opportunities for access and recreation resulting from shale oil and gas production (greatest for the KPMG high production scenario, and less for the central and low scenarios), CBM production and, to a lesser extent, a pilot development, would be avoided.

13.75 This is considered to be a **minor positive** effect.

Physical health and safety risks

Business as usual – shale oil and gas

13.76 As discussed previously, explosive risk associated with methane emissions from wells is a health and safety concern. High concentrations of methane (generally identified as making up more than 5% of the mix) mixed with air can be flammable or explosive in the presence of an ignition source. This could present a serious health and safety risk to the workforce. A recent study by the Health Protection Scotland³⁰⁴ has established that waterborne methane associated with unconventional oil and gas development occur at levels that could pose a **potential** explosive risk. As a result, careful monitoring of wellhead areas with automated sensors is common practice as it is a requirement by the Health and Safety Executive (HSE) which is expected to **minimise** explosive risks associated with unconventional oil and gas operations³⁰⁵.

13.77 The study by Health Protection Scotland also found that there is sufficient evidence to suggest that respirable crystalline silica, a component of fluids used in hydraulic fracturing processes, occurred at levels that could pose a risk to unconventional oil and gas workers' health. However, there is limited evidence to suggest that respirable crystalline silica could pose a risk to the health of nearby residents due to methodological weaknesses in original studies. Therefore, there is some **uncertainty** as to the extent to which crystalline silica could pose a risk to the health of nearby residents.

13.78 Physical health and safety risks would occur with **immediate** effect during the exploration, appraisal and production stage. These stages combined could occur over a period of approximately **30 years** for an individual development. The scale of

³⁰⁴ Health Protection Scotland, 2016. *A Health Impact Assessment of Unconventional Oil and Gas in Scotland – Summary*. Available at: <http://www.hps.scot.nhs.uk/resourcedocument.aspx?resourceid=3101>

³⁰⁵ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

these impacts is likely to be greatest during the production phase. The duration of when these effects may occur is judged to be **temporary**, although the effects on the health of individuals could be **permanent**.

- 13.79 Under the KPMG scenarios the scale of development under the high scenario means that the total number of workers and residents exposed to health and safety risks is greater than under the central and low scenarios. There is also a degree of uncertainty over some of the risks. The role of regulatory control is recognised, however **significant negative** but **uncertain** effects are identified. These effects are likely to be lower for the central and low KPMG scenarios.

Business as usual – CBM

- 13.80 The evidence base on CBM is more limited than that on shale oil and gas. The report by HPS Scotland concluded that the nature of hazards associated with CBM activities is very similar to those from shale-sourced unconventional oil and gas³⁰⁶. It is noted that risks associated with respirable crystalline silica would not occur where hydraulic fracturing does not take place. The scale of CBM development is assumed to be two pads and therefore the extent of health and safety risks is more limited than development of shale oil and gas. Although controlled by regulation, the nature of potential health and safety risks means that **significant negative** but **uncertain** effects are identified.

Pilot project

- 13.81 The development of a pilot project has the potential for health and safety impacts for workers and for residents. The nature of the risk to receptors is the same as for the 'business as usual' alternative. However, compared to the 'business as usual' alternative, the development of a single pilot location relates to a limited area over which these effects may occur, with a smaller number of potential receptors. The number of potential residential receptors to health and safety risks is lowest for a rural pilot location, and greater for semi-urban and urban fringe locations.
- 13.82 The scale of effects relate to the development of a single pad. However, as described for CBM, the nature of potential health and safety risks means that **significant negative** but **uncertain** effects are identified.

Preferred policy position

- 13.83 The preferred policy position means that adverse health and safety impacts resulting from shale oil and gas production (greatest for the KPMG high production scenario, and less for the central and low scenarios), CBM production and, to a lesser extent, a pilot development, would be avoided.
- 13.84 This is considered to be a **significant positive** effect.

Road accidents

Business as usual – shale oil and gas

- 13.85 Recent evidence has shown that a number of regions in the United States have reported increases in the rates of road accidents in recent years, correlating with the expansion of the shale gas industry. Current legislation in Scotland is expected to

³⁰⁶Health Protection Scotland (2016) Volume 1: A Health Impact Assessment of Unconventional Oil and Gas in Scotland. Available at: <http://www.hps.scot.nhs.uk/resourcedocument.aspx?resourceid=3102>

result in increased seatbelt use for commercial vehicle operators – potentially minimising the rate of work-related motor vehicle-related deaths³⁰⁷.

- 13.86 The increased risk of road accidents associated with unconventional oil and gas site activity and transport flows would occur with **immediate effect** during the exploration, appraisal and production stage. These stages combined could occur over a period of approximately **30 years** for an individual development. The scale of these impacts is likely to be greatest during the production phase, when traffic movements are required to support unconventional oil and gas operations. The duration of these effects are **temporary**, as the risk of road accidents would decrease with declining vehicle movements as the production phase ends. However the effect of any road accidents on the individuals involved could be **permanent**.
- 13.87 If pads are developed in close proximity to each other, cumulative effects on local roads could occur. However the location of developments is uncertain under all of the KPMG scenarios. Under the KPMG high scenario the level of road traffic movements would be greatest, reflecting the higher number of pads and wells. Cumulatively the high scenario also leads to the greatest overall increase in traffic. As the distribution of pads is unknown locally significant impacts under any of the three KPMG scenarios could occur and **minor negative** but **uncertain** effects are identified.

Business as usual – CBM

- 13.88 Ricardo Energy and Environment (2016) found that the range of unconventional oil and gas development scenarios considered could give rise to between 210 and 1,670 traffic movements per week on average across the country as a whole, with a further 99 movements associated with the coal bed methane scenario³⁰⁸. The scale of CBM development, and the potential for lower water requirements and associated vehicle movements, means that **negligible** but **uncertain** effects are identified for impacts on road safety.

Pilot project

- 13.89 The development of a pilot project is assumed to involve the development of a single pad and an unknown number of wells with the level of traffic movements associated with a single pad.. The location of a pilot is unknown, however the development of semi urban and urban fringe pilots have the potential for greater impacts on road safety due to their proximity to communities. Conversely such locations may also provide greater access to the main road network, reducing direct impacts on local communities in terms of road safety. **Negligible** but **uncertain** effects are identified for road safety for all three pilot locations.

Preferred policy position

- 13.90 The preferred policy position means that adverse impacts on road safety resulting from shale oil and gas production (greatest for the KPMG high production scenario,

³⁰⁷ Ricardo Energy & Environment, 2016. *Unconventional oil and gas development: Understanding and mitigating community impacts from transportation*. Available at: <http://www.gov.scot/Resource/0050/00509327.pdf>

³⁰⁸ Ricardo Energy & Environment, 2016. *Unconventional oil and gas development: understanding and mitigating community impacts from transportation*. Available at: <http://www.gov.scot/Resource/0050/00509327.pdf>

and less for the central and low scenarios), CBM production and, to a lesser extent, a pilot development, would be avoided.

13.91 This is considered to be a **minor positive** effect.

Cumulative, synergistic and secondary effects

Business as usual – shale oil and gas extraction

13.92 Impacts on health potentially arise from a number of activities associated with unconventional oil and gas development, and result in impacts on several different aspects of health and wellbeing.

13.93 The scale of effects that arise is likely to be most significant under the KPMG high scenario for shale oil and gas extraction, which has the highest number of pads and greatest number of wells developed per pad. This scenario could result in the greatest magnitude of effects, and also impacts on the great number of individuals and communities. Where unconventional oil and gas developments occur in closer proximity to each other, this also means that some communities may experience impacts from several different developments, with potential cumulative effects. However the location of pad developments is uncertain.

13.94 Reflecting the potential scale of development under the KPMG scenarios, **significant negative** but **uncertain** cumulative effects are identified for population and human health.

13.95 Environmental regulation plays a key role in reducing the overall risks to health for a number of impacts on health, particularly air and water pollution. However there may be inadequacies in the current regulatory framework for managing some risks to health linked to unconventional oil and gas development³⁰⁹.

Business as usual – CBM, Pilot Project

13.96 The development of CBM alone or a single pilot project would not result in significant cumulative effects.

Preferred policy position

13.97 The preferred policy position means that pressures on population and human health resulting from unconventional oil and gas development, in addition to the existing pressures on population and human health, would be avoided.

The **timeframe** for the avoidance of these additional effects is approximately the next 40 years reflecting the timescale of unconventional oil and gas development described in the KPMG scenarios. The avoidance of these effects is judged to be **permanent** within the context of the SEA. The **scale** of avoidance of effects reflects the geographic area identified as prospective for shale oil and gas, across the Central Belt of Scotland.

13.98 The preferred policy position means that cumulative adverse impacts on population and human health, resulting from shale oil and gas production (greatest for the KPMG high production scenario, and less for the central and low scenarios), CBM production and, to a lesser extent, a pilot development, would be avoided. This is considered to be a **significant positive** effect.

³⁰⁹Health Protection Scotland (2016) Volume 1: A Health Impact Assessment of Unconventional Oil and Gas in Scotland. Available at: <http://www.hps.scot.nhs.uk/resourcedocument.aspx?resourceid=3102>

Scope for further mitigation

- 13.99 The assessment results are based on the application of existing regulatory controls. The evidence base includes information on a number of processes which could be implemented to reduce the scale of impact on population and human health. These could reduce the overall potential scale of effect from unconventional oil and gas development, and therefore the associated scale of effect avoided as a consequence of the preferred policy position.
- 13.100 The applicability and practicality of many of these additional measures will be determined at a site specific level so it is not possible to draw firm conclusions as to the extent to which they would mitigate predicted effects successfully. Potential measures include:
- 13.101 **Noise and light pollution**– noise surveys could be carried out to establish whether noise exposure associated with unconventional oil and gas developments is likely to be hazardous. Noise impacts associated with traffic movements could be reduced if areas with a high density of sensitive receptors would be avoided, if possible. Furthermore, potential noise impacts could also be reduced through undertaking regular maintenance of equipment, the use of silencers or other noise attenuation equipment, the use of enclosures on noise generating equipment associated with drilling, minimising night-time vehicle movements, and minimising the use of audible vehicle reversing alarms at night. In addition, positioning and rotating the rig could help to mitigate drilling noise, as well as light nuisance.
- 13.102 **Odour nuisance**– nuisance caused by odour issues could be reduced through a number of mitigation measures. Examples include the disclosure and risk assessment of fracturing fluid chemicals and environmental monitoring (baseline and ongoing).
- 13.103 **Health issues associated with induced seismic activity** – contingency planning to deal with the impacts of induced seismic activity on human health could be used to reduce potential impacts.
- 13.104 **Impacts on local amenity and mental well-being** – screening of site activities through planting could help to reduce impacts on local amenity associated with unconventional oil and gas developments.
- 13.105 **Physical health and safety risks** – contingency planning to deal with the impacts of unexpected events and hazards could be used to reduce potential impacts.
- 13.106 **Road accidents** – the occurrence of road accidents associated with unconventional oil and gas development could be reduced if areas with a high density of sensitive receptors would be avoided, if possible. Additional safety measures are likely to further reduce the occurrence of road accidents. Examples of such measures include improving site access and junction design, signing, lining and providing anti-skid treatment³¹⁰.

Health impacts associated with air and water pollution – many of the water, soil and air mitigation measures could help to protect public health. These include careful soil stripping and restoration, the use of geotextiles and geo-synthetics, the

³¹⁰ Transport Scotland, 2016. *Strategic Road Safety Plan 2016*. Available at: https://www.transport.gov.scot/media/10323/ts_strategic_road_safety_plan_2016_digital_sep_2016.pdf

use of biodegradable fracking fluids, the (optimised) treatment of flowback and produced water through mobile units or at central facilities, the use of advanced monitoring technologies (e.g. DTS and DAS), annual inspections and repair, the use of supply chain management and ICT resources, and the re-use of wastewater.

Table 13.1: Summary of effects on population and human health

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
Noise	Business as usual – shale oil and gas extraction	Major	Short to long term	Temporary	A minor negative effect is identified reflecting potential noise impacts.	Noise impacts depend on a number of local factors and uncertainty over whether noise pollution associated with unconventional oil and gas could have significant impacts on human health.
	Business as usual – coal bed methane extraction	Minor	Short to long term	Temporary	A negligible effect is identified as potential noise impacts associated with CBM are expected to be lower than those associated with hydraulic fracturing for shale oil and gas.	
	Pilot project	Minor	Short to long term	Temporary	A negligible effect is identified as potential noise impacts associated with a single pad are local in effect.	
	Preferred policy	None	Short to long term	Permanent	A minor positive effect is identified reflecting the	

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
	position				avoidance of minor negative effects.	
Light pollution	Business as usual – shale oil and gas extraction	Major	Short to long term	Temporary	A minor negative effect is identified for all of the KPMG scenarios, reflecting the potential for the distribution of development to result in cumulative effects.	There is inadequate evidence to determine whether unconventional oil and gas-associated light pollution would occur at levels that could pose a risk to physical health
	Business as usual – coal bed methane extraction	Minor	Short to long term	Temporary	A negligible effect is identified as the scale of development limits the overall effect of light pollution.	
	Pilot project	Minor	Short to long term	Temporary	A negligible effect is identified as the scale of development limits the overall effect of light pollution.	
	Preferred policy position	None	Short to long term	Permanent	A minor positive effect is identified reflecting the avoidance of minor negative effects.	

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
Odour nuisance	Business as usual – shale oil and gas extraction	Major	Short to long term	Temporary	Odour nuisance associated with unconventional oil and gas developments are uncertain.	There is inadequate evidence to suggest that odour nuisance associated with unconventional oil and gas developments could pose a risk to human health.
	Business as usual – coal bed methane extraction	Minor	Short to long term	Temporary		
	Pilot project	Minor	Short to long term	Temporary		
	Preferred policy position	None	Short to long term	Permanent	The avoidance of uncertain effects associated with odour on human health.	
Felt seismic activity	Business as usual – shale oil and gas extraction	Major	Short to medium term	Temporary	A minor negative effect is identified under the KPMG high scenario, reflecting hydraulic fracturing over a wider area, however effects are likely to be lower for the central and low KPMG scenarios.	Location and occurrence of potential seismic events.

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
	Business as usual – coal bed methane extraction	Minor	Short to medium term	Temporary	A negligible effect is identified as CBM is usually extracted without hydraulic fracturing.	
	Pilot project	Minor	Short term	Temporary	A negligible effect is identified reflecting the limited scale of effect from a single pilot.	
	Preferred policy position	None	Short to long term	Permanent	A minor positive effect is identified reflecting the avoidance of minor negative effects.	
Amenity, mental wellbeing, recreation and physical activity	Business as usual – shale oil and gas extraction	Major	Short to long term	Temporary	A minor negative effect is identified reflecting potential loss of land for access and recreation, impacts on environmental quality.	The location of pads and potential impacts on recreational resources.
	Business as usual – coal bed methane extraction	Minor	Short to long term	Temporary	A minor negative effect is identified reflecting potential locally significant effects.	
	Pilot project	Minor	Short to long term	Temporary	A minor negative effect is identified reflecting	

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
					potential locally significant effects for the semi urban and urban fringe pilots.	
	Preferred policy position	None	Short to long term	Permanent	A minor positive effect is identified reflecting the avoidance of minor negative effects.	
Physical health and safety	Business as usual – shale oil and gas extraction	Major	Short to long term	Temporary and permanent	A significant negative effect is identified reflecting the physical health and safety risks.	Waterborne methane poses a potential explosive risk. The extent to which crystalline silica could pose a risk to the health of nearby residents.
	Business as usual – coal bed methane extraction	Minor	Short to long term	Temporary and permanent	A significant negative effect is identified reflecting the physical health and safety risks.	Limited evidence base on risks to physical health and safety for CBM.
	Pilot project	Minor	Short to long term	Temporary	A significant negative effect is identified reflecting the physical health and safety risks, although it is recognised	

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
					that there is a smaller number of potential receptors.	
	Preferred policy position	None	Short to long term	Permanent	A significant positive effect is identified reflecting the avoidance of significant negative effects.	
Road accidents	Business as usual – shale oil and gas extraction	Major	Short to medium term	Temporary and permanent	A minor negative effect is identified reflecting the effect of increased traffic movements and the impact on road accident risk.	The location of developments and proximity to each other and the potential for cumulative effects on road safety.
	Business as usual – coal bed methane extraction	Minor	Short to medium term	Temporary	A negligible effect is identified reflecting the lower level of traffic movements.	Potentially lower vehicle movements, if hydraulic fracturing is not required.
	Pilot project	Minor	Short term	Temporary	A negligible effect is identified reflecting the lower level of traffic movements.	Location in semi urban and urban fringe areas could have greater impacts on road safety due to their proximity to communities, or conversely could have better access to the main

Environmental impact	Alternative	Potential scale of development	Timescale when effect may occur	Duration of effect	Predicted effect taking account of existing regulation	Key areas of uncertainty
						road network.
	Preferred policy position	None	Short to long term	Permanent	A minor positive effect is identified reflecting the avoidance of minor negative effects.	
Cumulative	Business as usual – shale oil and gas extraction	Major	Short to long term	Temporary	A significant negative effect is identified reflecting the range of impacts on health and impacts on different aspects of health and wellbeing and the scale of development.	The location of unconventional oil and gas developments in close proximity to each other would lead to greater cumulative effects.
	Business as usual – coal bed methane extraction	Minor	Short to long term	Temporary	No cumulative effects identified.	
	Pilot project	Minor	Short to long term	Temporary	No cumulative effects identified.	
	Preferred policy position	None	Short to long term	Permanent	A significant positive effect is identified reflecting the avoidance of significant negative effects.	

14 Summary of environmental effects

- 14.1 Table 14.1 presents a high level summary of the predicted environmental effects associated with shale oil and gas extraction, coalbed methane production, a hypothetical pilot project and the preferred policy position. The predicted effects take into account the operation of existing regulatory controls, where appropriate, but do not take account of additional mitigation measures which are not statutorily required.
- 14.2 The development of unconventional oil and gas for shale oil and gas extraction at the levels described under the three KPMG scenarios is predicted to result in negative environmental effects for all SEA topic areas. Significant negative environmental effects are predicted for air, water, climate, biodiversity, cultural heritage, landscapes and population and human health. For some aspects of the environment there are greater risks associated with the development of unconventional oil and gas, reflecting a combination of the likely scale of development, the significance of potential environmental effects and the possibility of accidental or unplanned events.
- 14.3 The development of CBM typically results in lower levels of environmental effects than described for the KPMG shale oil and gas scenarios, reflecting the smaller scale and extent of extraction, and differences in the nature of some of the environmental effects. Significant negative effects are identified for water quality, biodiversity and population and human health and safety, although these effects are recognised as less extensive than those for shale oil and gas extraction..
- 14.4 The development of a single pilot project in a rural, semi urban or urban fringe location would also be likely to result in lower levels of environmental effect, again reflecting the smaller scale and extent of extraction. The assessment indicated that the pattern of potential effects is likely to depend on the location in question.
- 14.5 The preferred policy position means that adverse environmental effects across all SEA topic areas are avoided. Many of these adverse impacts would be significant. The assessment therefore predicts that the preferred policy position would result in minor or significant positive effects across all SEA topic areas.
- 14.6 Considerable uncertainty applies to these findings, reflecting a lack of firm information on the scale and location of unconventional oil and gas development in Scotland and on the scale of development that would have taken place in the absence of the preferred policy position, effects on oil and gas prices and wider patterns of production and use, and the extent to which additional mitigation measures could be successfully implemented.

Table 14.1: Summary of environmental effects

SEA topic	Impact type	Business as usual – shale oil and gas extraction	Business as usual – coal bed methane	Pilot project	Preferred policy position - significance of environmental effects avoided
Air	Fugitive emissions to air	Significant negative	Minor negative	Negligible	Significant positive
Air	Construction and site traffic emissions	Significant negative	Minor negative	Minor negative	Significant positive
Air	Cumulative	Significant negative	Minor negative	Minor negative	Significant positive
Water	Direct water pollution	Significant negative	Significant negative	Significant negative	Significant positive
Water	Water abstraction and supply, and indirect water pollution from abstraction	Negligible	Negligible	Negligible	Negligible
Water	Cumulative effects	Significant negative	Minor negative	Minor negative	Significant positive
Soil	Ground contamination	Minor negative	Negligible	Negligible	Minor positive
Soil	Soil sealing	Minor negative	Negligible	Negligible	Minor positive
Soil	Cumulative	None	None	None	None
Climatic factors	Controlled and uncontrolled release of produced gas	Significant negative	Minor negative	Negligible	Significant positive
Climatic factors	Combustion of gas or fossil fuels for on-site power and for transportation	Negligible	Negligible	Negligible	Negligible
Climatic factors	Greenhouse gas emissions associated with land use change	Significant negative	Minor negative	Negligible	Significant positive
Climatic factors	Greenhouse gas emissions from processing and use of unconventional oil and gas products	Significant negative	Minor negative	Negligible	Significant positive
Climatic factors	Cumulative	Significant	Minor	Negligible	Significant positive

SEA topic	Impact type	Business as usual – shale oil and gas extraction	Business as usual – coal bed methane	Pilot project	Preferred policy position - significance of environmental effects avoided
		negative	negative		
Biodiversity, flora and fauna	Habitat loss and fragmentation	Significant negative	Minor negative	Minor negative	Significant positive
Biodiversity, flora and fauna	Disturbance	Minor negative	Negligible	Negligible	Minor positive
Biodiversity, flora and fauna	Hazardous materials, INNS, hydrology impacts	Significant negative	Minor negative	Minor negative	Significant positive
Biodiversity, flora and fauna	Climate change impacts on habitats and species	Minor negative	Negligible	Negligible	Minor positive
Cultural and archaeological heritage	Loss and or damage of known and unknown archaeology, and other designated and undesignated historic assets	Minor negative	Minor negative	Minor negative	Minor positive
Cultural and archaeological heritage	Impacts on setting of cultural heritage	Significant negative	Minor negative	Minor negative	Significant positive
Cultural and archaeological heritage	Cumulative effects	Minor negative	Negligible	Negligible	Minor positive
Landscapes and geodiversity	Landscape and visual effects	Significant negative	Negligible	Negligible	Significant positive
Landscapes and geodiversity	Cumulative landscape and visual effects	Negligible	Negligible	Negligible	Negligible
Material assets	Land use change	Minor negative	Minor negative	Minor negative	Minor positive
Material assets	Impacts on infrastructure	Minor negative	Negligible	Negligible	Minor positive
Material assets	Cumulative	Minor negative	Negligible	Negligible	Minor positive
Population and human health	Noise	Minor negative	Negligible	Negligible	Minor positive

SEA topic	Impact type	Business as usual – shale oil and gas extraction	Business as usual – coal bed methane	Pilot project	Preferred policy position - significance of environmental effects avoided
Population and human health	Light pollution	Minor negative	Negligible	Negligible	Minor positive
Population and human health	Odour nuisance	Unknown	Unknown	Unknown	Unknown
Population and human health	Felt seismic activity	Minor negative	Negligible	Negligible	Minor positive
Population and human health	Amenity, mental wellbeing, recreation and physical activity	Minor negative	Minor negative	Minor negative	Minor positive
Population and human health	Physical health and safety	Significant negative	Significant negative	Significant negative	Significant positive
Population and human health	Road accidents	Minor negative	Negligible	Negligible	Minor positive
Population and human health	Cumulative	Significant negative	None	None	Significant positive

15 Mitigation

- 15.1 The 2005 Act requires that ‘*the measures envisaged to prevent, reduce and as fully as possible offset any significant adverse effects on the environment of implementing the plan or programme*’ are outlined within the Environmental Report. These measures are often referred to as mitigation measures.
- 15.2 The assessment has identified a range of potential environmental effects, and has concluded that the preferred policy position would not result in any potential significant negative effects in Scotland for all SEA topic areas. Therefore, no mitigation measures are identified in relation to this alternative.
- 15.3 However, the assessment has concluded that the other reasonable alternatives would result in potential significant negative effects in Scotland for certain SEA topic areas. Therefore, mitigation measures are identified in relation to the ‘business as usual’ and ‘pilot project’ alternatives.
- 15.4 The mitigation measures proposed are intended to be applied at the scale of individual unconventional oil and gas projects, rather than in relation to a policy. Furthermore, existing regulatory controls have been taken into account when considering potential, additional mitigation measures.

Air

- 15.5 **Fugitive emissions** – currently, there are technologies for limiting and monitoring fugitive methane emissions following shale gas extraction and CBM. Case studies from the US have demonstrated that these measures can be costly, lowering economic profitability. As a result, uptakes of measures for limiting emissions have been relatively low in the US due to the high costs of emission prevention and mitigation. Therefore, developments in the US unconventional oil and gas industry are currently focussed on reducing the cost of sensors and other related technologies³¹¹. However, it is recognised that the regulatory situation relating to emission limitations is different in Scotland.
- 15.6 **Vented emissions** – gases that are being vented could be burnt rather than dispersed into the atmosphere. Combustion would partially reduce the environmental impacts, because the process serves to incinerate many of the volatile organic compounds (VOCs) and hazardous air pollutants (HAPs) that would otherwise be released directly into the atmosphere. However, it is recognised that the combustion process would still result in adverse environmental impacts³¹².
- 15.7 **Super emitters** – a large proportion of the fugitive gas which is emitted has been found to come from a small group of ‘super emitters’. Although a complete avoidance of super-emitters may be unachievable, with suitable operational control

³¹¹ TNO, 2015. *Inventory of technologies and developments for reducing (residual) risks in shale gas extraction*. Available at: <https://publications.tno.nl/publication/34618831/wHLFqd/TNO-2014-R10919-Ef.pdf>

³¹² Congressional Research Service, 2016. *An Overview of Air Quality Issues in Natural Gas Systems*. Available at: <http://nationalaglawcenter.org/wp-content/uploads/assets/crs/R42986.pdf>

and maintenance procedures these high emitters could largely be eliminated. The International Climate Fund (ICF) suggests that annual inspections and repair would reduce emissions by 40%, quarterly inspections by 60% and monthly inspections by 80%. If the super emitters could be brought in line with the average, then total supply chain emissions would be reduced by 65%-87%³¹³.

- 15.8 **Leakage from decommissioned wells** – ensuring well integrity is highly dependent upon the application of best practice standards for well design and construction. The risk of gas leakage (including methane) from abandoned unconventional oil and gas wells is expected to be very low if constructed and abandoned to comply with international standards and industry best practice. To further reduce potential impacts, monitoring technology can be used so that remedial measures can be taken at an early stage. Examples include fibre optic sensing techniques including Fibre Bragg gratings (FBGs), Distributed Temperature Sensing (DTS) and Distributed Acoustic Sensing (DAS). Recent evidence suggests that fibre optic sensing technology has existed for decades, but most techniques are not yet mature for commercial deployment in the unconventional oil and gas industry. DAS has matured most rapidly, as is currently deployed on a commercial basis for selected geophysical and flow applications following a recent trial³¹⁴.
- 15.9 **Emissions from traffic associated with unconventional oil and gas developments** – there are a number of ways to reduce the air quality impacts of increased vehicle movements associated with unconventional oil and gas developments. Firstly, transport capacity can be optimally deployed using supply chain management systems and ICT resources. These measures have the potential to reduce the impacts on local air quality associated with vehicle movements. Secondly, emissions can be reduced or avoided through the use of pipelines or the re-use of wastewater³¹⁵.

Water

- 15.10 **Contamination caused by produced water and flowback water** – there are a number of feasible ways to process flowback and produced (FP) water:
- Through the treatment of the wastewater so that it can be returned (back) to the environment. For instance, a crystallisation plant was recently commissioned in Pennsylvania (US) that is able to convert wastewater into water that meets current standards for water discharge in the US. The salt that is extracted during the process can also be used as road salt. The crystallisation plant in Pennsylvania is the first of its kind, and is more efficient economically and environmentally compared to more conventional wastewater treatment plants. Efforts are currently undertaken to further refine existing techniques or invent new approaches to fully or partially reuse wastewater.

³¹³ Committee on Climate Change, 2016. *Scottish unconventional oil and gas: Compatibility with Scottish greenhouse gas targets*. Available at: <https://www.theccc.org.uk/wp-content/uploads/2016/11/Scottish-Unconventional-Oil-and-Gas-Committee-on-Climate-Change-2016.pdf>

³¹⁴ Lumens, 2014. *Fibre-optic sensing for application in oil and gas wells* Eindhoven: Technische Universiteit Eindhoven. Available at: <https://pure.tue.nl/ws/files/3823460/769555.pdf>

³¹⁵ Ricardo Energy & Environment, 2016. *Unconventional oil and gas development: Understanding and mitigating community impacts from transportation*. Available at: <http://www.gov.scot/Resource/0050/00509327.pdf>

- Injection of the wastewater into an empty gas field
- Reuse of wastewater in subsequent fracking activities.

15.11 In addition, there are various substitutes that can be used to (partially) replace water in hydraulic fracturing fluids – carbon dioxide, LPG and/or propane being the most commonly used substances in the US and Canada. However, it is recognised that alternative substances have their respective disadvantages. For instance, they are often harmful or hazardous by nature (e.g. LPG) and their effect and risk is insufficiently known as nearly all alternative substances are hardly used or at the experimental stage.³¹⁶

15.12 **Gas and fluid leakage associated with poor well construction** – ensuring well integrity is highly dependent upon the application of best practice standards for well design and construction. In addition, a significant reduction in risks can be achieved by using monitoring technology so that remedial measures can be taken at an early stage. Examples include fibre optic sensing techniques including Fibre Bragg gratings (FBGs), Distributed Temperature Sensing (DTS) and Distributed Acoustic Sensing (DAS). Recent evidence suggests that fibre optic sensing technology has existed for decades, but most techniques are not yet mature for commercial deployment in the unconventional oil and gas industry. DAS has matured most rapidly, as is currently deployed on a commercial basis for selected geophysical and flow applications following a recent trial³¹⁷.

15.13 **Aquifer cross contamination** – further development of high resolution sensors for monitoring could be used to prevent or reduce methane migration to aquifers.

15.14 **Accidental releases of hazardous materials** – increased traffic safety measures could help to reduce the number of vehicles carrying hazardous substances getting involved in traffic accidents.

15.15 **Surface spills** – geotextiles and geo-synthetics can be used on surfaces to reduce the risk of surface water pollution. It is important to note that geotextiles and geo-synthetics are already available, but are not yet widely used.

15.16 **Borehole leaks** – there are other ways to mitigate or limit the effects caused by the contamination of fracking fluids; the advancement of alternative hydraulic fracturing and drilling techniques may increase the efficiency of the hydraulic fracturing process so that the use of hazardous chemicals can be reduced or avoided.

Soil

15.17 **Ground contamination** – many of the water mitigation measures could help to protect soils, and reduce or avoid ground contamination. These include the use of geotextiles and geo-synthetics, the use of biodegradable fracking fluids, the (optimised) treatment of flowback and produced water through mobile units or at central facilities, and the use of advanced monitoring technologies (e.g. DTS and DAS). Other mitigation measures include careful soil stripping, storage, and restoration in accordance with best practice. Furthermore, contingency planning to

³¹⁶ TNO, 2015. *Inventory of technologies and developments for reducing (residual) risks in shale gas extraction*. Available at: <https://publications.tno.nl/publication/34618831/wHLFqd/TNO-2014-R10919-Ef.pdf>

³¹⁷ Lumens, 2014. *Fibre-optic sensing for application in oil and gas wells Eindhoven: Technische Universiteit Eindhoven*. Available at: <https://pure.tue.nl/ws/files/3823460/769555.pdf>

deal with accidental spillages and contamination of soil is likely to significantly reduce the potential impacts on soil quality and quantity associated with unconventional oil and gas developments.

- 15.18 **Greenhouse gas emissions associated with land use change** – avoiding development on high carbon soils is likely to have positive effects in terms of reducing greenhouse gas emissions associated with land use change.
- 15.19 **Soil sealing resulting from construction of the well pad and access road** – mitigating the effects of soil sealing can be achieved by using permeable materials that reduce water runoff and allow more rain water to infiltrate through the underlying soils. This could help to lower water treatment costs and reduces the risk of flooding and water erosion. Furthermore, impacts on soil quality could be reduced or potentially avoided if the works would be undertaken in suitable weather conditions to prevent soil damage i.e. avoiding periods of high rainfall.

Climatic factors

- 15.20 **Direct greenhouse gas emissions** – many of the air mitigation measures are relevant to mitigating greenhouse gas emissions, particularly direct greenhouse gas emissions including: controlled and uncontrolled releases of produced gas; and, the combustion of fossil fuels for on-site power and transportation. These include annual inspections and repair, the use of advanced monitoring technologies (e.g. DTS and DAS), the use of supply chain management and ICT resources, the use of pipelines to replace transport, and the re-use of wastewater.
- 15.21 **Greenhouse gas emissions associated with land use change** – avoiding development on high carbon soils is likely to have positive effects in terms of reducing greenhouse gas emissions associated with land use change.
- 15.22 Furthermore, greenhouse gas emissions could also be reduced through carbon offsetting. Carbon offsets are typically achieved through financial support for projects that aim to reduce the emission of greenhouse gases, which, in turn, compensate for emissions made elsewhere. Examples of such projects include forestry projects (e.g. wood planting), energy efficiency projects, and renewable energy projects such as wind farms, biomass energy, or hydroelectric dams. As such, carbon offsets could be achieved through investments in Scotland's renewable energy sector or woodland planting in Scotland.

Biodiversity, flora and fauna

- 15.23 **Loss of habitat, habitat fragmentation and impacts on hydro-ecological functioning** – potential impacts could be reduced if site selection and the laying of pipes associated with that development would avoid sites of high biodiversity value, particularly areas characterised by sensitive hydro-ecological regimes. Surveys, such as bats and birds surveys, could help to identify potential ecological constraints and provide initial recommendations for avoidance of impacts and mitigation measures, as well as further ecological investigations where necessary.
- 15.24 **Disturbance of species** – disturbance to species is highly dependent on the timing of works. To minimise potential impacts on breeding birds, for instance, the construction works that effect nesting habitat should be carried out during winter to

avoid the bird breeding season (March-August). Furthermore, disturbance to local fauna could be reduced if lighting would avoid illuminating habitats such as woodland and hedgerows. Other mitigation measures include covering up any excavated holes/trenches overnight to prevent mammals from becoming trapped.

- 15.25 **Accidental release of hazardous material to air, soil, or water** – many of the water, soil and air mitigation measures could help to protect or reduce potential impacts on local biodiversity. These include careful soil stripping and restoration, use of permeable materials during soil sealing, the use of geotextiles and geo-synthetics, the use of biodegradable fracking fluids, the (optimised) treatment of flowback and produced water through mobile units or at central facilities, the use of advanced monitoring technologies (e.g. DTS and DAS), annual inspections and repair, the use of supply chain management and ICT resources, and the re-use of wastewater.
- 15.26 **Introduction of non-native species** – contingency planning to deal with accidental releases and spread of invasive species is likely to reduce the potential impacts on biodiversity, flora and fauna.

Cultural and archaeological heritage

- 15.27 **Loss and/or damage of known and unknown archaeology, and other designated and undesignated heritage assets** – potential impacts could be reduced or avoided if the siting of development would avoid sites of cultural heritage significance. Site survey to identify previously unknown cultural heritage assets and monitoring during site construction and decommissioning phases will also help minimise impacts.
- 15.28 **Direct and indirect impacts on the setting of cultural and archaeological heritage** –screening (e.g. planting hedges) and landscape treatment could minimise potential impacts on the setting of cultural heritage sites.

Landscapes and geodiversity

- 15.29 Site selection to avoid sensitive, locally important sites and visually prominent locations.
- 15.30 Mitigation measures such as screening, landscape treatment and landscape restoration after decommissioning could further reduce landscape and visual impacts that may arise from unconventional oil and gas developments.
- 15.31 Sharing of infrastructure could reduce the number of traffic movements over the lifetime of an unconventional oil and gas site, with associated positive effects by reducing impacts on landscape quality and local amenity.

Material assets

- 15.32 **Land use change** – potential impacts in relation to land use change could be reduced if brownfield sites are promoted for re-development, rather than greenfield land. This would ensure the prudent use of resources.

15.33 **Impacts on infrastructure** – many of the water, soil and air mitigation measures could help to reduce impacts on infrastructure and the wider environment. These include careful soil stripping and restoration, the use of advanced monitoring technologies (e.g. DTS and DAS), annual inspections and repair, the use of supply chain management and ICT resources, and the re-use of wastewater.

Population and human health

- 15.34 **Noise and light pollution**– noise surveys could be carried out to establish whether noise exposure associated with unconventional oil and gas developments is likely to be hazardous. Noise impacts associated with traffic movements could be reduced if areas with a high density of sensitive receptors would be avoided, if possible. Furthermore, potential noise impacts could also be reduced through undertaking regular maintenance of equipment, the use of silencers or other noise attenuation equipment, the use of enclosures on noise generating equipment associated with drilling, minimising night-time vehicle movements, and minimising the use of audible vehicle reversing alarms at night. In addition, positioning and rotating the rig could help to mitigate drilling noise, as well as light nuisance.
- 15.35 **Odour nuisance**– nuisance caused by odour issues could be reduced through a number of mitigation measures. Examples include the disclosure and risk assessment of fracturing fluid chemicals and environmental monitoring (baseline and ongoing).
- 15.36 **Health issues associated with induced seismic activity** – contingency planning to deal with the impacts of induced seismic activity on human health could be used to reduce potential impacts.
- 15.37 **Impacts on local amenity and mental well-being** – screening of site activities through planting could help to reduce impacts on local amenity associated with unconventional oil and gas developments.
- 15.38 **Physical health and safety risks** – contingency planning to deal with the impacts of unexpected events and hazards could be used to reduce potential impacts.
- 15.39 **Road accidents** – the occurrence of road accidents associated with unconventional oil and gas development could be reduced if areas with a high density of sensitive receptors would be avoided, if possible. Additional safety measures are likely to further reduce the occurrence of road accidents. Examples of such measures include improving site access and junction design, signing, lining and providing anti-skid treatment³¹⁸.
- 15.40 **Health impacts associated with air and water pollution** – many of the water, soil and air mitigation measures could help to protect public health. These include careful soil stripping and restoration, the use of geotextiles and geo-synthetics, the use of biodegradable fracking fluids, the (optimised) treatment of flowback and produced water through mobile units or at central facilities, the use of advanced monitoring technologies (e.g. DTS and DAS), annual inspections and repair, the use of supply chain management and ICT resources, and the re-use of wastewater.

³¹⁸ Transport Scotland, 2016. *Strategic Road Safety Plan 2016*. Available at: https://www.transport.gov.scot/media/10323/ts_strategic_road_safety_plan_2016_digital_sep_2016.pdf

16 Monitoring

- 16.1 Monitoring the significant environmental effects for any unforeseen adverse environmental effects is a statutory requirement within the 2005 Act. Monitoring seeks to ensure that plans avoid generating unforeseen adverse environmental effects.
- 16.2 There is a strong relationship between the preferred policy position on unconventional oil and gas in Scotland and the Scottish Government's energy policy. It is anticipated that any unforeseen environmental effects would most likely relate to the energy sector, and the sourcing, production and use of different energy sources.
- 16.3 Therefore the proposed monitoring and reporting mechanism for unforeseen adverse effects will be the Annual Energy Statement which will be published by the Scottish Government. This Statement will set out:
- the latest energy statistics;
 - the progress made towards existing targets and the new 2030 targets progress made under each of the six Strategic Priorities;
 - changes within the UK energy market and international frameworks; and
 - an assessment of technological changes and advances with a bearing on Scotland's energy system.
- 16.4 Official Statistics on Scotland's greenhouse gas emissions inventory are published annually by the Scottish Government. Independent reports on Scotland's progress in reducing emissions are published annually by the Committee on Climate Change. The Scottish Government's current Climate Change Plan has established a new monitoring framework, with annual reports on progress towards a suite of policy output and implementation indicators.

17 Next steps

Consultation timescales

- 17.1 The consultation on the preferred policy position on unconventional oil and gas development and the Environmental Report runs for an eight week period from 23 October 2018 to 18 December 2018. Comments on the preferred policy position and the Environmental Report can be submitted to the Scottish Government's consultation platform Citizen Space. You can view and respond to the consultation online at: <https://consult.gov.scot/energy-and-climate-change-directorate/preferred-policy-position-on-uog/>.
- 17.2 You can save and return to your responses while the consultation is still open. Please ensure that consultation responses are submitted before the closing date of 18 December 2018. If you are unable to respond online, please complete the Respondent Information Form (see 'Handling your Response' below) and send it to:
- Onshore Oil and Gas Team
The Scottish Government
3J South
Victoria Quay
Edinburgh EH6 6QQ

Handling your response

- 17.3 If you respond using Citizen Space you will be directed to the Respondent Information Form. Please indicate how you wish your response to be handled and, in particular, whether you are happy for your response to be published.
- 17.4 If you are unable to respond via Citizen Space, please complete and return the Respondent Information Form included in this document. If you ask for your response not to be published, we will regard it as confidential, and we will treat it accordingly.
- 17.5 All respondents should be aware that the Scottish Government is subject to the provisions of the Freedom of Information (Scotland) Act 2002 and would therefore have to consider any request made under the Act for information relating to responses made to this consultation exercise.

Suggested questions for responses to this Environmental Report

- 17.6 Respondents may find the following questions helpful to provide a focus for their responses to this Environmental Report.
- What are your views on the accuracy and scope of the information used to describe the SEA environmental baseline set out in the Environmental Report?

- What are your views on the predicted environmental effects as set out in the Environmental Report?
- What are your views on the ‘reasonable alternatives’ outlined in the Environmental Report? Please provide any other ‘reasonable alternatives’ which you think should be considered.
- What are your views on the findings of the SEA and the proposals for mitigation and monitoring of the environmental effects set out in the Environmental Report?
- Do you have any views on the proposals contained within the Scottish Government’s preferred policy position statement?

17.7 Please note there is no need to restate views already expressed in relation to the Talking “Fracking” public consultation as these have been, and will continue to be, taken into account as we move towards finalising the Scottish Government’s policy position.

Next steps

Analysis of responses

- 17.8 Following the consultation period, the consultation responses on the preferred policy position and this Environmental Report will be analysed.
- 17.9 Responses to the consultation will be taken into account in the preparation of the final policy position.

Finalising the Scottish Government’s position

- 17.10 Following analysis of the consultation responses, Ministers can finalise their policy position on unconventional oil and gas and communicate it via a package of actions which would include:
- the publication of the SEA post-adoption statement. This statement will reflect on the findings of the SEA assessment and the views expressed in the consultation. It will outline how the issues raised have been considered in finalising the Scottish Government’s position.
 - the updating of the preferred policy position with the finalised position.

Appendices

Appendix 1

Baseline information

Introduction

Baseline information provides a benchmark against which the environmental effects of a policy or plan can be assessed.

Schedule 3 of the Environmental Assessment (Scotland) Act 2005 requires the following information to be provided when undertaking an SEA:

- (1) An outline of the contents and main objectives of the plan or programme, and of its relationship (if any) with other qualifying plans and programmes.*
- (2) The relevant aspects of the current state of the environment and the likely evolution thereof without implementation of the plan.*
- (3) The environmental characteristics of areas likely to be significantly affected.*
- (4) Any existing environmental problems which are relevant to the plan including, in particular, those relating to any areas of a particular environmental importance, such as areas designated pursuant to Directives 79/409/EEC on the conservation of wild birds and Council Directive 92/43/EEC on the conservation of natural habitats and wild flora and fauna (as last amended by Council Directive 97/63/EC).*
- (5) The environmental protection objectives, established at international, Community or Member State level, which are relevant to the plan or programme and the way those objectives and any environmental considerations have been taken into account during its preparation.*

The following text sets out the environmental baseline for the Environmental Report. The environmental baseline includes a description of the relevant policy framework, the current state in Scotland as well as an overview of key pressures, trends and environmental problems.

Biodiversity, flora and fauna

Significant work has been undertaken at the international, European and national level to tackle the issues affecting biodiversity, flora and fauna.

Most notable are the Aichi Targets for 2020³¹⁹. The Aichi Targets are a product of the 10th Conference of Parties (COP) to the UN Convention on Biological Diversity³²⁰ held in Nagoya, Japan, in 2010. The twenty Aichi Targets relate to various aspects of biodiversity conservation, such as reducing direct pressures on biodiversity assets and raising awareness of key drivers behind biodiversity loss. In addition, they underpin the Strategic Plan for Biodiversity 2011-2020³²¹ which provides an international overarching framework on biodiversity. Parties agreed to translate this

³¹⁹ Convention on Biological Diversity, 2010. *Aichi Biodiversity Targets*. Available at:

<https://www.cbd.int/sp/targets/default.shtml>

³²⁰ Convention on Biological Diversity (1993) *Text of the CBD*. Available at:

<https://www.cbd.int/convention/text/>

³²¹ Convention on Biological Diversity (2010). *Strategic Plan for Biodiversity 2011-2020*. Available at:

<https://www.cbd.int/decision/cop/?id=12268>

overarching framework into updated national biodiversity strategies and action plans³²².

The EU Biodiversity Strategy to 2020³²³ was launched to adopt the Strategic Plan for Biodiversity 2011-2020, including the twenty Aichi Targets. There are additional European Directives in place to protect Europe's biodiversity and habitats. The Habitats Directive (92/43/EEC)³²⁴ and the Birds Directive (2009/147/EC)³²⁵ set out legislation to create protected areas and promote the conservation of outstanding natural habitats, wildlife and landscape features. Natura 2000³²⁶ is a primary vehicle for achieving the collective aims of these Directives. It is an ecological network of protected areas developed under the Birds Directive and Habitats Directive – covering over 18% of the EU's land area and almost 6% of its marine territory.

At the national level, the UK Post-2010 Biodiversity Framework³²⁷ was a response to the publication of the Strategic Plan for Biodiversity 2011-2020 and the Aichi Targets, and the launch of the EU Biodiversity Strategy to 2020. The Scottish Government has also published a strategic document, 2020 Challenge for Scotland's Biodiversity³²⁸, which defines the measures needed to meet the international Aichi Biodiversity Targets³²⁹. It also supplements the 2004 Scotland's Biodiversity: It's in Your Hands³³⁰. The two documents together comprise the Scottish Biodiversity Strategy. In 2015, the Scottish Government published Scotland's Biodiversity Route Map to 2020³³¹ which sets out the priority work needed to meet the targets of the 2020 Challenge for Scotland's Biodiversity.

Current state

Scotland's natural environment is diverse. This is reflected in the number and variety of designated biodiversity areas located across Scotland.

There are 252 Special Areas of Conservation (SACs), 153 Special Protection Areas (SPAs) and 51 Ramsar sites in Scotland³³². Scotland also contains 1,423 Sites of Special Scientific Interest (SSSIs), covering 1,022,000 hectares which amounts to about 13% of Scotland's land area. The sites range in size from the very small,

³²² Convention on Biological Diversity (2017). *Strategic Plan for Biodiversity 2011-2020, including Aichi Biodiversity Targets*. Available at: <https://www.cbd.int/sp/>

³²³ European Commission, 2016. *Biodiversity Strategy*. Available at: http://ec.europa.eu/environment/nature/biodiversity/strategy/index_en.htm

³²⁴ European Commission, 2016. *The Habitats Directive*. Available at: http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm

³²⁵ European Commission, 2016. *The Birds Directive*. Available at: http://ec.europa.eu/environment/nature/legislation/birdsdirective/index_en.htm

³²⁶ European Commission, 2017. *Natura 2000*. Available at: http://ec.europa.eu/environment/nature/natura2000/index_en.htm

³²⁷ Joint Nature Conservation Committee, 2012. *UK Post-2010 Biodiversity Framework*. Available at: http://jncc.defra.gov.uk/pdf/UK_Post2010_Bio-Fwork.pdf

³²⁸ Scottish Government, 2013. *2020 Challenge for Scotland's Biodiversity*. Available at: <http://www.gov.scot/Resource/0042/00425276.pdf>

³²⁹ Convention on Biological Diversity, 2011. *Strategic Plan for Biodiversity 2011-2020 and the Aichi Targets*. Available at: <https://www.cbd.int/doc/strategic-plan/2011-2020/Aichi-Targets-EN.pdf>

³³⁰ Scottish Government, 2004. *Scotland's Biodiversity Strategy: It's in Your Hands – A strategy for the conservation and enhancement of biodiversity in Scotland*. Available at: <http://www.gov.scot/Resource/Doc/25954/0014583.pdf>

³³¹ The Scottish Government, 2015. *Scotland's Biodiversity: A Route Map to 2020*. Available at: <http://www.gov.scot/Resource/0048/00480289.pdf>

³³² The Scottish Government, 2016. *Key Scottish Environment Statistics 2016*. Available at: <http://www.gov.scot/Publications/2016/10/7565/334171>

such as Bo'mains Meadow SSSI at just under one hectare, to the vast Cairngorms SSSI which extends to more than 29,000 hectares.

In addition, Scotland's rivers, lochs and wetlands support many important habitats and species. Scotland has more than 30,000 freshwater lochs, ranging from small lochs to the likes of Loch Ness. The conditions in Scotland's lochs greatly vary from soft, relatively acidic water to hard waters with higher alkaline and nutrient concentrations – providing a wide variety of aquatic habitats³³³.

Following from the above, the key characteristics of Scotland's natural environment are listed below.

- Scotland's coastal environment provides vast and diverse habitats for internationally important seabirds and shorebirds³³⁴.
- Key terrestrial habitats present in Scotland include upland areas stretching over 50% of Scotland's land area³³⁵, followed by blanket bog covering another 23%. Blanket bog has been classified as globally rare and endemic to Scotland³³⁶.
- Although forests cover about 17% of Scotland's land area, they support a high share of Scotland's biodiversity³³⁷ – particularly native, ancient and semi-natural woodlands which are likely to have a higher biodiversity value than more uniform planted woods³³⁸.

Scotland's central belt contains diverse natural environments which support a rich array of flora and fauna species, including (but not limited to) the following major biodiversity assets;

- The Firth of Forth is a complex of estuarine and coastal habitats in south east Scotland, stretching for over 100km from the River Forth at Stirling eastwards past Edinburgh and along the coasts of Fife and East Lothian to a wide estuary mouth. The floodplains of the Inner Firth contain a range of riverine features such as tidal banks, rare saltmarsh habitat and extensive areas of mudflats. The shoreline of the Outer Firth includes sandy shores, some rocky outcrops, mussel beds and some artificial seawalls. In addition, the coast of North Berwick contains cliffs and dune grasslands, with extensive dune systems at Aberlady³³⁹. The Firth of Forth is home to internationally important numbers of wintering waders such as the oystercatcher, knot and

³³³ SNH, 2017. *Lochs, rivers and wetlands*. Available at:

<https://www.nature.scot/habitats-and-ecosystems/habitat-types/lochs-rivers-and-wetlands>

³³⁴ SNH, 2015. *Seabirds and shorebirds*. Available at: <https://www.nature.scot/plants-and-animals/birds/seabirds-and-shorebirds>

³³⁵ SNH, 2017. *Upland and moorland*. Available at:

<https://www.nature.scot/professional-advice/land-and-sea-management/managing-land/upland-and-moorland>

³³⁶ SNH, 2017. *Blanket bog*. Available at:

<https://www.nature.scot/landscapes-habitats-and-ecosystems/habitat-types/mountains-heaths-and-bogs/blanket-bog>

³³⁷ Forestry Commission Scotland, 2012. *Biodiversity*. Available at:

<http://scotland.forestry.gov.uk/supporting/strategy-policy-guidance/biodiversity>

³³⁸ Forestry Commission Scotland, 2014. *Native Woodland Survey of Scotland (NWSS) – Ancient Woodland information*. Available at: <http://scotland.forestry.gov.uk/supporting/strategy-policy-guidance/native-woodland-survey-of-scotland-nwss/scotlands-native-woodlands>

³³⁹ Joint Nature Conservation Committee, 2001. *SPA Description – Firth of Forth*. Available at: <http://jncc.defra.gov.uk/default.aspx?page=1979>

bar-tailed godwit³⁴⁰. As such the Firth of Forth is designated as a Special Protection Area (SPA)³⁴¹ under the European Birds Directive.

- Raised bogs are widespread throughout the UK, but there are notable concentrations in the Central Belt of Scotland. The Central Belt of Scotland contains several protected lowland moss areas such as the Flanders Mosses, which have been designated as a Special Area of Conservation (SAC)³⁴². Therefore, new development in the Central Belt in particular could have the potential to adversely impact upon the integrity of lowland moss habitats.
- The Galloway and Southern Ayrshire Biosphere is a major bio-geographic region which is partially located in the Midland Valley, covering 526,888 ha in total with a core area of 10,658 ha. The Biosphere is represented by upland massif centred on the Merrick and the rivers that flow from this upland down to the sea. Moreover, the Biosphere contains two predominant topographic regions: rolling uplands and lowlands of gently undulating topography with incised river valleys³⁴³.

Existing pressures

Land-use change and intensive land use are key drivers of biodiversity loss and ecosystem degradation.

- New development has the potential to adversely impact upon local biodiversity through habitat damage, habitat loss, disturbance to species³⁴⁴, water pollution³⁴⁵, increased recreation pressures³⁴⁶, changes to hydrological regimes that are of particular relevance to wetlands³⁴⁷, among other negative impacts.
- The conversion of semi-natural habitats has had adverse impacts on biodiversity and ecosystems. Bogs significantly decreased over the period between 1947 and 1988 – with a decrease of around 21% in blanket bog and a decrease of around 44% in lowland bog. Semi-natural woodlands decreased by 28%, followed by heather moorland which saw a decrease in

³⁴⁰ SNH, 2015. *Seabirds and shorebirds*. Available at: <https://www.nature.scot/plants-and-animals/birds/seabirds-and-shorebirds>

³⁴¹ SNH, 2015. A review of literature on the qualifying interest species of Special Protection Areas (SPAs) in the Firth of Forth and development related influences. Available at: <https://www.nature.scot/snh-commissioned-report-804-review-literature-qualifying-interest-species-special-protection-areas>

³⁴² Joint Nature Conservation Committee, undated. *Habitat account – Raised bogs and mires and fens*. Available at: <http://jncc.defra.gov.uk/ProtectedSites/SACselection/habitat.asp?FeatureIntCode=H7120>

³⁴³ UNESCO, 2012. *Galloway and southern Ayrshire*. Available at: <http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/biosphere-reserves/europe-north-america/united-kingdom-of-great-britain-and-northern-ireland/galloway-and-southern-ayrshire-biosphere/>

³⁴⁴ SNH, 2017. *Habitat Fragmentation*. Available at: <https://www.nature.scot/professional-advice/land-and-sea-management/managing-land/habitat-networks/habitat-fragmentation>

³⁴⁵ SNH, 2017. *Water pollution*. Available at: <https://www.nature.scot/professional-advice/land-and-sea-management/managing-freshwater/water-pollution>

³⁴⁶ SNH, 2017. *Managing access and recreation*. Available at: <https://www.nature.scot/professional-advice/land-and-sea-management/managing-access-and-recreation>

³⁴⁷ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

23% over that period. Moreover, just over half of Scotland's hedgerows (equalling to about 40,000 kilometres) were lost over the same period. The rate of habitat change has slowed over the last 30 years, but the pressures from land use change are still causing biodiversity loss and ecosystem degradation across Scotland³⁴⁸.

- Agricultural development is a key driver in habitat loss and habitat degradation. Farming constitutes major land-use in Scotland with about 75% of the land area devoted to agriculture. However, each type of farming has different effects on biodiversity. For example, hill farming is known to benefit biodiversity whilst dairy and meat production is linked to negative impacts on biodiversity³⁴⁹. Nevertheless, farming can also potentially benefit biodiversity as hedgerows support habitat corridors, connect habitats and promote species mobility³⁵⁰.

Potential pressures associated with unconventional oil and gas development

Current scientific evidence has identified a number of potential pressures on biodiversity associated with unconventional oil and gas development.

- Traffic movements, fencing and road construction could cause habitat fragmentation. For instance, aboveground pipes could bisect important biodiversity corridors³⁵¹.
- Increases in environmental noise associated with site activity could lead to species disturbance, particularly in areas with low background noise levels. Flaring may also constitute a source of noise pollution and disturbance³⁵².
- Fugitive air emissions could indirectly affect local biodiversity, primarily through increased emissions of greenhouse gases. Fugitive air emissions arise from unintentional leaks, venting and flaring. These include greenhouse gases such as carbon dioxide (CO₂) and methane (CH₄). Fugitive methane emissions are a concern given that methane is a potent greenhouse gas, which could exacerbate climate change impacts on local biodiversity³⁵³.
- Dewatering processes associated with Coal Bed Methane (CBM) operations require significant amounts of water, which in turn could have the potential to adversely impact upon biodiversity, flora and fauna. Reduced water levels could have adverse hydro-ecological impacts, and surface water and groundwater abstraction could lead to the intrusion of saline water into waterbodies. Furthermore, buried linking infrastructure used in

³⁴⁸Biodiversity Scotland, 2017). *Habitat Change*.

³⁴⁹ SNH, 2017. *Farming and crofting*. Available at: <https://www.nature.scot/professional-advice/land-and-sea-management/managing-land/farming-and-crofting>

³⁵⁰ SNH, 2015. *Field margins and hedgerows*. Available at: <https://www.nature.scot/landscapes-habitats-and-ecosystems/habitat-types/farmland-and-croftland/hedgerows-and-field-margins>

³⁵¹ Ricardo Energy & Environment, 2016. *Unconventional oil and gas development: understanding and mitigating community impacts from transportation*. Available at:

<http://www.gov.scot/Resource/0050/00509327.pdf>

³⁵² Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

³⁵³ KPMG, 2016. *Economic Impact Assessment and Scenario Development of Unconventional Oil and Gas in Scotland*. Available at: <http://www.gov.scot/Resource/0050/00509321.pdf>

unconventional oil and gas developments could induce changes in surface flows and groundwater levels, which could adversely impact upon hydro-ecological functioning³⁵⁴.

- The accidental release of hazardous materials during transportation could have harmful effects on local biodiversity given the toxic nature of most substances used in hydraulic fracturing fluid³⁵⁵.
- Light pollution, like noise pollution, could result in species disturbance. Light pollution is caused by flaring or by lighting for safe working, particularly during the drilling phase³⁵⁶.
- A finding by New York State DEC highlights the potential effects on biodiversity arising from the introduction of invasive species associated with industrial activity³⁵⁷.

It needs to be noted that the aforementioned effects are included regardless of their significance.

Population and Human Health

Public health is the subject of a variety of policies and statutes, either directly or indirectly.

Many of these focus on preventing or limiting exposure to air pollutants. At the European level are various directives that address air quality issues. The Ambient Air Quality Directive (2008/50/EC)³⁵⁸ sets legally binding limits for concentrations of major air pollutants such as particulate matter (PM₁₀, PM_{2.5}) and nitrogen oxide (NO₂). Directive 2008/50/EC is transposed into Scots law through the Air Quality Standards (Scotland) Regulations 2010³⁵⁹. Separate emissions limits for SO₂, NO_x, NH₃ and volatile organic compounds are set in European law under the National Emission Ceilings Directive (2001/81/EC)³⁶⁰, which was subsequently made into UK law as the National Emissions Ceilings Regulations 2002³⁶¹. Specific legislation on integrated prevention and control of pollution arising from industrial activities is

³⁵⁴ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

³⁵⁵ Ricardo Energy & Environment, 2016. *Unconventional oil and gas development: understanding and mitigating community impacts from transportation*. Available at: <http://www.gov.scot/Resource/0050/00509327.pdf>

³⁵⁶ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

³⁵⁷ Ricardo Energy & Environment, 2016. *Unconventional oil and gas development: understanding and mitigating community impacts from transportation*. Available at: <http://www.gov.scot/Resource/0050/00509327.pdf>

³⁵⁸ European Commission, 2008. Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe. Available at: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0050>

³⁵⁹ Air Quality Standards (Scotland) Regulations 2010 (Scottish Statutory Instrument 2010/204)

³⁶⁰ European Commission, 2001. Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants. Available at: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32001L0081>

³⁶¹ The National Emission Ceilings Regulations 2002 (2002/3118)

entrenched in the Industrial Emissions Directive (2010/75/EU)³⁶², which has been implemented as the Pollution Prevention and Control (Scotland) Regulations 2012³⁶³. Other relevant legislation includes the Environment Act 1995³⁶⁴. Under Section 83(1) of the Environment Act 1995, local authorities have a duty to declare Air Quality Management Areas (AQMAs) at locations in which air quality objectives are not being met or are unlikely to be met.

- 17.1 Other policies and statutes aim to minimise the potential impacts of environmental nuisances such as noise pollution, light pollution and disturbance from vibration. Noise pollution is addressed through the EU Noise Directive (2000/14/EC)³⁶⁵ and the Environmental Noise Directive (2002/49/EC)³⁶⁶, which were made into UK and Scots law as the Noise Emissions in the Environment by Equipment for use Outdoors Regulations 2001 (as amended)³⁶⁷ and the Environmental Noise (Scotland) Regulations 2006³⁶⁸, respectively. Furthermore, the Public Health etc. (Scotland) Act 2008³⁶⁹ also makes provision for law on statutory nuisances such as artificial light nuisances.
- 17.2 There is also legislation in place to prevent and control any adverse health effects arising from the contamination of water resources. At the European level, these are entrenched in both the Bathing Water Quality Directive (2006/7/EC)³⁷⁰ and the Drinking Water Directive (98/83/EC)³⁷¹ at the European level. The Bathing Water Quality Directive (2006/7/EC) has been transposed through the Bathing Waters (Scotland) Regulations 2008 (as amended)³⁷² and the Bathing Waters (Sampling & Analysis) (Scotland) Directions 2008³⁷³. The Water Supply (Water Quality) (Scotland) 2001³⁷⁴ and the Water Quality (Scotland) Regulations 2010³⁷⁵ regulations transpose the Drinking Water Directive.

³⁶² European Commission, 2010. Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control). Available at: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32010L0075>

³⁶³ The Pollution Prevention and Control (Scotland) Regulations 2012 (Scottish Statutory Instrument 2012/360)

³⁶⁴ Environment Act 1995 (Chapter 25)

³⁶⁵ European Commission, 2000. Directive 2000/14/EC of the European Parliament and the Council of 8 May 2000 on the approximation of the laws of the Member States relating to the noise emission in the environment by equipment for use outdoors. Available at: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32000L0014>

³⁶⁶ European Commission, 2000. Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise. Available at: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32002L0049>

³⁶⁷ The Noise Emission in the Environment by Equipment for use Outdoors Regulations 2001 (2001/1701)

³⁶⁸ The Environmental Noise (Scotland) Regulations 2006 (Scottish Statutory Instrument 2006/465)

³⁶⁹ Public Health etc. (Scotland) Act 2008 (Scottish Statutory Instrument 2008/asp 5)

³⁷⁰ European Commission, 2006. Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC. Available at:

<http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32006L0007>

³⁷¹ European Commission, 1998. Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption. Available at: <http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A31998L0083>

³⁷² The Bathing Waters (Scotland) Regulations 2008 (Scottish Statutory Instrument 2008/170)

³⁷³ Scottish Government, 2008. *The Bathing Waters (Sampling and Analysis) (Scotland) Directions 2008*. Available at: <http://www.gov.scot/Resource/Doc/1057/0072275.pdf>

³⁷⁴ The Water Supply (Water Quality) (Scotland) Regulations 2001 (Scottish Statutory Instrument 2001/207)

³⁷⁵ The Water Quality (Scotland) Regulations 2010 (Scottish Statutory Instrument 2010/95)

17.3 A range of policies and statutes is in place to prevent and control health hazards associated with unconventional oil and gas operations, such as the physical health risks associated with respirable crystalline silica. At the European level are the Seveso Directive III (2012/18/EU)³⁷⁶ which lays down rules for the prevention of major accidents which involve dangerous substances, and the limitation of their consequences for human health and the environment as well as the Directive on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) (1907/2006/EC)³⁷⁷ which was designed to improve the protection of human health from the risks that can be posed by chemicals used in various industrial activities. At the national level, the REACH Directive has been implemented as the REACH Enforcement Regulations 2008³⁷⁸. The COMAH Regulations 2015 implements the Seveso Directive. It sets out regulations to reduce to risks of potential major accident hazards that are associated with storing or handling large quantities of industrial chemicals of a hazardous nature. Other relevant legislation includes Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013³⁷⁹. Under Section 20 of the 2013 Regulations, any unplanned release of fluids from a well in the UK must be reported.

Current state

According to the 2011 Census, the population in Scotland was estimated to be 5,295,000 people, of whom 2,728,000 (51.5%) are women and 2,567,000 (48.5%) men. This was a 4.6% rise compared to 2001, and the highest population recorded for the country since records began³⁸⁰.

The mid-2016 population estimates³⁸¹ suggest that Scotland's population is continuing to grow, with 5,404,700 residents recorded in the country as of June 2016. This was an increase of 0.6% compared to 2015. Although there has been a general trend for growth in Scotland as a whole, growth in population has been variable across different areas of the country over the report period. The cities of Edinburgh and Glasgow have seen the highest levels of population growth at 1.68% and 1.44%, respectively. Conversely, Inverclyde and Na h-Eileanan an Iar displayed losses of population equating to 0.63% and 0.43% over the same time, respectively. There is significant variation between the more densely populated

³⁷⁶ European Commission, 2012. Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC. Available at: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32012L0018>

³⁷⁷ European Commission, 2006. Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC. Available at: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02006R1907-20140410>

³⁷⁸ European Commission, 2008. Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006. Available at: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32008R1272>

³⁷⁹ The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013 (2013/1471).

³⁸⁰ Scottish Government, 2012. *Scotland's Census – Census 2011: Population Estimates for Scotland*. Available at: <http://www.scotlandscensus.gov.uk/news/first-results-scotland-census-now-available>

³⁸¹ National Records of Scotland, 2017. *Mid-Year Population Estimates for Scotland, Mid-2016 – Population estimates by sex, age and area*. Available at: <https://www.nrscotland.gov.uk/files/statistics/population-estimates/mid-year-2016/16mype-cahb.pdf>

areas in the Central Belt of Scotland and areas such as the Highlands and Western Isles.

In addition, there is a recent trend for an overall increase in the proportion of older people. Between 1996 and 2016, the age group which reported the highest percentage of growth was those aged 75 and over, with a reported increase of 31% over that period. Over the same period, the number of people aged 45-64 and aged 64-74 grew by 26% and 24%, respectively³⁸².

Use of the outdoors for access and recreation is an important contributor to health and wellbeing. Current work is underway to extend and improve the National Walking and Cycling Network (NWCN) which will build on existing path and trail networks, close key gaps, upgrade connecting routes, link to public transport and promote shared use of paths. This will increase opportunities for active travel and recreation and bring benefits for health and wellbeing in Scotland. Figures 6a and 6b, Appendix 1, show the distribution of national cycling and walking trails and country parks, and the number of routes and country parks within the area prospective for unconventional oil and gas development.

Data on visits to the outdoors shows 48.5% of adults visited the outdoors at least once a week in 2016, a similar proportion to 2015 where 48.6% of adults visited the outdoors at least once a week.³⁸³

The Health and Safety Executive (HSE) has published a list of case studies of industry-related major accidents in Scotland that occurred over the last few decades³⁸⁴. All of these case studies pre-date the implementation of the COMAH Regulations 2015.

The crucial role of environmental quality in maintaining human health is well-documented, particularly in relation to protecting water quality and air quality.

- Air pollution represents a significant threat to public health. Poor air quality is associated with a number of diseases and health problems such as lung cancer, strokes, asthma, dementia and cardiovascular disease. Across the UK, air pollution is estimated to cause 40,000 deaths per year. The high-risk groups most prone to the effects of poor air quality include infants, young children, the elderly and those with existing heart and lung conditions. Pregnant women are also considered to be a vulnerable group given that harmful particulates could potentially infiltrate the placenta via the bloodstream³⁸⁵.
- The main pollutants of current concern in Scotland are oxides of nitrogen (NO_x), particulate matter (PM₁₀ and PM_{2.5}), sulphur dioxide (SO₂), non-methane volatile organic compounds (NMVOCs), ground level ozone (O₃)

³⁸² National Records of Scotland, 2017. *Mid-Year Population Estimates for Scotland, Mid-2016 – Population estimates by sex, age and area*. Available at: <https://www.nrscotland.gov.uk/files/statistics/population-estimates/mid-year-2016/16mype-cahb.pdf>

³⁸³ National Indicator: Scotland's Outdoors. Available at: <http://www.gov.scot/About/Performance/scotPerforms/indicator/outdoors>

³⁸⁴ Health and Safety Executive, undated. *Case studies*. Available at: <http://www.hse.gov.uk/comah/sragtech/casestudyind.htm>

³⁸⁵ Scottish Government, 2016. *SPICe Briefing – Air Quality in Scotland*. Available at: http://www.parliament.scot/ResearchBriefingsAndFactsheets/S5/SB_16-35_Air_Quality_in_Scotland.pdf

and Ammonia (NH₃)³⁸⁶. For instance, fine particulate matter was associated with 2,000 premature deaths and around 22,500 lost life-years across the population in Scotland in 2010³⁸⁷.

- Densely populated areas have relatively high elevated air pollution levels. There are currently 38 AQMAs declared across 15 local authorities in Scotland, many of which are located in the densely populated Midland Valley (City of Edinburgh, East Dunbartonshire, East Lothian, Falkirk, Fife, Glasgow, Midlothian, North Lanarkshire, South Lanarkshire and West Lothian)³⁸⁸. This is reflected in premature death rates across Scotland. For example, large Scottish cities have the highest proportion of total death associated with particulate (PM) pollution in Scotland, with 4.9% and 4.7% of deaths linked to particulate pollution in Edinburgh and Glasgow, respectively³⁸⁹.
- Scotland's water resources are important for commercial water supplies, including drinking water. According to the latest annual report (2016) by the Drinking Water Quality Regulator (DWQR), Scottish Water's compliance with the stringent standards for drinking water is extremely high at 99.91%³⁹⁰.
- There has been a steady improvement in the water quality of Scotland's designated bathing sites since SEPA's regulation and monitoring of EU bathing water compliance began in 1988. In 2016, about 80% of Scotland's designated bathing waters met the sufficient or better classification. The remaining bathing sites (20%) were considered to have poor water quality³⁹¹.

Existing pressures

Impacts on air and water quality are primarily caused by increases in environmental pollutants arising from new development and industrial activities.

- Air pollution remains a chronic issue in many areas, particularly urban locations that experience high volumes of traffic³⁹². Road transport and industrial emissions account for a large share of air pollutant emissions³⁹³.
- Key pressures on the surface water environment originate from human activity, particularly urbanisation and intensive agriculture and aquaculture³⁹⁴.

³⁸⁶ Transport Scotland, 2017. *Scottish Transport Statistics No 35: 2016 Edition*. Available at:

<https://www.transport.gov.scot/media/33814/sct01171871341.pdf>

³⁸⁷ Scottish Government, 2015. *Cleaner Air for Scotland – The Road to a Healthier Future*. Available at:

<http://www.gov.scot/Resource/0048/00488493.pdf>

³⁸⁸ Air Quality in Scotland, 2017. *Air Quality Management Areas*. Available at:

<http://www.scottishairquality.co.uk/laqm/aqma>

³⁸⁹ Scottish Government, 2016. *SPICe Briefing – Air Quality in Scotland*. Available at:

http://www.parliament.scot/ResearchBriefingsAndFactsheets/S5/SB_16-35_Air_Quality_in_Scotland.pdf

³⁹⁰ DWQR, 2016. *Drinking Water Quality in Scotland 2016 – Public water supply*. Available at:

<http://dwqr.scot/media/34946/drinking-water-quality-in-scotland-in-2016-dwqr-annual-report.pdf>

³⁹¹ SEPA, 2016. *Scottish Bathing Waters 2016*. Available at:

https://www.sepa.org.uk/media/219168/1282_sepa_bathing_waters_2016_web.pdf

³⁹² Scotland's Environment, 2014. *Get Informed – Air – Air Quality*. Available at:

<https://www.environment.gov.scot/our-environment/air/air-quality/>

³⁹³ Scottish Government, 2015. *Cleaner Air for Scotland – The Road to a Healthier Future*. Available at:

<http://www.gov.scot/Resource/0048/00488493.pdf>

³⁹⁴ SEPA, 2017. *River Basin Management Planning*. Available at:

<https://www.sepa.org.uk/environment/water/river-basin-management-planning/>

- Key pressures on water bodies in general include rural diffuse pollution, wastewater and hydropower generation. Low standards of water bodies may affect drinking water quality in Scotland, due to the presence of certain bacteria that can pose a potential risk to public health³⁹⁵.
- In Scotland, the primary causes of poor bathing water quality are short episodes of pollution induced by heavy rainfall which affects the operation of sewerage assets, surface drains, field run-off and agricultural activity³⁹⁶.

Potential pressures associated with unconventional oil and gas development

Present scientific evidence has identified a number of potential pressures on population and human health associated with unconventional oil and gas development.

- Felt seismic activity has been observed with hydraulic fracturing³⁹⁷. However, these seismic events are expected to be small in magnitude³⁹⁸.
- Environmental noise from site activity has the potential to increase noise impacts on nearby residents, particularly in areas with low background noise. In addition, unconventional oil and gas developments would result in increased traffic movements which could potentially bring about further noise impacts³⁹⁹.
- There is the risk of accidental releases of hazardous materials (e.g. wastewater spills) during transportation, particularly if a collision involves a vehicle carrying dangerous substances. The release of hazardous materials could have the potential to adversely impact upon public health⁴⁰⁰.
- Unconventional oil and gas development would lead to increased traffic movements and heavy vehicle movements, increasing the risk of road accidents⁴⁰¹.
- Light pollution caused by flaring or by lighting for safe working could increase impacts on nearby residents. However, there is inadequate evidence to determine whether unconventional oil and gas-associated light pollution would occur at levels that could pose a risk to physical health⁴⁰².

³⁹⁵ Scottish Government, 2016. *Key Scottish Environment Statistics 2016*. Available at: <http://www.gov.scot/Publications/2016/10/7565/334167>

³⁹⁶ SEPA, 2016. *Scottish Bathing Waters 2016*. Available at: https://www.sepa.org.uk/media/219168/1282_sepa_bathing_waters_2016_web.pdf

³⁹⁷ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

³⁹⁸ British Geological Society, 2016. *Unconventional Oil and Gas Development: Understanding and Monitoring Induced Seismic Activity*. Available at: <http://www.gov.scot/Resource/0050/00509318.pdf>

³⁹⁹ Ricardo Energy & Environment, 2016. *Unconventional oil and gas development: understanding and mitigating community impacts from transportation*. Available at: <http://www.gov.scot/Resource/0050/00509327.pdf>

⁴⁰⁰ Ibid.

⁴⁰¹ Ibid.

⁴⁰² Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

- Odours associated with unconventional oil and gas could potentially result in nuisance, particularly in neighbouring areas⁴⁰³.
- The use of drilling rigs for shale gas operations could have the potential to have negative impacts on landscape quality, although it is difficult to determine the extent and magnitude of such impacts given the contextual nature of visual impacts⁴⁰⁴.
- Physical health and safety risks are associated with unconventional oil and gas development, such as the physical risks associated with respirable crystalline silica⁴⁰⁵ and the immediate physical risks caused by potentially explosive mixtures of methane and air. Such risks particularly apply to industry workers⁴⁰⁶.
- Other relevant threats to public health include impacts on mental well-being i.e. anxiety caused by living near an unconventional oil and gas site⁴⁰⁷.

Soil

At the European level, the importance of protecting soil quality has been recognised through the European Commission's Thematic Strategy for Soil Protection⁴⁰⁸. The Strategy aims to establish common principles for the protection and sustainable use of soils by promoting responsible management practices and the restoration of degraded soils. Many of these aims are reflected in The Scottish Soil Framework⁴⁰⁹ which was launched in 2009. The Framework sets out a vision for the enhancement and protection of soils within the context of the economic, social and environmental needs of Scotland.

At the national level, there is specific legislation in place to promote the remediation of contaminated land. These include the Environmental Protection Act 1990⁴¹⁰ and the Contaminated Land (Scotland) Regulations 2000⁴¹¹.

Peatland soils have been given special attention through Scotland's National Peatland Plan⁴¹² which sets out a number of targets regarding the improvement and restoration of Scotland's peatlands. The Scottish Government's Draft Peatland and

⁴⁰³ Health Protection Scotland, 2016. *A Health Impact Assessment of Unconventional Oil and Gas in Scotland – Summary*. Available at: <http://www.hps.scot.nhs.uk/resourcedocument.aspx?resourceid=3101>

⁴⁰⁴ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

⁴⁰⁵ Health Protection Scotland, 2016. *A Health Impact Assessment of Unconventional Oil and Gas in Scotland – Summary*. Available at: <http://www.hps.scot.nhs.uk/resourcedocument.aspx?resourceid=3101>

⁴⁰⁶ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

⁴⁰⁷ KPMG, 2016. *Economic Impact Assessment and Scenario Development of Unconventional Oil and Gas in Scotland*. Available at: <http://www.gov.scot/Resource/0050/00509321.pdf>

⁴⁰⁸ European Commission, 2006. *Thematic Strategy for Soil Protection*. Available at: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52006DC0231>

⁴⁰⁹ Scottish Government, 2009. *The Scottish Soil Framework*. Available at: <http://www.gov.scot/Publications/2009/05/20145602/0>

⁴¹⁰ Environmental Protection Act 1990 (Chapter 43)

⁴¹¹ The Contaminated Land (Scotland) Regulations 2000 (Scottish Statutory Instrument 2000/178)

⁴¹² SNH, 2015. *Scotland's National Peatland Plan: Working for our future*. Available at:

https://www.nature.scot/sites/default/files/2017-07/A1697542%20-%20150730%20-%20peatland_plan.pdf

Energy Policy Statement⁴¹³ seeks to align energy policies with policies that aim to protect peatlands in order to minimise greenhouse gas emissions, which are known to adversely affect peatlands.

Current state

Scotland's soils are diverse and differ markedly from those in the rest of the UK. The majority have acidic and organic-rich surface layers. Such soils are often not managed intensively. As a result, they generally have a high biodiversity and landscape value. Soils suitable for agricultural uses are largely limited to eastern Scotland⁴¹⁴.

The state and functionality of Scotland's soils is well-documented, particularly in relation to peat soils.

- Peatland soils make up a significant portion of Scotland's land surface. Blanket bog is the most widespread and semi-natural peatland type in Scotland – extending to over 1.5 million hectares, which equals to about 20% of Scotland's land area of 7.8 million hectares. Scotland supports around 15% of the world's peatland habitats given its considerable rarity internationally. Other peatland types in Scotland include raised bogs and fens which are designated as UK priority habitats.
- The Flow Country of Caithness and Sutherland is the largest area of peatland in Scotland, with a total size of 400,000 hectares of which 145,000 hectares (36%) is designated as Site of Special Scientific Interest (SSSI), Special Area of Conservation (SAC), Special Protection Area (SPA) or Ramsar site. Other designated biodiversity sites also contain peatland habitats; 51 SACs and 106 SSSIs cover blanket bog; 26 SACs and 50 SSSIs are located on raised bogland; and 22 SACs are set around alkaline fen⁴¹⁵. A large proportion of designated peatlands are in poor condition. According to reporting by Scottish Natural Heritage (SNH)⁴¹⁶, 72 out of 188 (38%) upland (blanket) bogs is in unfavourable condition. The same applies to 47 out of 111 (42%) lowland raised bogs, and 39% of upland fens, marshes and swamps.
- Scotland's soils are an important carbon sink. It is estimated that Scotland's soils contain 3,000 million tonnes (Mt) of carbon (C), of which peatlands alone contain about 1,600 million tonnes (Mt) of carbon⁴¹⁷. Other soils also act as a sink for greenhouse gases. Agricultural soils have the potential to hold an estimated 115 megatonnes, which would be the equivalent of 22% of total carbon dioxide (CO₂) emissions from Scotland's energy sector⁴¹⁸.

⁴¹³ Scottish Government, 2016. *Draft Peatland and Energy Policy Statement*. Available at:

<http://www.gov.scot/Topics/Business-Industry/Energy/Energy-sources/19185/Draft-Peatland-Policy>

⁴¹⁴ Scottish Government, 2006. *Scotland's Soil Resource – Current State and Threats – Chapter 7: Soil Contamination*. Available at: <http://www.gov.scot/Resource/Doc/149337/0039742.pdf>

⁴¹⁵ Scottish Government, 2010. *Executive Summary: Management of Carbon-Rich Soils – Overview and Discussion Paper*. Available at: <http://www.gov.scot/Resource/Doc/921/0109512.pdf>

⁴¹⁶ Scottish Natural Heritage, 2010. *Condition of Designated Sites*. Available at: <https://www.nature.scot/condition-designated-sites>

⁴¹⁷ Scottish Government, 2010. *Executive Summary: Management of Carbon-Rich Soils – Overview and Discussion Paper*. Available at: <http://www.gov.scot/Resource/Doc/921/0109512.pdf>

⁴¹⁸ SNH, 2017. *Managing nature for carbon capture*. Available at:

<https://www.nature.scot/climate-change/taking-action/carbon-management/managing-nature-carbon-capture>

Existing pressures

The principal threats to soil functions are erosion and soil sealing, landslides, changes in soil biodiversity, loss of organic matter and land-use changes⁴¹⁹. These are discussed in greater detail below.

- Erosion and soil sealing (i.e. the process of compacting or covering soil with impervious material) have a profound effect on soil functions. Erosion can irretrievably disturb the soils' characteristics, and soil sealing is known to interfere with the soils' ability to perform key functions such as water absorption and is effectively irreversible⁴²⁰.
- Landslides, which are tightly linked to erosion, can pose additional pressures to Scottish soils⁴²¹.
- Scotland's soils support a wide variety of habitats and biodiversity. Soil biodiversity is essential to most soil functions, including the physical and chemical characteristics of soil. For instance, soil organisms play a vital role in soil carbon and nitrogen turnover, and, subsequently, in the exchange of greenhouse gases. Soil organisms are also known to break down contaminants. Thus, changes in land management practices could affect the structure, physical and chemical characteristics of the soil⁴²².
- Loss of organic matter is a major threat to soil functions and is often the result of a number of environmental pressures, most notably land-use change and climate change⁴²³.
- Land-use changes could adversely impact upon the quality of peatland habitats and other carbon-rich soils. New development is very likely to lead to the excavation or drainage of peatland and other carbon-rich soils, which in turn could result in increased greenhouse gas emissions from these soils. Developments in the horticulture industry, fuel industry and the whisky industry may also have adverse impacts on peatland soils, but it is expected that the severity of these impacts greatly vary⁴²⁴.

Potential pressures associated with unconventional oil and gas development

Present scientific evidence has identified a number of potential pressures on soils associated with unconventional oil and gas development.

- There is a possible risk of groundwater contamination through any escape of 'flowback water' into the ground. Typically 25-75% of the water injected during hydraulic fracturing returns to the surface as wastewater, or flowback fluid. As such flowback fluids may contain chemical additives associated with

⁴¹⁹ SEPA, 2011. *The State of Scotland's Soil*. Available at: <https://www.sepa.org.uk/media/138741/state-of-soil-report-final.pdf>

⁴²⁰ Scottish Government, 2006. *Scotland's Soil Resource – Current State and Threats – Chapter 7: Soil Contamination*. Available at: <http://www.gov.scot/Resource/Doc/149337/0039742.pdf>

⁴²¹ SEPA, 2017. *Guidance on consideration of soil in Strategic Environmental Assessment*. Available at: <https://www.sepa.org.uk/media/162986/lups-sea-gu2-consideration-of-soil-in-sea.pdf>

⁴²² SEPA, 2017. *Guidance on consideration of soil in Strategic Environmental Assessment*. Available at: <https://www.sepa.org.uk/media/162986/lups-sea-gu2-consideration-of-soil-in-sea.pdf>

⁴²³ SEPA, 2011. *The State of Scotland's Soil*. Available at: <https://www.sepa.org.uk/media/138741/state-of-soil-report-final.pdf>

⁴²⁴ Scottish Government, 2010. *Executive Summary: Management of Carbon-Rich Soils – Overview and Discussion Paper*. Available at: <http://www.gov.scot/Resource/Doc/921/0109512.pdf>

hydraulic fracturing, naturally occurring radioactive materials (NORM), inorganic materials and organic matter⁴²⁵.

- Poorly constructed and decommissioned oil and gas wells can develop leaks along the casing after production has ceased. Such leaks often take years to unfold after decommissioning, allowing hydrocarbons and other well fluids to eventually migrate out of the well and into the environment. During the decommissioning stage, there is also the risk of leaks in tanks and pipework which could potentially contaminate the ground⁴²⁶.
- New development could result in significant land-use emissions, particularly if it occurs on carbon-rich land. For instance, it is estimated that land-use change emissions associated with grassland would be in the region of 920 tCO₂ per well or 1,800 tCO₂ for TWh. It is estimated that development of locations on peat soil could lead to emissions that are around 10 times higher, at around 10,000 tCO₂ per well or 20,000 tCO₂ per TWh⁴²⁷.

Water

The importance of protecting water quality has been recognised through the EU's Water Framework Directive (2000/60/EC)⁴²⁸ which sets out a comprehensive approach to protect Europe's inland surface waters, transitional waters, coastal waters and ground waters. The Water Framework includes a requirement for an assessment of both chemical and ecological states, alongside additional requirements to consider the status of biodiversity as an indicator in determining overall water quality.

Scotland fulfils the obligations as set out in the Water Environment and Water Services (Scotland) Act 2003⁴²⁹, which guides the establishment of River Basin Management Plans (RBMPs), and the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended)⁴³⁰ which provides a regulatory framework for controlling activities, known as 'CAR', that could have negative effects on Scotland's water environment. Examples of CAR activities include water abstraction for irrigation, discharges of wastewater, impoundments, hydropower and surface water drainage. Other relevant legislation

⁴²⁵ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

⁴²⁶ Aecom, 2016. *Unconventional Oil and Gas Development in Scotland: Decommissioning, Site Restoration and Aftercare – Obligations and Treatment of Financial Liabilities*. Available at: <http://www.gov.scot/Resource/0050/00509373.pdf>

⁴²⁷ Committee on Climate Change, 2016. *Compatibility with Scottish greenhouse gas emissions targets*. Available at: <https://www.theccc.org.uk/publication/scottish-unconventional-oil-and-gas-compatibility-with-scottish-emissions-targets/>

⁴²⁸ European Commission, 2000. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. Available at: http://eur-lex.europa.eu/resource.html?uri=cellar:5c835afb-2ec6-4577-bdf8-756d3d694eeb.0004.02/DOC_1&format=PDF

⁴²⁹ Water Environment and Water Services (Scotland) Act 2003 (Scottish Statutory Instrument 2003/asp 3)

⁴³⁰ Water Environment (Controlled Activities) (Scotland) Regulations 2012 (Scottish Statutory Instrument 2011/209)

includes the Pollution Prevention and Control (Scotland) Regulations 2012⁴³¹ which aim to specifically control pollution relating to industry discharges.

Other policies focus on avoiding or limiting the impacts of flood risk. At the European level is the Floods Directive (2007/60/EC)⁴³² which establishes a framework for the assessment and management of flood risks – aiming at the reduction of the adverse consequences of flood for human health, the environment, cultural heritage and economic activity. The Floods Directive has been made into national law through the Flood Risk Management (Scotland) Act 2009⁴³³ which established the requirement for Flood Risk Management Strategies and Local Flood Risk Management Plans to be produced. Each of Scotland's 14 Local Plan Districts has a Flood Risk Management Strategy published by SEPA, in collaboration with all of Scotland's 32 local authorities. Flood Risk Plans have been developed in parallel to the Flood Risk Management Strategies, and are set out to provide further detail on the delivery and funding of local actions⁴³⁴.

Current state

The state of Scotland's water resources and the location of flood risk areas have been well-documented.

- Scotland has large water resources compared to its total land area – both inland and along the coast. Scotland has an extensive coastline, stretching 19,000 kilometres which makes up 8% of Europe's coastline⁴³⁵. There are 30,000 freshwater lochs in Scotland, ranging from small lochs to the likes of Loch Ness⁴³⁶. Scotland's rivers, lochs, canals and ponds cover around 2% of Scotland's land area which equates to around 70% of the UK's surface water whilst equating to 90% of the volume of freshwater in the UK⁴³⁷.
- In recent decades, significant improvements in water quality have been observed in many rivers, canals and estuaries due to decreases in the releases of environmental pollutants. Recent data⁴³⁸ shows that 80% of groundwaters in Scotland were at good status in 2016. In addition, 62% of surface waters (rivers, lochs, and estuaries) were at good status or better in 2016⁴³⁹. However, rivers across Scotland's Central Belt and East Coast require further works in order to ensure that they achieve 'good or better'

⁴³¹ The Pollution Prevention and Control (Scotland) Regulations 2012 (Scottish Statutory Instrument 2012/360)

⁴³² European Commission, 2007. *Directive 2007/60/EC of the European Parliament and of the Council of 2007 on the assessment and management of flood risks*. Available at: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32007L0060>

⁴³³ Flood Risk Management (Scotland) Act 2009 (Scottish Statutory Instrument 2009/asp 6)

⁴³⁴ SEPA, 2016. *Flood Risk Management Strategies*. Available at: <http://apps.sepa.org.uk/FRMStrategies/>

⁴³⁵ Scotland's Water Environment, 2014. *Scotland's State of the Environment Report, 2014*. Available at: <https://www.environment.gov.scot/media/1170/state-of-environment-report-2014.pdf>

⁴³⁶ SNH, 2017. *Lochs, rivers and wetlands*. Available at:

<https://www.nature.scot/habitats-and-ecosystems/habitat-types/lochs-rivers-and-wetlands>

⁴³⁷ Scotland's Water Environment, 2014. *Scotland's State of the Environment Report, 2014*. Available at: <https://www.environment.gov.scot/media/1170/state-of-environment-report-2014.pdf>

⁴³⁸ SEPA, 2016. *Water Classification Hub – groundwaters*. Available at: <https://www.sepa.org.uk/data-visualisation/water-classification-hub/>

⁴³⁹ SEPA, 2016. *Water Classification Hub – surface waters*. Available at: <https://www.sepa.org.uk/data-visualisation/water-classification-hub/>

overall status under Scotland's overarching target framework for waterbodies⁴⁴⁰.

- It is estimated that 4% of residential properties in Scotland, which is just over 108,000 properties, are exposed to any type of flooding. Reporting by the Scottish Government (2015)⁴⁴¹ suggests that about 8% of data zones considered as part of the corresponding study are classified as having a high or acute vulnerability to flood risk. These zones are mainly located within large Scottish cities, with Glasgow containing 191 flood risk zones and Edinburgh containing 82 such zones. The remaining flood risk zones are mainly located within smaller Scottish cities, with Dundee containing 44 such zones and Aberdeen containing 27.
- Reporting by the Scottish Government (2015)⁴⁴² also reveals that coastal flooding and fluvial flooding affected more properties in Scotland than surface flooding during that year. The Orkney Islands, Perth and Kinross, Moray and a number of local authorities located in the Midland Valley (Stirling, Falkirk, West Dunbartonshire and Scottish Borders) have the highest proportion of properties which are likely to be exposed to either coastal flooding or fluvial flooding. It was demonstrated that social vulnerability to flooding in Scotland tends to be concentrated in urban areas. It is estimated that 73% of the extremely or acutely vulnerable data zones were located in large urban areas and a further 23% were located in other urban areas.

Existing pressures

Scotland's waterbodies are under increasing pressure from various human activities.

- Key pressures on water quality originate from human activity, particularly through loss of natural habitat due to development, climate change, erosion of peatlands, fragmentation of habitats such as wetlands and pollution caused by runoff from the rural and urban environment⁴⁴³.
- It is known that climate change could affect water quality. Climatic changes could have the potential to extend the growing season, which could place additional pressures on water quality as agriculture is a key source of environmental pollutants⁴⁴⁴. Moreover, changes in climate could limit the capacity of aquatic environments to safely absorb and decompose contaminants⁴⁴⁵.

⁴⁴⁰ SEPA, 2017. *River Basin Management Planning*. Available at:

<https://www.sepa.org.uk/environment/water/river-basin-management-planning/>

⁴⁴¹ Scottish Government, 2015. *Mapping Flood Disadvantage in Scotland 2015*. Available at:

<http://www.gov.scot/Resource/0049/00490788.pdf>

⁴⁴² Scottish Government, 2015. *Mapping Flood Disadvantage in Scotland 2015*. Available at:

<http://www.gov.scot/Resource/0049/00490788.pdf>

⁴⁴³ SEPA, 2015. *Strategic Environmental Assessment: Flood Risk Strategies, Environmental Report – consultation*. Available at: https://www.sepa.org.uk/media/163415/sea_environmental_report.pdf

⁴⁴⁴ DPMAG (undated). *Rural diffuse pollution plan for Scotland*. Available at:

<https://www.sepa.org.uk/media/37557/rural-diffuse-pollution-plan-scotland.pdf>

⁴⁴⁵ Scotland's Environment, 2014.

- Local communities in Scotland, particularly coastal communities, could face a heightened flood risk associated with projected rates of climate change⁴⁴⁶.
- Changes in climate are having significant effects on Scotland's rivers and streams. An increase of almost 70% in winter precipitation has been recorded in North Scotland since 1961. For the same period, annual precipitation across Scotland has increased by 20%. In addition, surface water temperatures in lakes and rivers have increased by 1°C to 3°C during this period. These climatic changes are likely to result in disruptions to rainfall patterns and to waterlogging of the soil, which in turn could influence the timing of peak flows, seasonal river flow pattern and flow velocity. Moreover, rivers are directly affected by changes in water temperature and flow. Even small increases in temperature could disrupt the life-cycles of fish and other aquatic creatures, which in turn could impact upon community composition⁴⁴⁷.
- Wetlands, rivers, peatlands and other natural features play a crucial role in managing flood risk. Hence, key pressures on these natural habitats could indirectly increase flood risk. Primary threats to wetlands and peatland habitats include land-use change and greenhouse gas emissions⁴⁴⁸.

Potential pressures associated with unconventional oil and gas development

Present scientific evidence has identified a number of potential pressures on water resources associated with unconventional oil and gas development.

- Contamination of produced water is a concern associated with unconventional oil and gas development. Naturally occurring radioactive materials (NORM) are present in many geological formations. NORM are likely to adhere to the surface of pipework. In addition, 'flowback waters' may also contain NORM, as well as chemical additives associated with hydraulic fracturing, inorganic materials and organic matter. These substances could negatively affect groundwater quality⁴⁴⁹.
- Poor well construction could lead to gas and fluid leakage into groundwater. Surface water pollution and the contamination of groundwater with methane has been a particular concern⁴⁵⁰.
- There is the risk of surface water contamination caused by produced water e.g. if it is not treated properly before disposal⁴⁵¹.

⁴⁴⁶ CREW, 2012. *Coastal Flooding in Scotland – A guidance document for coastal practitioners*. Available at: http://www.crew.ac.uk/sites/default/files/sites/default/files/publication/Coastal%20Flooding_300812_Final.pdf

⁴⁴⁷ SNH, 2011. *Trend Note – Climate change and rivers*. Available at: <https://www.nature.scot/sites/default/files/B1043758%20-%20Natural%20Heritage%20Trends%20-%20Climate%20change%20and%20rivers%20-%20PDF.pdf>

⁴⁴⁸ SEPA, 2015. *Strategic Environmental Assessment: Flood Risk Strategies, Environmental Report – consultation*. Available at: https://www.sepa.org.uk/media/163415/sea_environmental_report.pdf

⁴⁴⁹ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

⁴⁵⁰ Aecom, 2016. *Unconventional Oil and Gas Development in Scotland: Decommissioning, Site Restoration and Aftercare – Obligations and Treatment of Financial Liabilities*. Available at: <http://www.gov.scot/Resource/0050/00509373.pdf>

⁴⁵¹ Scotland, 2017. *'Talking Fracking' – A Consultation on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

- There is the risk of accidental releases of hazardous materials (e.g. wastewater spills) during transportation, particularly if a collision involves a vehicle carrying dangerous substances. The release of hazardous materials could have the potential to adversely impact upon surface water quality⁴⁵².
- Dewatering processes associated with Coal Bed Methane (CBM) operations require significant amounts of water, which in turn could have the potential to adversely impact upon local water quality. Reduced water levels could have adverse hydro-ecological impacts, and surface water and groundwater abstraction could lead to the intrusion of saline water into waterbodies. Furthermore, buried linking infrastructure used in unconventional oil and gas developments could induce changes in surface flows and groundwater levels, which could adversely impact upon hydro-ecological functioning⁴⁵³.
- Poorly constructed and decommissioned oil and gas wells can develop leaks along the casing after production has ceased. Such leaks often take years to unfold after decommissioning, allowing hydrocarbons and other well fluids to eventually migrate out of the well and into the environment. During the decommissioning stage, there is also the risk of leaks in tanks and pipework which could potentially contaminate the ground⁴⁵⁴.

Air

European legislation addresses the issues associated with air pollution. The Ambient Air Quality Directive (2008/50/EC)⁴⁵⁵ sets targets for key pollutants such as SO₂, NO_x, particulates, lead, benzene and ground-level ozone. Moreover, the European National Emission Ceilings Directive (2016/2284/EU)⁴⁵⁶ sets targets for reducing emissions of five important air pollutants including nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOCs), sulphur dioxide (SO₂), ammonia (NH₃) and fine particulate matter (PM_{2.5}) as well as carbon monoxide (CO).

The National Emission Ceilings Directive (2001/81/EC)⁴⁵⁷ was subsequently made into UK law as the National Emissions Ceilings Regulations 2002⁴⁵⁸. Air quality is a devolved matter in the UK – administrations in Scotland (SEPA), Wales (NRW) and Northern Ireland (Northern Ireland Air) are required to produce their own air quality

⁴⁵² Ibid.

⁴⁵³ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

⁴⁵⁴ Aecom, 2016. *Unconventional Oil and Gas Development in Scotland: Decommissioning, Site Restoration and Aftercare – Obligations and Treatment of Financial Liabilities*. Available at: <http://www.gov.scot/Resource/0050/00509373.pdf>

⁴⁵⁵ European Commission, 2008. Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe. Available at: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:en:PDF>

⁴⁵⁶ European Commission, 2016. Directive 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2016.344.01.0001.01.ENG

⁴⁵⁷ European Commission, 2001. Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants. Available at: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32001L0081>

⁴⁵⁸ The National Emission Ceilings Regulations 2002 (2002/3118)

policy and legislation⁴⁵⁹. As a result, the Ambient Air Quality Directive has been transposed into Scots law through the Air Quality Standards (Scotland) Regulations 2010⁴⁶⁰. The Regulations also satisfy the requirements of the EC's 4th Air Quality Daughter Directive (2004/107/EC)⁴⁶¹ which sets limits to ambient concentration of certain heavy metals including arsenic, cadmium, mercury, nickel and polycyclic hydrocarbons.

Other relevant legislation include Part IV of the Environment Act 1995⁴⁶², the Environmental Protection Act 1990 (Part III)⁴⁶³ and Clean Air Act 1993⁴⁶⁴ which set out provisions for protecting air quality throughout the UK. Under Section 83(1) of the Environment Act 1995, local authorities are required to declare Air Quality Management Areas (AQMAs) at locations in which air quality objectives are not being met or are unlikely to be met. Local authorities have a duty to develop and implement Air Quality Action Plans in these locations in order to improve air quality to an acceptable level⁴⁶⁵.

Scotland's National Transport Strategy⁴⁶⁶ aims to reduce the need to travel, widen travel choices and drive more efficiently in Scotland to improve air quality. The Strategy will play a part in reducing air pollution in Scotland in line with the Cleaner Air for Scotland Strategy⁴⁶⁷.

Current state

The state of air quality is well-recorded as a number of air pollutants are continuously measured across a range of urban and rural locations throughout Scotland. In Scotland, there are 93 automatic monitoring sites for ambient pollutants, with a few being run as part of a UK-wide monitoring network.

- The main air pollutants of current concern in Scotland are oxides of nitrogen (NO_x), particulate matter (PM₁₀ and PM_{2.5}), sulphur dioxide (SO₂), non-methane volatile organic compounds (NMVOCs), ground level ozone (O₃) and Ammonia (NH₃)⁴⁶⁸.
- Air quality in Scotland has improved significantly since the 1950s, with dramatic reductions in some air pollutants such as sulphur, due to tighter

⁴⁵⁹ CIEEM, 2015. *UK Environmental Legislation and UK Implementation*. Available at:

https://www.cieem.net/data/files/Resource_Library/Policy/Policy_work/CIEEM_EU_Directive_Summaries.pdf

⁴⁶⁰ The Air Quality Standards (Scotland) Regulations 2010 (Scottish Statutory Instrument 2010/204)

⁴⁶¹ European Commission, 2004. Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air. Available at:

<http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1486475021303&uri=CELEX:02004L0107-20150918>

⁴⁶² Environment Act 1995 (Chapter 25)

⁴⁶³ Environmental Protection Act 1990 (c. 43)

⁴⁶⁴ Clean Air Act 1993 (c.11)

⁴⁶⁵ Scottish Government, 2005. *Part IV of the Environment Act 1995 – Local Air Quality Management Revised Policy Guidance*. Available at: <http://www.gov.scot/Publications/2003/02/16265/17537>

⁴⁶⁶ Transport Scotland, 2016. *National Transport Strategy*. Available at:

<https://www.transport.gov.scot/media/10310/transport-scotland-national-transport-strategy-january-2016-final-online.pdf>

⁴⁶⁷ Scottish Government, 2015. *Cleaner Air for Scotland – the Road to a Healthier Future*. Available at:

<http://www.gov.scot/Resource/0048/00488493.pdf>

⁴⁶⁸

Transport Scotland, 2017. *Scottish Transport Statistics No 35: 2016 Edition*. Available at:

<https://www.transport.gov.scot/media/33814/sct01171871341.pdf>

controls on emissions from industry, transport and domestic sources. This has associated positive effects on habitats. Due to decreased emissions of sulphur dioxide (SO₂), the area of acid sensitive habitats in the UK with exceedance of acidity critical loads has fallen by over a third, from 72.6% in 1995-97 to 44.1% in 2013-15. In addition, the area of nitrogen-sensitive habitats with critical load exceedance in Scotland has fallen from 59.4% in 1995-97 to 32.8% in 2013-15⁴⁶⁹. In Scotland, ammonia concentrations are generally low as less than 3% of the habitat area coincides with ammonia concentrations above 1 µg m⁻³ and less than 1% with concentrations above 3 µg m⁻³.

- Scotland is considered to have good levels of air quality. In most areas, the majority of ambient pollutions are present at levels well below limits set for protecting human health and the environment. It is estimated that air quality levels in Scotland will remain stable or continue to improve⁴⁷⁰.
- Poor air quality is of particular concern in urban areas. There are currently 38 AQMAs declared across 15 local authorities in Scotland, many of which are located in the densely populated Midland Valley (City of Edinburgh, East Dunbartonshire, East Lothian, Falkirk, Fife, Glasgow, Midlothian, North Lanarkshire, South Lanarkshire and West Lothian)⁴⁷¹.

Existing pressures

Key drivers behind air pollution include industrial activities and new development.

- Scotland is not yet fully compliant with EU and Scottish legal requirements for air quality. The main reasons for non-compliance include trends such as diesel abatement on vehicles not operating to expected levels of performance, limited integration of air quality policies and the transboundary nature of emission sources⁴⁷². Other major drivers behind air pollution include emissions from industry, energy, agriculture, as well as household activities⁴⁷³.
- Air pollution remains an issue in certain localised, hotspot areas – particularly urban locations that experience high volumes of traffic⁴⁷⁴. Road transport and industrial emissions account for a large share of air pollutant emissions. In Scotland, just over one-sixth of Scotland's total PM₁₀ emissions and over one-third of the total nitrogen oxide emissions are generated through transport movements, with the majority of these emissions attributed to road

⁴⁶⁹ Defra, 2017. *Trends Report 2017: Trends in critical load and critical level exceedances in the UK*. Available at: https://uk-air.defra.gov.uk/assets/documents/reports/cat07/1802190916_Trends_Report_2017_Final_Version.pdf

⁴⁷⁰ Scotland's Environment, 2014. *June 2014 State of the Environment Report*. Available at: <https://www.environment.gov.scot/media/1170/state-of-environment-report-2014.pdf>

⁴⁷¹ Air Quality in Scotland, 2017. *Air Quality Management Areas*. Available at: <http://www.scottishairquality.co.uk/laqm/aqma>

⁴⁷² Scottish Government, 2015. *Cleaner Air for Scotland – The Road to a Healthier Future*. Available at: <http://www.gov.scot/Resource/0048/00488493.pdf>

⁴⁷³ Scotland's Environment, 2014. *June 2014 State of the Environment Report*. Available at: <https://www.environment.gov.scot/media/1170/state-of-environment-report-2014.pdf>

⁴⁷⁴ Scotland's Environment, 2014. *Get Informed – Air – Air Quality*. Available at: <https://www.environment.gov.scot/our-environment/air/air-quality/>

transport⁴⁷⁵. Congestion plays a major role in the impacts of traffic movements on local air quality, as longer journeys amount to higher emissions of air pollutants and greenhouse gas emissions. It is estimated that 11.7% of car driver journeys in 2016 were delayed due to traffic congestion – an increase from 9.7% in 2013, but below the 14.4% perceived in 2007⁴⁷⁶.

- Changes in economic activity and demographic changes could potentially influence the development of Scottish towns and cities, which in turn could affect traffic volumes and associated emissions of pollutants and greenhouse gases⁴⁷⁷.
- Although some types of air pollution can be locally damaging, they may have little effect on a national scale. A good example of this is hotspots of air pollution caused by traffic congestion. Conversely, other types of air pollution may result in damage at a national scale e.g. atmospheric deposition of acids and nutrients⁴⁷⁸.

Potential pressures associated with unconventional oil and gas development

Present scientific evidence has identified a number of potential pressures on air quality associated with unconventional oil and gas development.

- Fugitive air emissions could have adverse effects on air quality. Fugitive air emissions include vented emissions due to maintenance and safety operations, as well as unintentional leaks of Volatile Organic Compounds (VOCs), higher hydrocarbons, CO₂ and methane⁴⁷⁹.
- Incomplete combustions from on-site burning of fossil fuels are known to contribute to air pollution. Incomplete combustions arise from engines, flares and other equipment used in unconventional oil and gas development. It is estimated that most gas is combusted during operation, particularly in relation to natural gas flares which are estimated to combust 98% of gas⁴⁸⁰.
- Unconventional oil and gas development would lead to increased traffic movements, particularly heavy truck movements. Traffic movements are known to generate nuisance from dust and increase levels of particulate matter, NO_x and exhaust fumes. The potential for localised air quality impacts from traffic flows would depend on the nature, scale and location of proposed development⁴⁸¹.

⁴⁷⁵ Scottish Government, 2015. *Cleaner Air for Scotland*. Available at:

<http://www.gov.scot/Resource/0048/00488493.pdf>

⁴⁷⁶ Scottish Government, 2017. *National Indicator: Traffic Congestion – Reduce traffic congestion*. Available at: <http://www.gov.scot/About/Performance/scotPerforms/indicator/congestion>

⁴⁷⁷ Scottish Government, 2017. *Scotland's Draft Climate Change Bill – Strategic Environmental Assessment Scoping Report*. Available at: <http://www.gov.scot/seag/seagDocs/SEA-01269/19390.pdf>

⁴⁷⁸ Scotland's Environment, 2014. *June 2014 State of the Environment Report*. Available at:

<https://www.environment.gov.scot/media/1170/state-of-environment-report-2014.pdf>

⁴⁷⁹ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

⁴⁸⁰ Ibid.

⁴⁸¹ Ricardo Energy & Environment, 2016. *Unconventional oil and gas development: understanding and mitigating community impacts from transportation*. Available at:

<http://www.gov.scot/Resource/0050/00509327.pdf>

- Greater exploitation of unconventional oil and gas could lead to indirect changes to air quality. The reasoning is that greater uptake of gas as a fuel could result in lower emissions of key air pollutants such as sulphur. However, fuel-switching scenarios are uncertain – making it difficult to derive any quantitative impacts on air quality⁴⁸².
- There is a risk that wells may fail (i.e. gas leakage) after production has ceased. Such leakages are mainly caused by cement shrinkage which often occurs a few years after decommissioning. The risk of gas leakage from abandoned unconventional oil and gas wells is expected to be low if constructed and abandoned to comply with international standards and industry practice. However, there is an increased risk of well failure if permeable rocks such as sandstones overlie unconventional oil and gas sources as such a specific rock formation could be an indication that high formation pressures exist in that particular well⁴⁸³.

Climatic Factors

The impacts of climate change have been addressed through numerous international agreements, most notably the Kyoto Protocol and the UN Paris Agreement.

The Kyoto Protocol is a legally binding treaty to reduce greenhouse gas emissions. It was adopted in 1997 and came into force in 2005. At present, 192 countries have adopted the Kyoto Protocol.

The Paris Agreement aims to keep global temperature rise well below 2°C above pre-industrial levels and to pursue further efforts to limit it to 1.5°C. It came into force in 2016 after being adopted by 195 countries. It is the first universal, legally binding global climate deal. Furthermore, the Paris Agreement covers a wide range of related issues such as mitigation measures and adaptation⁴⁸⁴.

International climate change targets have been translated into specific policies and statutes at the European level. The EU Emissions Trading System (EU ETS) is a cornerstone of the EU's strategy to tackle climate change and operates in 31 countries (all EU countries plus Iceland, Liechtenstein and Norway). The EU ETS is an emissions trading framework which works on the 'cap and trade principle' – meaning that emission allowances are issued through a combination of auction and allocation, whilst offering participants the opportunity to trade their permits on a secondary carbon market⁴⁸⁵. The Emissions Trading System (2009/29/EC)⁴⁸⁶ forms the foundation of the EU ETS and sets out specific legislation on emissions trading.

⁴⁸² Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

⁴⁸³ Aecom, 2016. *Unconventional Oil and Gas Development in Scotland: Decommissioning, Site Restoration and Aftercare – Obligations and Treatment of Financial Liabilities*. Available at: <http://www.gov.scot/Resource/0050/00509373.pdf>

⁴⁸⁴ European Commission, 2016. *Climate Action – Paris Agreement*. Available at: https://ec.europa.eu/clima/policies/international/negotiations/paris_en

⁴⁸⁵ European Commission, 2018. *Climate Action – The EU Emissions Trading System (EU ETS)*. Available at: https://ec.europa.eu/clima/policies/ets_en

⁴⁸⁶ European Commission, 2009. Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission

At the European level there is also the EC's 2030 Climate and Energy Framework⁴⁸⁷ which sets key targets related to tackling climate change, namely 40% cuts in greenhouse gas emissions (from 1990 levels), 27% increases in the share of renewable energy and a 27% improvement in energy efficiency. The 2030 Climate and Energy Framework is in line with the longer term perspective set out in the EC's Roadmap for moving to a competitive low carbon economy in 2050⁴⁸⁸, the Energy Roadmap 2050⁴⁸⁹ and the Transport White Paper⁴⁹⁰. Other relevant EC statutes include the Renewable Energy Directive (2009/28/EC)⁴⁹¹ and the Energy Efficiency Directive (2012/27/EU)⁴⁹². The Renewable Energy Directive sets targets for renewable energy use within the EU, and requires that 20% of the energy consumed within the EU is renewable. The Energy Efficiency Directive establishes a set of binding targets to help the EU to reach its 20% energy efficiency target by 2020.

Scotland has set ambitious domestic climate change targets under the Climate Change (Scotland) Act 2009⁴⁹³. The Act sets statutory targets for the reduction of greenhouse gas emissions by setting an interim 42% reduction target by 2020 and an 80% reduction target from baseline levels (1990) for 2050.

Under section 53 of the Climate Change (Scotland) Act 2009, Scotland published its first statutory 2014 Scottish Climate Change Adaptation Programme⁴⁹⁴ which is also a means to address the climate change impacts identified for Scotland in the UK Climate Change Risk Assessment. Under the Climate Change Act 2008⁴⁹⁵, the UK Government is also required to publish a UK-wide Climate Change Risk Assessment (CCRA)⁴⁹⁶ every 5 years which defines the impacts from climate change. CCRA reports to date include the 2012 UK Climate Change Risk

allowance trading scheme of the Community. Available at: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32009L0029>

⁴⁸⁷ European Commission, 2014. *2030 Climate & Energy Framework*. Available at: https://ec.europa.eu/clima/policies/strategies/2030_en

⁴⁸⁸ European Commission, 2011. *The roadmap for moving to a competitive low-carbon economy in 2050*. Available at: https://ec.europa.eu/clima/sites/clima/files/2050_roadmap_en.pdf

⁴⁸⁹ European Commission, 2012. *Energy Roadmap 2050*. Available at:

https://ec.europa.eu/energy/sites/ener/files/documents/2012_energy_roadmap_2050_en_0.pdf

⁴⁹⁰ European Commission, 2011. *WHITE PAPER Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system*. Available at: <http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A52011DC0144>

⁴⁹¹ European Commission, 2009. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. Available at: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32009L0028>

⁴⁹² European Commission, 2012. Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC. Available at: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32012L0027>

⁴⁹³ Climate Change (Scotland) Act 2009 (Scottish Statutory Instrument 2009/asp 12)

⁴⁹⁴ Scottish Government, 2014. *Climate Ready Scotland: Scottish Climate Change Adaptation Programme*. Available at: <http://www.gov.scot/Publications/2014/05/4669>

⁴⁹⁵ Climate Change Act 2008 (Chapter 27)

⁴⁹⁶ Committee on Climate Change, 2017. *UK Climate Change Risk Assessment 2017 Evidence Report – Introduction to the CCRA*. Available at: <https://www.theccc.org.uk/tackling-climate-change/preparing-for-climate-change/uk-climate-change-risk-assessment-2017/introduction-to-the-ccra/>

Assessment (CCRA)⁴⁹⁷ and the 2017 UK Climate Change Risk Assessment (CCRA2)⁴⁹⁸. A second five-year Programme will be published in 2019.

The Climate Change (Scotland) Act 2009 also requires that, as soon as reasonably practicable after setting annual targets, Ministers publish a report setting out policies and proposals for meeting those targets. The Climate Change Plan is the Scottish Government's current report on proposals and policies for meeting its climate change targets. .

Current state

A growing body of evidence suggests that Scotland's climate has undergone changes over the last 100 years. The UK Climate Change Projections (UKCP09) indicates that the country's climate may continue to evolve.

- Scotland has a temperate maritime climate characterised by generally cool summers, mild winters and rainfall spread throughout the year. However, there are regional differences due to factors such as latitude, altitude, prevailing winds and ocean currents. For instance, the south of Scotland is generally warmer than the north in summer, primarily due to differences of latitude⁴⁹⁹.
- Scotland's climate is affected by a range of global pressures including natural pressures such as the emissions of particles from volcanoes. However, global warming caused by increases in atmospheric greenhouse gases constitutes the overriding pressure on changes in climate over the last decades. The Intergovernmental Panel on Climate Change (IPCC)⁵⁰⁰ reports that existing scientific evidence reveals with at least 95% certainty that human activity is the main cause of global warming over the last century. The main greenhouse gases causing rapid changes in climate are carbon dioxide (CO₂), nitrous oxide (N₂O), methane (CH₄), ozone (O₃) and water vapour (H₂O)⁵⁰¹.
- A direct result of global warming is its impacts on the environment and atmosphere; the world's atmosphere has warmed, the amounts of snow and ice have diminished and the sea level has risen. Globally, 13 out of 14 of the warmest years since records began in 1850 occurred in the 21st century. Scotland's climate has changed as well; changes in precipitation patterns have led to drier summers, wetter winters and more frequent heavy rainfall in the UK. According to the UKCP09⁵⁰², the temperatures across Scotland have increased by about 0.7-0.8°C since 1980. Across Scotland, the mean annual temperature has increased by 1.3°C, with the mean temperature increasing

⁴⁹⁷ UK Government, 2012. *UK Climate Change Risk Assessment: Government Report*. Available at: <https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-government-report>

⁴⁹⁸ UK Government, 2017. *UK Climate Change Risk Assessment 2017*. Available at: <https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-2017>

⁴⁹⁹ Scotland's Environment, 2014. *June 2014 State of the Environment Report*. Available at: <https://www.environment.gov.scot/media/1170/state-of-environment-report-2014.pdf>

⁵⁰⁰ Intergovernmental Panel on Climate Change (IPCC), 2013. *Climate Change 2013 – The Physical Science Basis*. Available at: <http://www.ipcc.ch/report/ar5/wg1/>

⁵⁰¹ Scotland's Environment, 2017. *Climate – Changing Climate*. Available at: <https://www.environment.gov.scot/our-environment/climate/changing-climate/>

⁵⁰² UK Climate Projections, 2009. *Briefing report*. Available at: <http://ukclimateprojections.metoffice.gov.uk/media.jsp?mediaid=87868&filetype=pdf>

for all seasons in all regions by at least 1°C⁵⁰³. Furthermore, annual rainfall has increased by about 7% between 1961-1990 and 1981-2010⁵⁰⁴.

- Scotland has made good progress in cutting its greenhouse gas emissions. According to recent statistics published by the Scottish Government⁵⁰⁵, Scotland has seen a general decline in greenhouse gas emissions between 1994 and 2016, with a 49.0% reduction (a 37.0 MtCO₂e decrease) over this period compared to 1990 levels.
- In 2016, transport (including international aviation and shipping) was the largest source of net emissions (14.4 MtCO₂e) followed by agriculture and related land use (10.0 MtCO₂e), business and industrial processes (8.6 MtCO₂e), energy supply (7.2 MtCO₂e), residential use (6.3 MtCO₂e) and development (2.0 MtCO₂e). Forestry was the only aggregate sector in which there has been a net emissions sink (-12.7 MtCO₂e)⁵⁰⁶.
- Global increases in concentrations of carbon dioxide (CO₂) are primarily from transport, burning fossil fuels and changes in land use, whilst increases in methane (CH₄) and nitrous oxide (N₂) are mainly due to agriculture activities and waste management⁵⁰⁷. Greenhouse gas emissions from agricultural activities and landfills have a high warming potential which could significantly impact upon the state of the global climate. Methane (CH₄) is 25 times more potent in the atmosphere than CO₂ measured over 100 years, whilst nitrous oxide (N₂O) is 298 times more potent⁵⁰⁸.

Existing pressures

Present scientific evidence shows that emissions of greenhouse gases into the atmosphere are a key driver behind climate change, which in turn could have adverse impacts on environmental quality and human well-being.

- Climate projections indicate that the UK may experience milder, wetter winters and hotter, drier summers as a result of changes in climate. Increases in summer heatwaves, drought, reduced frost and increased incidence of extreme temperatures are also expected⁵⁰⁹.
- The UKCP09 provides the latest impacts of the likely scenarios for Scotland's projected climate, including the estimated impacts of emissions scenarios

⁵⁰³ Scotland's Environment, 2017. *Climate – Changing Climate*. Available at:

<https://www.environment.gov.scot/our-environment/climate/changing-climate/>

⁵⁰⁴ Committee on Climate Change, 2017. *UK Climate Change Risk Assessment 2017 Evidence Report – Summary for Scotland*. Available at: <https://www.theccc.org.uk/wp-content/uploads/2016/07/UK-CCRA-2017-Scotland-National-Summary.pdf>

⁵⁰⁵ The Scottish Government, 2016. *Scottish Greenhouse Gas Emissions 2016*. Available at: <https://beta.gov.scot/publications/scottish-greenhouse-gas-emissions-2016/documents/00536542.pdf?inline=true>

⁵⁰⁶ The Scottish Government, 2016. *Scottish Greenhouse Gas Emissions 2016*. Available at: <https://beta.gov.scot/publications/scottish-greenhouse-gas-emissions-2016/documents/00536542.pdf?inline=true>

⁵⁰⁷ The Scottish Government, 2016. *Scottish Greenhouse Gas Emissions 2016*. Available at: <https://beta.gov.scot/publications/scottish-greenhouse-gas-emissions-2016/documents/00536542.pdf?inline=true>

⁵⁰⁸ Scottish Government, 2017. *Section E. Further Information, Glossary and Acknowledgements*. Available at: <http://www.gov.scot/Publications/2017/06/9986/342098>

⁵⁰⁹ Scotland's Environment, 2014. *June 2014 State of the Environment Report*. Available at: <https://www.environment.gov.scot/media/1170/state-of-environment-report-2014.pdf>

(low, medium, high). Under a medium emissions scenario, it is estimated that summer temperatures will increase by 3.5°C in eastern Scotland and west Scotland and 3°C in North Scotland by the 2080s, respectively⁵¹⁰. Regional winter precipitation totals are projected to change between -2% and +31% for the same scenario⁵¹¹.

- According to the UKCP09, major changes in sea levels are projected over the next few decades⁵¹². Sea level rise rates of up to 1.9 metres have been estimated for a plausible high emissions scenario, with the sea level in Edinburgh expected to increase by 20-40cm by 2090 compared to the 1990 baseline under a central scenario. Even under a low emission scenario, sea levels are projected to continue to rise by 2100. The majority (79%) of Scotland's 21,000 km coastline consists of hard and rocky material, making it more resistant to sea level rise. However, the remaining 21% is more vulnerable to coastal changes, particularly in relation to the proportion of infrastructure and assets that lie behind these coastlines⁵¹³.
- Climate change is inextricably linked to pressures on other SEA topic areas such as water and air quality, as well as biodiversity and human health. Climate change could have adverse knock-on effects on the environment. Climate change poses risks to Scotland's soils, wildlife, agriculture and natural carbon resources. For example, pests may become more prevalent as they are more likely to survive throughout warmer winters⁵¹⁴.
- Indirect negative impacts may also arise from mitigation and adaptation measures. For instance, individual renewable energy technologies may also have negative environmental impacts such as visual effects⁵¹⁵.
- A progress report by the Committee on Climate Change⁵¹⁶ concluded that Scotland has made good progress in reducing its greenhouse gas emissions. Scotland's emissions fell 3% between 2014 and 2015 to 38% below 1990 levels, mainly due to reductions in the power sector. This means that Scotland is on track to meet its ambitious interim reduction target of 42% below 1990 levels by 2020. However, little progress has been made in other sectors such as agriculture, transport and non-residential buildings. Emissions from these sectors have not decreased in the last few years.

⁵¹⁰ Scotland's Environment, 2017. *Climate – Changing Climate*. Available at:

<https://www.environment.gov.scot/our-environment/climate/changing-climate/>

⁵¹¹ Committee on Climate Change, 2017. *UK Climate Change Risk Assessment 2017 Evidence Report – Summary for Scotland*. Available at: <https://www.theccc.org.uk/wp-content/uploads/2016/07/UK-CCRA-2017-Scotland-National-Summary.pdf>

⁵¹² SEPA, undated. *The effects of climate change*. Available at:

<https://www.sepa.org.uk/environment/climate-change/the-effects-of-climate-change/>

⁵¹³ Committee on Climate Change, 2017. *UK Climate Change Risk Assessment 2017 Evidence Report – Summary for Scotland*. Available at: <https://www.theccc.org.uk/wp-content/uploads/2016/07/UK-CCRA-2017-Scotland-National-Summary.pdf>

⁵¹⁴ Scotland's Environment, 2014. *June 2014 State of the Environment Report*. Available at: <https://www.environment.gov.scot/media/1170/state-of-environment-report-2014.pdf>

⁵¹⁵ Carbon Trust, 2012. *Making sense of renewable energy technologies*. Available at: <https://www.carbontrust.com/media/63632/ctg011-renewable-energy-technologies.pdf>

⁵¹⁶ Committee on Climate Change, 2017. *Reducing emissions in Scotland – 2017 Progress Report to Parliament*. Available at: <https://www.theccc.org.uk/wp-content/uploads/2017/09/Reducing-emissions-in-Scotland-2017-Progress-Report-CCC.pdf>

Potential pressures associated with unconventional oil and gas development

Present scientific evidence has identified a number of potential climatic pressures associated with unconventional oil and gas development.

- There is a risk that gas leakage may occur after production has ceased in an unconventional oil and gas well. Such leakages are mainly caused by cement shrinkage which often occurs a few years after decommissioning. The risk of gas leakage from abandoned unconventional oil and gas wells is expected to be low if constructed and abandoned to comply with international standards and industry practice. However, there is an increased risk of well failure if permeable rocks such as sandstones overlie unconventional oil and gas sources as such a specific rock formation could be an indication that high formation pressures exist in that particular well. In such wells, a greater possibility exists that gases migrate out of the well and into the atmosphere⁵¹⁷.
- Fugitive air emissions could exacerbate climate change through increased greenhouse gas emissions. Fugitive air emissions arise from unintentional leaks, venting and flaring. These include greenhouse gases such as carbon dioxide (CO₂) and methane (CH₄). Fugitive methane emissions are a concern given that methane is a potent greenhouse gas⁵¹⁸.
- ‘Super emitters’ have been identified as a key source of greenhouse gas emissions. Super emitters are large methane leaks left unchecked for extended periods of time. Further work is required to understand the mechanisms that cause sites to become super emitters. This would help to inform suitable operational control and maintenance procedures⁵¹⁹.
- The potential impacts of the unconventional oil and gas industry on reducing Scotland’s greenhouse gas emissions are unknown as they depend on complex, transboundary trends and processes⁵²⁰.

Cultural Heritage and the Historic Environment

The importance of protecting cultural heritage assets is acknowledged through the 1992 European Convention on the Protection of the Archaeological Heritage⁵²¹. The primary aim of the Convention is to protect archaeological heritage, including any physical evidence of the human past that can be investigated archaeologically both on land and underwater. The Convention also makes a provision for the creation of archaeological reserves and the conservation of excavated sites.

⁵¹⁷ Aecom, 2016. Unconventional Oil and Gas Development in Scotland: Decommissioning, Site Restoration and Aftercare – Obligations and Treatment of Financial Liabilities. Available at: <http://www.gov.scot/Resource/0050/00509373.pdf>

⁵¹⁸ KPMG, 2016. *Economic Impact Assessment and Scenario Development of Unconventional Oil and Gas in Scotland*. Available at: <http://www.gov.scot/Resource/0050/00509321.pdf>

⁵¹⁹ Committee on Climate Change, 2016. *Compatibility with Scottish greenhouse gas emissions targets*. Available at: <https://www.theccc.org.uk/publication/scottish-unconventional-oil-and-gas-compatibility-with-scottish-emissions-targets/>

⁵²⁰ Scotland, 2017. *‘Talking Fracking’ – A Consultation on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

⁵²¹ Council of Europe, 1992. *European Convention on the Protection of the Archaeological Heritage (Revised)*. Available at: <https://rm.coe.int/168007bd25>

In Scotland, cultural heritage objectives are set out under the Historic Environment Scotland Act 2014⁵²² which established Historic Environment Scotland (HES) as a Non Departmental Public Body (NDPB). As such HES is a statutory consultee in relation to listed buildings and conservation area consents, as well as in relation to EIA, where required. Moreover, the Act amended the Ancient Monuments and Archaeological Areas Act 1979⁵²³, Planning (Listed Buildings and Conservation Areas) (Scotland) Act 1997, Environmental Assessment (Scotland) Act 2005 and the Marine (Scotland) Act 2010.

Our Place in Time – The Historic Environment Strategy for Scotland⁵²⁴, published in 2014, provides a high-level framework which sets out a 10 year vision for protecting the cultural, social, environmental and economic value of Scotland’s heritage assets. The vision is underpinned by three fundamental aims of understanding, recording and protecting Scotland’s historic environment.

Other relevant policies include the National Planning Framework⁵²⁵, Scottish Planning Policy⁵²⁶, Historic Environment Circular 1⁵²⁷, The Town and Country Planning (Historic Environment Scotland) Amendment Regulations 2015⁵²⁸ and Historic Environment Scotland’s Managing Change in the Historic Environment⁵²⁹ guidance note series. These documents provide guidance for local planning authorities pertaining to applications for Conservation Areas and Listed Building consents, as well as the consideration of more general planning applications.

Current state

Scotland’s historic environment includes thousands of historic buildings and monuments which attract approximately 14.6 million visitors every year. It is estimated that over 5-10% of the historic environment in Scotland is designated, which amounts to more than 56,000 historic assets⁵³⁰. Below is an overview of Scotland’s designated heritage assets.

- According to Scotland’s Historic Environment Audit 2016⁵³¹, there are six World Heritage Sites in Scotland – at St. Kilda, Edinburgh Old Town and New

⁵²² Historic Environment Scotland Act 2014 (Scottish Statutory Instrument 2014/asp 19)

⁵²³ Ancient Monuments and Archaeological Areas Act 1979 (Chapter 46)

⁵²⁴ Historic Scotland, 2014. *Our Place in Time – the Historic Environment Strategy for Scotland*. Available at: <http://www.gov.scot/Resource/0044/00445046.pdf>

⁵²⁵ Scottish Government, 2014. *National Planning Framework 3*. Available at:

<http://www.gov.scot/Topics/Built-Environment/planning/National-Planning-Framework>

⁵²⁶ Scottish Government, 2014. *Scottish Planning Policy*. Available at: <http://www.gov.scot/Topics/Built-Environment/planning/Policy>

⁵²⁷ Historic Environment Scotland, 2016. *Historic Environment Circular 1*. Available at:

<https://www.historicenvironment.scot/archives-and-research/publications/publication/?publicationId=ec209755-9bf8-4840-a1d8-a61800a9230d>

⁵²⁸ The Town and Country Planning (Historic Environment Scotland) Amendment Regulations (Scottish Statutory Instrument 2015/237)

⁵²⁹ Historic Environment Scotland, undated. *Managing Change in the Historic Environment*. Available at:

<https://www.historicenvironment.scot/advice-and-support/planning-and-guidance/legislation-and-guidance/managing-change-in-the-historic-environment-guidance-notes/>

⁵³⁰ Historic Environment Scotland, 2016. *Scotland’s Historic Environment Audit 2016*. Available at:

<https://www.historicenvironment.scot/archives-and-research/publications/publication/?publicationId=315b3f0d-631b-4a24-b12b-a6db00ba1696>

⁵³¹ Historic Environment Scotland, 2016. *Scotland’s Historic Environment Audit 2016*. Available at:

<https://www.historicenvironment.scot/archives-and-research/publications/publication/?publicationId=315b3f0d-631b-4a24-b12b-a6db00ba1696>

Town, the Heart of Neolithic Orkney, New Lanark, the Antonine Wall and The Forth Bridge. There are a further 47,288 Listed Buildings (of which 3,552 Category A Listed Buildings, 23,382 Category B Listed Buildings and 20,110 Category C Listed Buildings), 8,164 Scheduled Monuments, 377 Gardens and Designated Landscapes, 39 nationally important battlefields, 7 scheduled wrecks and 8 Historic Marine Protected Areas.

- Currently, there are 2,387 buildings at risk register for Scotland⁵³². An analysis of Category A Listed Buildings at risk within Scotland's four largest cities showed a variable performance in terms of conserving the state of the buildings at risk. Edinburgh and Aberdeen demonstrated an improvement in terms of reducing the number of Category A Listed Buildings at risk between 2009 and 2012 – with a recorded reduction from 30 to 24 in Edinburgh and a reduction of 22 to 21 in Aberdeen over that period. Conversely, the number of Category A Listed Building in Glasgow and Dundee increased, with increases from 16 to 71 in Dundee and increases from 35 to 47 in Glasgow⁵³³.
- There are 663 Conservation Areas across Scotland, which are designated through the Planning (Listed Buildings and Conservation Areas) (Scotland) Act 1997. Conservation Areas play an important role in preserving the character of areas of special architectural or historic interest⁵³⁴.

There are a number of important historic assets located in the Midland Valley, including (but not limited to);

- World Heritage Sites including the Antonine Wall and The Forth Bridge are located within the Midland Valley.
- There are 633 Conservation Areas across Scotland, including designations in the Midland Valley such as the medieval core of the South Queensferry⁵³⁵
- The Midland Valley contains several battlefield sites such as Stirling Old Bridge⁵³⁶.
- Other notable features in the Midland Valley include historic structures such as Blackness Castle and Clackmannan Tower⁵³⁷.
- There are numerous designed landscapes located across the Midland Valley such as the Pineapple and Dunmore Park⁵³⁸.

⁵³² Historic Environment Scotland, 2017. *Buildings at Risk – Register for Scotland*. Available at: <https://www.buildingsatrisk.org.uk/>

⁵³³ City of Edinburgh Council, 2012. *National and Local Performance for the Historic Environment*. Available at: http://www.edinburgh.gov.uk/news/article/817/preserving_historic_buildings_for_future_generations

⁵³⁴ Historic Environment Scotland, 2016. *Scotland's Historic Environment Audit 2016*. Available at: <https://www.historicenvironment.scot/archives-and-research/publications/publication/?publicationId=315b3f0d-631b-4a24-b12b-a6db00ba1696>

⁵³⁵ Edinburgh Council, 2014. *South Queensferry Conservation Area Character Appraisal*. Available at: https://consultationhub.edinburgh.gov.uk/sfc/queensferry-caca/supporting_documents/S_Queens_CACA_14.pdf

⁵³⁶ Historic Environment Scotland, undated. *Stirling Old Bridge*. Available at: <https://www.historicenvironment.scot/visit-a-place/places/stirling-old-bridge/>

⁵³⁷ Historic Environment Scotland, undated. *Clackmannan Tower*. Available at: <https://www.historicenvironment.scot/visit-a-place/places/clackmannan-tower/>

⁵³⁸ Historic Environment Scotland, undated. *Inventory Garden & Designated Landscape – Dunmore Park*. Available at: <http://portal.historicenvironment.scot/designation/GDL00158>

- Other heritage assets include remains of former industries such as disused salt pans, limekilns, coal mines, whisky distilleries and infrastructure associated with the ship-building, fishing and export industries, local ironworks, colliery, docks and harbours⁵³⁹.

Existing pressures

Key threats facing Scotland's historic assets are related to significant changes in the wider environment.

- Key impacts on the historic environment relate to development and land use change, depending on the total area required for new infrastructure and other ancillary development. Indirect impacts include impacts on setting arising from new development, as well as changes to surface drainage patterns⁵⁴⁰.
- Climate change is one of the principal pressures that may affect Scotland's historic environment. Rising sea levels and increased storm events could adversely impact upon historic landscapes, structures and archaeology in the coastal zone. Intense rainfall events could cause flooding and erosion in historic settlements and archaeological sites. Further threats include water damage to masonry, which in turn could increase the risk of dampness, condensation, mould/fungal growth, algal growth and accelerated decay of building materials. Furthermore, changes in hydrology may alter vegetation patterns in the setting of designated sites, historic landscapes and archaeological remains. Internationally recognised sites such as part of the Heart of Neolithic Orkney are considered to be at a high risk from issues relating to climate change⁵⁴¹.

Potential pressures associated with unconventional oil and gas development

At this stage, it is difficult to identify potential impacts on the historic environment given the localised nature of such impacts.

- The review of the existing evidence base commissioned by the Scottish Government shows that the use of drilling rigs for shale gas operations may cause visual impacts⁵⁴². However, landscape impacts are a complex area as they are highly contextual. As such, the potential severity of landscape impacts greatly depends on local factors such as the design of the existing built-up environment and the nature of the surrounding landscape, amongst other factors.
- Climate change impacts associated with unconventional oil and gas development could have indirect effects on Scotland's historic environment

⁵³⁹ Inner Forth Landscape Initiative, 2014. *About the Landscape – Historical & Cultural Heritage*. Available at: <https://www.innerforthlandscape.co.uk/about/about-the-landscape>

⁵⁴⁰ Historic Environment Scotland, undated. *Assessing impacts on the historic environment*.

⁵⁴¹ Historic Scotland, 2012. *A Climate Change Action Plan 2012-2017*. Available at: <https://www.historicenvironment.scot/media/2611/climate-change-plan-2012.pdf>

⁵⁴² Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

e.g. erosion of historic structures caused by sea level rise. However, the potential magnitude and duration of such effects is currently unknown⁵⁴³.

Landscape and Geodiversity

Landscape protection is acknowledged through a variety of policies and legislation. The European Landscape Convention⁵⁴⁴, also known as the 'Florence Convention', strives to promote landscape protection, management and planning and to organise European co-operation on landscape issues. The Convention introduces a national landscape policy that is not only restricted to internationally protected landscapes, but also takes account of less remarkable or even degraded landscapes. This scope encompasses all kinds of environments including rural, urban and peri-urban landscapes across terrestrial, marine and coastal environments.

The National Scenic Areas (NSAs) Programme identifies Scottish landscapes of outstanding scenic quality. In this context, 'special qualities' are defined as the characteristics that comprise an area's outstanding scenery – both individually and combined. Section 263(A) of the Town and Country Planning (Scotland) Act 1997 requires planning authorities to take notice of the scenic characteristics of an NSA when exercising any powers under that Act to any land within that NSA⁵⁴⁵.

Further policies have been implemented at the national level to protect Scotland's landscapes. Scottish Planning Policy⁵⁴⁶ aims to protect and enhance Scotland's natural heritage and landscapes. The National Planning Framework 3⁵⁴⁷ acknowledges wild land areas identified on the SNH 2014 map as a nationally important asset. SNH's Landscape Policy Framework⁵⁴⁸ strives to protect the natural and aesthetic qualities of Scotland's landscapes. In this context, the Landscape Policy Framework identifies a number of key landscape types including distinctive settlements, crofting landscapes, forests and woodland, upland hills, moorland landscapes and coastal landscapes.

Local landscape designations occur across Scotland and help to protect landscape from inappropriate development. Local development plans show their location and associated policy, and a number of local landscape designations are located across the Central Belt including coastal areas of the Firth of Forth, upland areas such as the Ochils and policy landscapes.

⁵⁴³ Scottish Government, 2017. *Talking 'Fracking' – A Consultation on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0051/00513575.pdf>

⁵⁴⁴ Council of Europe, 2000. *The European Landscape Convention*. Available at: <https://rm.coe.int/1680080621>

⁵⁴⁵ Scottish Government, 2017. *Countryside and Landscape in Scotland – National Scenic Areas*. Available at: <http://www.gov.scot/Topics/Environment/Countryside/Heritage/Areas>

⁵⁴⁶ Scottish Government, 2014. *Scottish Planning Policy*. Available at: <https://beta.gov.scot/publications/scottish-planning-policy/documents/00453827.pdf>

⁵⁴⁷ Scottish Government, 2014. *National Planning Framework 3*. Available at: <http://www.gov.scot/Topics/Built-Environment/planning/National-Planning-Framework>

⁵⁴⁸ Scottish Natural Heritage (SNH), 2005. *SNH Landscape Policy Framework*. Available at: <https://www.nature.scot/professional-advice/landscape-change/framework-landscape-policy/snh-landscape-policy-framework>

Current state

Scotland contains a wide variety of landscapes. At present, Scotland's natural environment contains a number of designated landscapes, including: 40 National Scenic Areas (NSAs)⁵⁴⁹, two national parks⁵⁵⁰ and three geoparks⁵⁵¹.

Scotland's NSAs represent the type of scenic beauty Scotland is renowned for. They cover a total of approximately 13% of the country's total land area⁵⁵².

There are two national parks in Scotland: Loch Lomond and The Trossachs national park and the Cairngorms – covering 5,665 square kilometres together. The protection of these areas is crucial to rural economic development and recreation, as well as the conservation of diverse natural habitats. Following the *Strategic Review of Scotland's National Parks* in 2008, national parks were given more delegation of planning functions⁵⁵³.

- There are three geoparks in Scotland. These are North West Highlands Geopark, Geopark Shetland and Lochaber Geopark. These geoparks cover about 10% of Scotland's land area. The geopark status recognises an area's outstanding geological heritage value, as well as its benefits to local people through tourism and education. As such, geoparks have the same level of status as World Heritage Sites and biosphere reserves⁵⁵⁴.
- There are nearly 900 Geological Conservation Review (GCR) sites across Scotland. GCR sites contain outstanding geodiversity features including internationally and nationally important rock formations, minerals and fossils, landform features. Scotland's National Parks have also been recognised for their geodiversity value – 12.8% of the Cairngorms National Park and 1.5% of the Loch Lomond and The Trossachs National Park having GCR site status. Moreover, a considerable proportion of Scotland's National Nature Reserves (NNRs) contain sites of geological and geomorphological interest with around 37% of NNR areas in Scotland having GCR site status⁵⁵⁵.
- Between 1994 and 1999, SNH undertook a National Landscape Character Assessment in collaboration with local authorities and other parties. The Assessment identified 372 'landscape character types' in total, which were then categorised into 18 'natural heritage settings' on the basis of their dominant land cover and the relevant forms of socio-economic activities occurring within that landscape character type. The 18 natural heritage settings include urban greenspace; lowland grassland; low arable land;

⁵⁴⁹ Scottish Government, 2008. *National Scenic Areas of Scotland*. Available at: <http://www.gov.scot/Resource/Doc/1051/0058088.pdf>

⁵⁵⁰ Scottish Government, 2009. *National Parks Strategic Review Recommendations*. Available at: <http://www.gov.scot/Resource/Doc/281970/0085205.pdf>

⁵⁵¹ NWHG, 2017. *North West Highlands UNESCO Global Geopark Business Plan 2017-18*. Available at: <http://www.nwhgeopark.com/wp-content/uploads/ThePlan.pdf>

⁵⁵² Scottish Government, 2008. *National Scenic Areas of Scotland*. Available at: <http://www.gov.scot/Resource/Doc/1051/0058088.pdf>

⁵⁵³ Scottish Government, 2014. *Scotland's Third National Planning Framework*. Available at: <http://www.gov.scot/Resource/0045/00453683.pdf>

⁵⁵⁴ NWHG, 2017. *North West Highlands UNESCO Global Geopark Business Plan 2017-18*. Available at: <http://www.nwhgeopark.com/wp-content/uploads/ThePlan.pdf>

⁵⁵⁵ Gordon, J.E. & Barron, H.F. for Scottish Natural Heritage, 2011. *Scotland's geodiversity: Development of the basis for a national framework*. Available at: http://nora.nerc.ac.uk/id/eprint/19222/1/National_Geodiversity_Framework_417.pdf

upland grassland; crofting; lowland broadleaved; upland broadleaved; coniferous plantation; peatland; native pinewoods; heather moorland; montane; running waters; and, standing waters. Due to the complexity of certain landscapes it is difficult to categorise them within any of the landscape character types⁵⁵⁶. Partially as a result of advancements in technology, a review of SNH's National Landscape Character Assessment is currently underway.

- Scotland's landscapes provide numerous intangible benefits, including enjoyment and tranquillity⁵⁵⁷. As such, Scotland's landscapes play an important role in enhancing visitor experience and, thus, generating socio-economic benefits derived from the tourism industry. Further tangible benefits are derived from providing opportunities for recreation. For instance, rivers are important recreational resources, providing a place for a wide variety of activities such as fishing or swimming⁵⁵⁸.

Existing pressures

Competing land uses remain a principal threat to managing landscape change. Key drivers behind land-use change include climate change, changing economic base and economic efficiency.

- New development is putting increased pressure on Scotland's landscapes and agricultural land. Between 1947 and 1988, the total area of built land increased by an estimated 46% and the land used for infrastructure increased by around 22%. Most of these changes were at the expense of agricultural land, and the remainder was largely on upland or woodland habitats⁵⁵⁹. Over that same period, further land-use changes took place. Rough grassland decreased by 10%, heather moorland decreased by 23% and semi-natural features reduced by 17%. Conversely, forestry plantations increased by 613% over that period⁵⁶⁰.
- Climate change will have implications for Scottish landscapes and the social, economic and environmental benefits they provide. Landscape change will result from the direct impacts of a changing climate as well as from indirect impacts of human attempts to slow climate change (mitigation) and the way that we respond to a changing climate (adaptation). Overall, mitigation and adaptation measures are likely to have a more significant influence on landscape character than the direct effects of climate change. The combined influence of these direct, mitigation and adaptation effects are likely to be greatest in lowland and coastal landscapes reflecting the dominance of land

⁵⁵⁶ SNH, 2000. *Landscape Character Vignettes*. Available at: <https://www.nature.scot/sites/default/files/2017-07/Publication%201999%20-%20SNH%20Commissioned%20Report%20F99NB07%20-%20Landscape%20Character%20Vignettes.pdf>

⁵⁵⁷ SNH, 2017. *Why our landscapes are important*. Available at: <https://www.nature.scot/landscapes-habitats-and-ecosystems/about-scotlands-landscapes/why-our-landscapes-are-important>

⁵⁵⁸ Scotland's Environment, 2014. *Rivers and canals*. Available at: <https://www.environment.gov.scot/media/1179/water-rivers-and-canals.pdf>

⁵⁵⁹ SNH, 2003. *Trend note – Land Cover Change 1940s – 1980s: Built land*. Available at: <https://www.nature.scot/sites/default/files/2017-09/B1009926%20-%20Trend%20note%20-%20Land%20Cover%20Change%201940s%20%E2%80%93%201980s%20-%20Built%20land.pdf>

⁵⁶⁰ SNH, 2009. *Trend note – A summary of land cover change in Scotland from 1947 – 1988*. Available at: <https://www.nature.scot/sites/default/files/B1009930%20-%20Trend%20note%20-%20Land%20Cover%20Change%201947%20to%201988%20summary%20-%20pdf.pdf>

management, settlement and land use in shaping landscape character, and the likely impacts of changing sea levels.⁵⁶¹

Potential pressures associated with unconventional oil and gas development

Present scientific evidence has identified a number of potential pressures on landscape quality associated with unconventional oil and gas development.

- Visual impacts may arise from the use of construction machinery and associated machinery used for shale gas operations, particularly where multiple pads are developed. The initial drilling requires a drilling rig with a mast typically 30m in height⁵⁶², although there is a variety of rigs currently available on the market with heights up to 60m⁵⁶³. Drilling rigs are temporary structures as they are typically on-site for a couple of months during the initial drilling phase. After this period, the drill hole is capped with an extraction point and protective cage which are typically about 3m high⁵⁶⁴.

Material Assets

The SEA topic 'material assets' encompasses a wide variety of topics, and, as such, can be interpreted in a number of different ways⁵⁶⁵. In the context of this report, this SEA topic refers to the potential impacts of unconventional oil and gas developments on mineral resources, environmental pollution, and the treatment of waste products arising from the unconventional oil and gas industry. As mentioned previously, land-use changes associated with unconventional oil and gas operations could also adversely impact upon Scotland's soils and agricultural land.

Many of the relevant policies and legislation pertaining to material assets are concerned with the environmental hazards associated with industries such as unconventional oil and gas operations. One of the main concerns associated with industrial activity is environmental pollution. At the European level, there are several statutes for the purposes of preventing and controlling pollution caused by industrial activity. The EU Industrial Emissions Directive (2010/75/EU)⁵⁶⁶ lays down

⁵⁶¹ Land Use Consultants (2011). An assessment of the impacts of climate change on Scottish landscapes and their contribution to quality of life: Phase 1 - Final report. Scottish Natural Heritage Commissioned Report No. 488. Available at: <https://www.nature.scot/sites/default/files/2017-08/Publication%202012%20-%20SNH%20Commissioned%20Report%20488%20-%20An%20assessment%20of%20the%20impacts%20of%20climate%20change%20on%20Scottish%20landscapes%20and%20their%20contribution%20to%20quality%20of%20life%20-%20Final%20report%20-%20reduced%20size.pdf>

⁵⁶² KPMG, 2016. Economic Impact Assessment and Scenario Development of Unconventional Oil and Gas in Scotland – A Report for the Scottish Government. Available at: <http://www.gov.scot/Resource/0050/00509321.pdf>

⁵⁶³ Ineos Shale (2017) Planning Statement Land Adjacent to Bramley Moor Lane, Marsh Lane. Available at: <https://www.ineos.com/globalassets/ineos-group/businesses/ineos-shale/our-operations/bramleymoore-lane/pedl-doc/pedl-300-1-doc-6-planning-statement.pdf>

⁵⁶⁴ KPMG, 2016. Economic Impact Assessment and Scenario Development of Unconventional Oil and Gas in Scotland – A Report for the Scottish Government. Available at: <http://www.gov.scot/Resource/0050/00509321.pdf>

⁵⁶⁵ SEPA, 2016. *Guidance on consideration of material assets in Strategic Environmental Assessment*. Available at: <https://www.sepa.org.uk/media/219432/lups-sea-gu4-consideration-of-material-assets-in-sea.pdf>

⁵⁶⁶ European Commission, 2010. Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control). Available at: <http://eur-lex.europa.eu/legal-content/NL/TXT/?uri=CELEX%3A32010L0075>

rules on integrated prevention and control of pollution arising from industrial activities. It also sets out legislation designed to prevent or reduce emissions into land to prevent the generation of waste. The Directive has been transposed into Scots law through the Pollution Prevention and Control (Scotland) Regulations 2012 (as amended)⁵⁶⁷. In addition, the Environmental Liability Directive (2004/35/CE)⁵⁶⁸ establishes a framework based on the 'polluter pays principle' and remedy environmental damage. At the national level, the Environmental Liability Directive was made into Scots law through the Environmental Liability (Scotland) Regulations 2009 (as amended)⁵⁶⁹ which sets out an environmental protection legislative framework which is based on the 'polluter pays principle'. However, the Regulations do not apply to all types of damage to the environment. The types of significant damage are: damages to protected species or habitats, impacts on surface water or ground water and impacts on land.

Waste generated by industrial activity is a further concern in relation to the protection of human health and the environment from the harmful impacts caused by industry. As with pollution, there is European legislation in place to prevent or control the environmental impacts of waste associated with industry. The EU Waste Framework Directive (2008/98/EC)⁵⁷⁰ sets out legislation to prevent or reduce waste production and its harmfulness on the wider environment. One of the primary objectives of the Directive is to ensure that waste is recovered or disposed of without endangering human health and without using processes that could harm the environment. The Directive has been transposed into UK law through the Environmental Protection Act 1990⁵⁷¹. In addition, the EU Management of Waste from Extractive Industries (2006/21/EC)⁵⁷² aims to prevent water and soil pollution from the deposition of waste by ensuring the long-term stability of waste facilities. The Management of Extractive Waste (Scotland) 2010 Regulations⁵⁷³, also known as 'MEW', implements the Directive and sets out conditions for granting planning permission for extractive waste areas and waste facilities, along with additional requirements for category A (high risk) waste facilities.

Unconventional oil and gas development is classed as a Naturally Occurring Radioactive Materials (NORM) Industrial Activity, as NORM materials are concentrated through such operations. NORM wastes can present significant radiotoxic and chemotoxic hazards, and often result in the concentration of other pollutants such as heavy metals and organic compounds. Environmental legislation

⁵⁶⁷ The Pollution Prevention and Control (Scotland) Regulations 2012 (Scottish Statutory Instrument 2012/360)

⁵⁶⁸ European Commission, 2004. Directive 2004/35/CE of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage. Available at:

<http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32004L0035>

⁵⁶⁹ The Environmental Liability (Scotland) Regulations 2009 (Scottish Statutory Instrument 2009/266)

⁵⁷⁰ European Commission, 2008. Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives. Available at: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32008L0098>

⁵⁷¹ Environmental Protection Act 1990 (Chapter 43)

⁵⁷² European Commission, 2006. Directive 2006/21/EC of the European Parliament and of the Council of 15 March on the management of waste from extractive industries and amending Directive 2004/35/EC. Available at:

<http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02006L0021-20090807>

⁵⁷³ The Management of Extractive Waste (Scotland) 2010 Regulations (Scottish Statutory Instrument 2010 No. 60)

across the UK is designed to control these hazards⁵⁷⁴. The Radioactive Substances Act 1993 (as amended)⁵⁷⁵ which sets out regulations for the control of radioactive materials and the disposal of radioactive waste in the UK.

Other relevant policies concern the impacts of industrial activities on mineral resources. For example, the Planning Advice Note (PAN) 64 – Reclamation of Surface Mineral Workings (2003)⁵⁷⁶ provides guidance for local authorities to ensure that mineral workings are reclaimed to an acceptable environmental condition as after operations have ceased.

Current state

The state of Scotland's environment is well-recorded, in relation to the availability mineral resources, soils and past records of industry-related major accidents.

- Peatland soils make up a significant portion of Scotland's land surface. Blanket bog is the most widespread and semi-natural peatland type in Scotland – extending to over 1.5 million hectares, which equals to about 20% of Scotland's land area of 7.8 million hectares⁵⁷⁷. Peat is a major mineral resource in Scotland, and is extracted for a number of reasons: compost production for horticulture, fuel and for use during 'kilning' in the whiskey industry. Information on the extent of peat extraction⁵⁷⁸ shows that approximately 5.5% of Scotland's blanket bogs show evidence of peat cutting.
- The Central Belt of Scotland contains a wide range of minerals including a highly productive coalfield, extensive igneous rock aggregate quarries and significant deposits of sand, gravel and clay. These mineral resources are finite assets. It is therefore important to ensure that minerals are used in the most efficient and sustainable manner⁵⁷⁹.
- Quantities of waste disposed by landfill or incineration show an overall decreasing trend. In 2016, there were 3.8 million tonnes of waste disposed by landfill or incineration. This is a decrease of 463,397 tonnes (10.8%) from 2015. The waste type with the largest amount disposed in 2016 was Household and similar waste followed by Soils, and sorting residues. In 2016, the main category of hazardous waste generated was Chemical wastes (106,018 tonnes, 23.0% of all hazardous waste) followed by Industrial

⁵⁷⁴ Scottish Government, 2014. Strategy for the management of Naturally Occurring Radioactive Material (NORM) waste in the United Kingdom. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/335821/Final_strategy_NORM.pdf

⁵⁷⁵ Radioactive Substances Act 1993 (Chapter 12)

⁵⁷⁶ Scottish Government, 2002. *Planning Advice Note 64: Reclamation of Surface Mineral Workings*. Available at: <http://www.gov.scot/Resource/Doc/47021/0026442.pdf>

⁵⁷⁷ Scottish Government, 2010. *Executive Summary: Management of Carbon-Rich Soils – Overview and Discussion Paper*. Available at: <http://www.gov.scot/Resource/Doc/921/0109512.pdf>

⁵⁷⁸ Scottish Government, 2012. *SPICe Briefing – Peatlands and Climate Change*. Available at: http://www.parliament.scot/ResearchBriefingsAndFactsheets/S4/SB_12-28.pdf

⁵⁷⁹ Scottish Government, 2008. *A guide to minerals information in the Central Belt of Scotland*. Available at: <http://www.gov.scot/Publications/2008/05/27155411/1>

effluent sludges (52,596 tonnes, 11.4%) and Spent solvents (52,181 tonnes, 11.3%)⁵⁸⁰.

- There has been a positive trend in water pollution in Scotland's rivers, the proportion of river length classed as unpolluted rose from 83.3% in 2013 to 85.1% in 2016⁵⁸¹.

Existing pressures

It is difficult to identify key threats relating to this SEA topic given the localised nature of such impacts.

- New development could sterilise sites and reduce access to mineral resources.
- Land-use changes could adversely impact upon the quality of peatland habitats and other carbon-rich soils. New development is very likely to lead to the excavation or drainage of peatland and other carbon-rich soils, which in turn could result in increased greenhouse gas emissions from these soils⁵⁸².

Potential pressures associated with unconventional oil and gas development

Present scientific evidence has identified a number of potential pressures on material assets associated with unconventional oil and gas development.

- There is a possible risk of groundwater contamination through any escape of 'flowback water' into the ground. Typically 25-75% of the water injected during hydraulic fracturing returns to the surface as wastewater, or flowback fluid. As such flowback fluids may contain chemical additives associated with hydraulic fracturing, naturally occurring radioactive materials (NORM), inorganic materials and organic matter⁵⁸³. However, the risk of flowback water getting contaminated by NORM will be influenced by the specific geology that is being exploited. Evidence from the US and preliminary results from exploration activities in the UK shows that concentration of natural radionuclides in flowback waters generated by unconventional oil and gas operations is likely to be higher than those found in 'conventional' produced waters⁵⁸⁴.

⁵⁸⁰ Scottish Environment Protection Agency (2016) Waste from all sources – Summary data 2016. Available at: https://www.sepa.org.uk/media/356705/wfas_2016_official_statistics.pdf

⁵⁸¹ Scottish Government high level summary statistics River Water Quality. Last updated October 2017. Available at: <https://www.gov.scot/Topics/Statistics/Browse/Environment/TrendRiverWater>

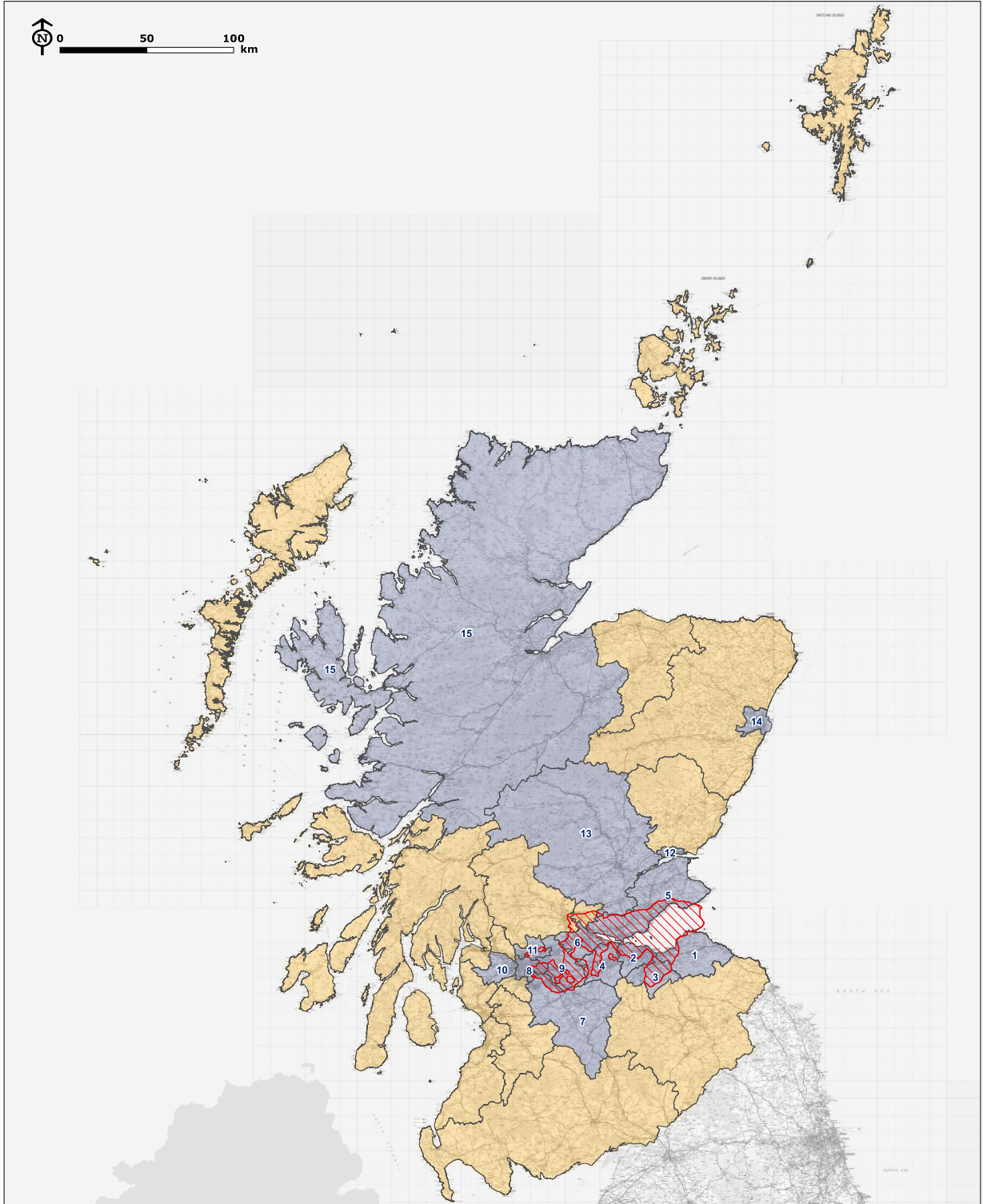
⁵⁸² Scottish Government, 2010. Executive Summary: Management of Carbon-Rich Soils – Overview and Discussion Paper. Available at: <http://www.gov.scot/Resource/Doc/921/0109512.pdf>

⁵⁸³ Scottish Government, 2014. *Independent Expert Scientific Panel – Report on Unconventional Oil and Gas*. Available at: <http://www.gov.scot/Resource/0045/00456579.pdf>

⁵⁸⁴ Scottish Government, 2014. *Strategy for the management of Naturally Occurring Radioactive Material (NORM) waste in the United Kingdom*. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/335821/Final_strategy_NORM.pdf

- Poorly constructed and decommissioned oil and gas wells can develop leaks along the casing after production has ceased. Such leaks often take years to unfold after decommissioning, allowing hydrocarbons and other well fluids to eventually migrate out of the well and into the environment. During the decommissioning stage, there is also the risk of leaks in tanks and pipework which could potentially contaminate the ground⁵⁸⁵.

⁵⁸⁵ Aecom, 2016. Unconventional Oil and Gas Development in Scotland: Decommissioning, Site Restoration and Aftercare – Obligations and Treatment of Financial Liabilities. Available at: <http://www.gov.scot/Resource/0050/00509373.pdf>



- Local Authority boundary
- Prospecting area (indicative)
- No current Air Quality Management Area (AQMA)
- AQMA currently declared

- 1: East Lothian
- 2: City of Edinburgh
- 3: Midlothian
- 4: West Lothian
- 5: Fife
- 6: Falkirk
- 7: South Lanarkshire
- 8: Glasgow City
- 9: North Lanarkshire
- 10: Renfrewshire
- 11: East Dunbartonshire
- 12: Dundee City
- 13: Perth and Kinross
- 14: Aberdeen City
- 15: Highland

SEA
Onshore Unconventional Oil and Gas

Figure 1: Local Authorities with Declared Air Quality Management Area

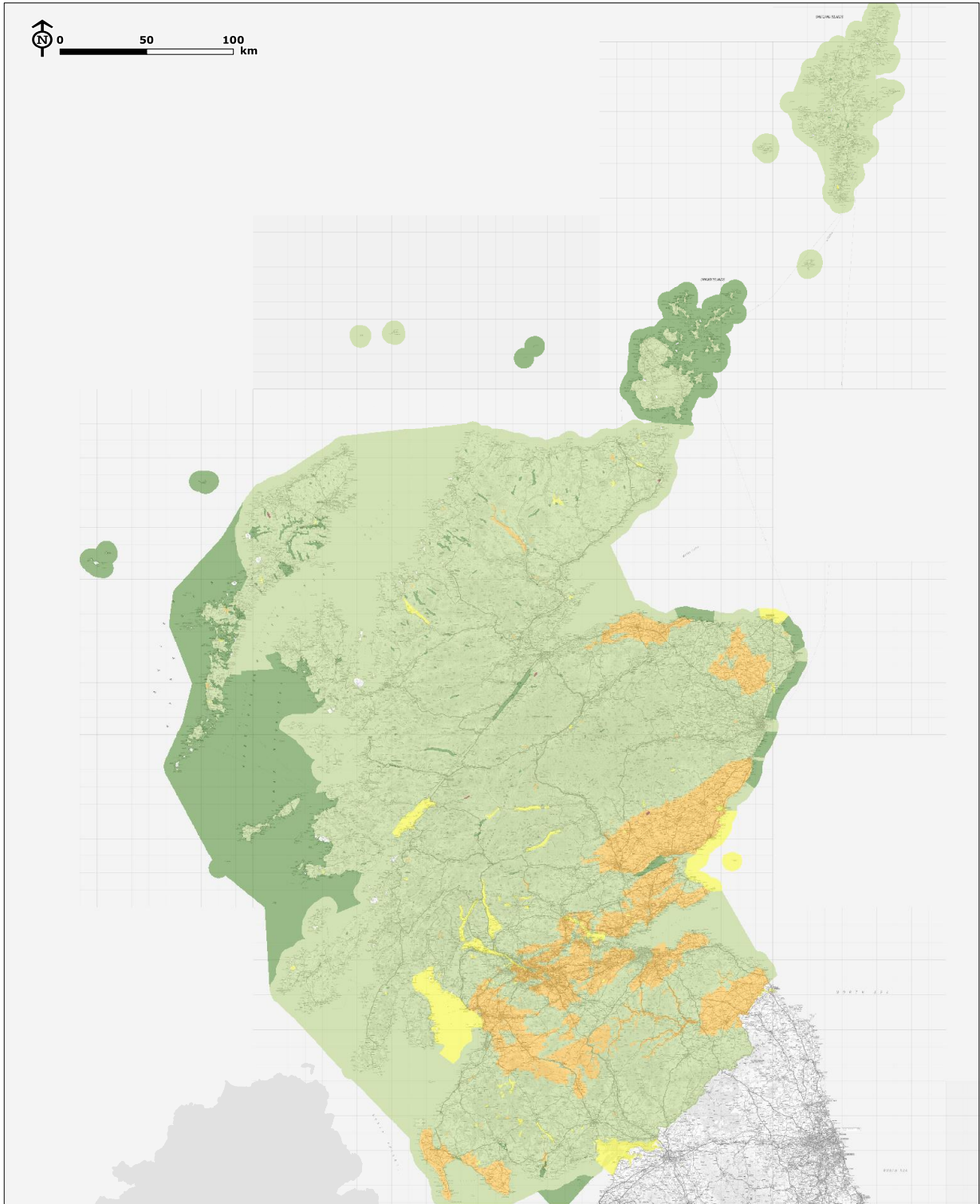
Source: SG, AQMA 2018 - Ricardo

Map Scale @A3: 1:2,150,000



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Water condition classification

- High
- Good
- Moderate
- Poor
- Bad

Source: SEPA (coastal, loch, estuary and groundwater 2014 classification)

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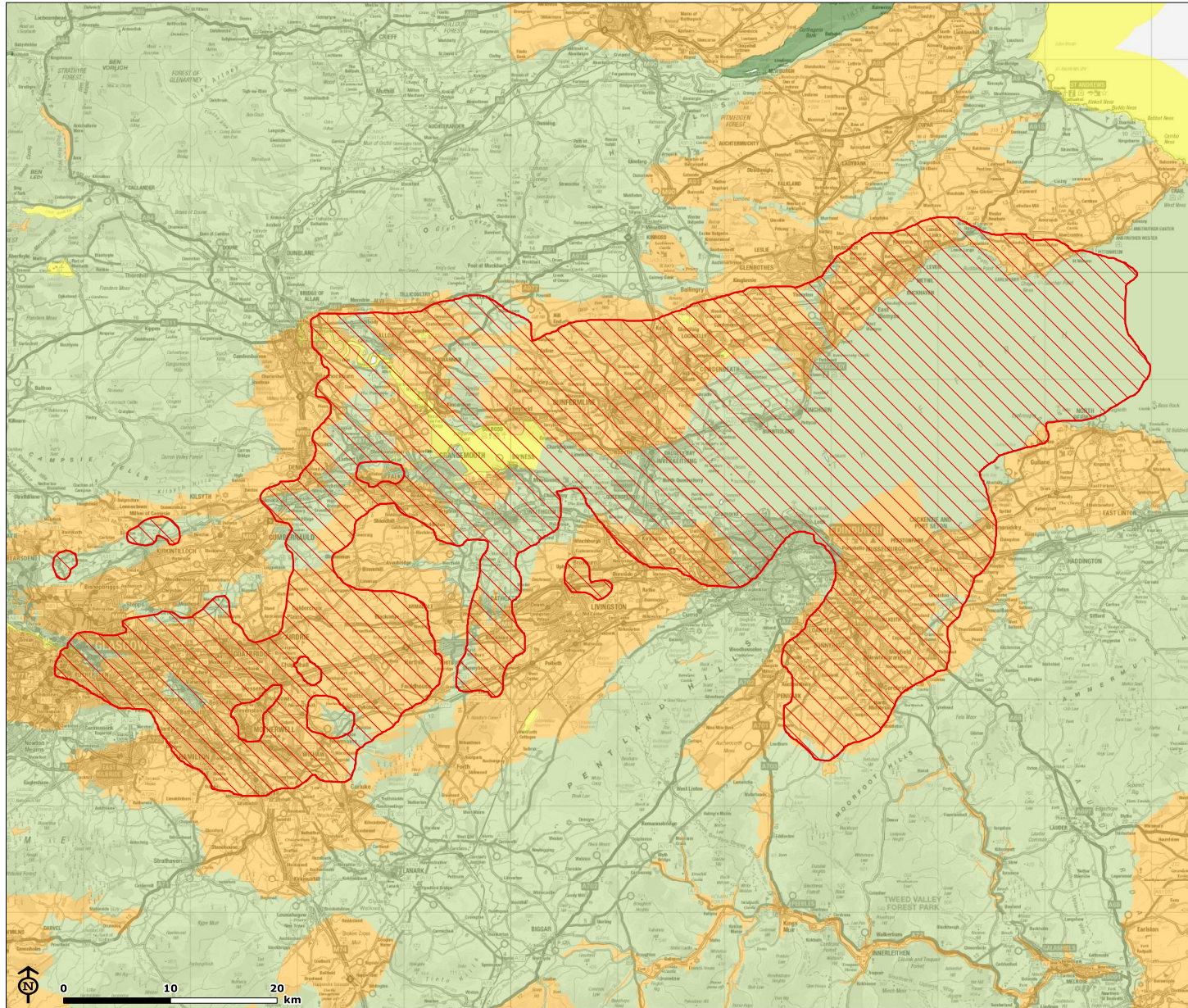
**Figure 2a: Water Condition in
Scotland**



Map Scale @A3: 1:2,150,000







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Figure 2b: Water Condition within Indicative Prospecting Area

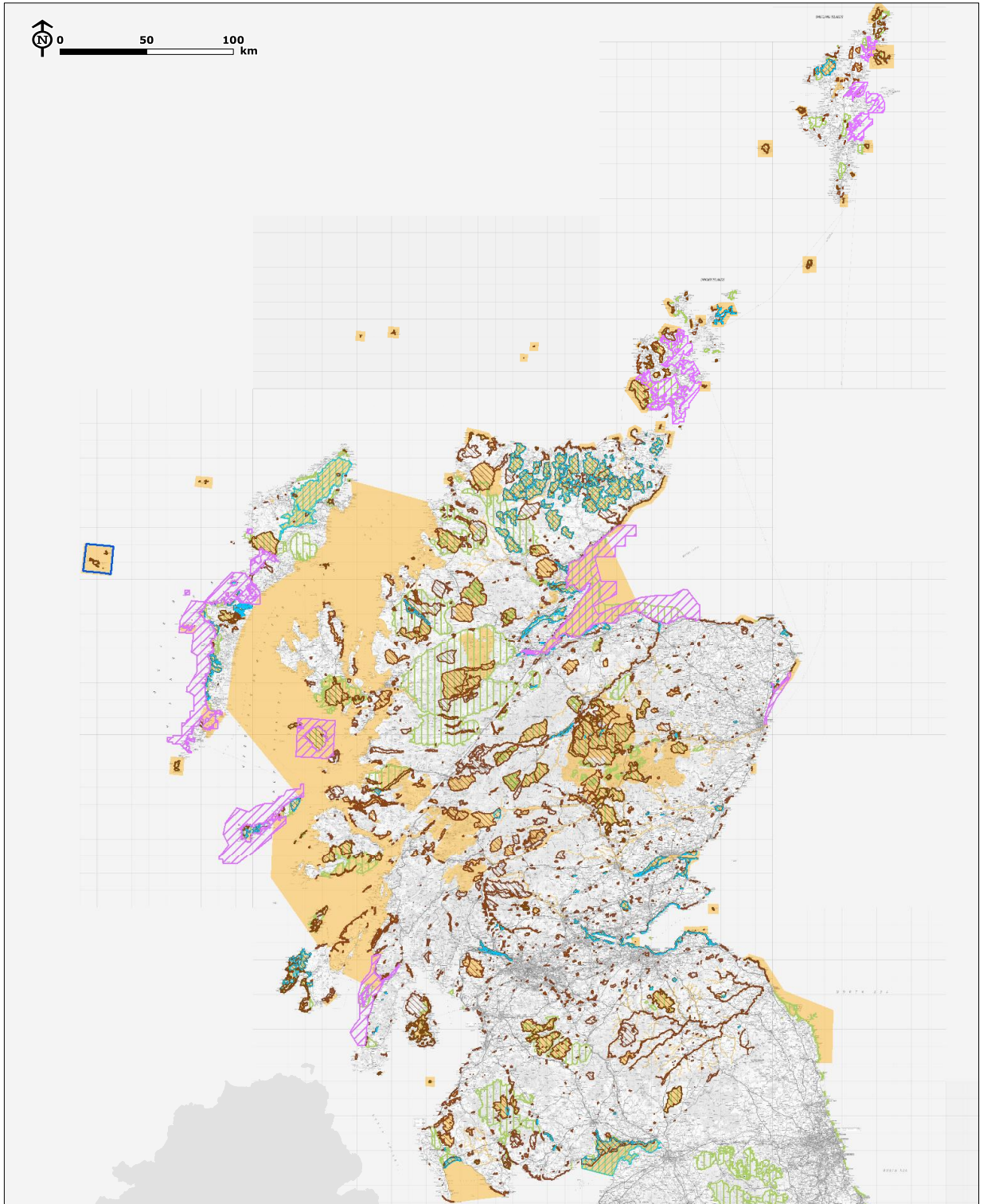
-  Prospecting area (indicative)
- Water condition classification**
-  High
-  Good
-  Moderate
-  Poor
-  Bad

Map Scale @A3: 1:350,000



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CB-EL EB-Iendak_e LUC FIG2b_10225_r2_WaterCntrl_A3P 03/09/2018 Source: SG, SEPA (coastal, loch, estuary and groundwater 2014 classification)



- World Heritage Site (St Kilda)
- Ramsar site
- Natura 2000 sites
(Special Area of Conservation and Special Protection Area)
- Proposed Special Protection Area
- Important Bird Area
- National designations including
National Nature Reserves
and Sites of Special Scientific Interest

Source: SNH, RSPB

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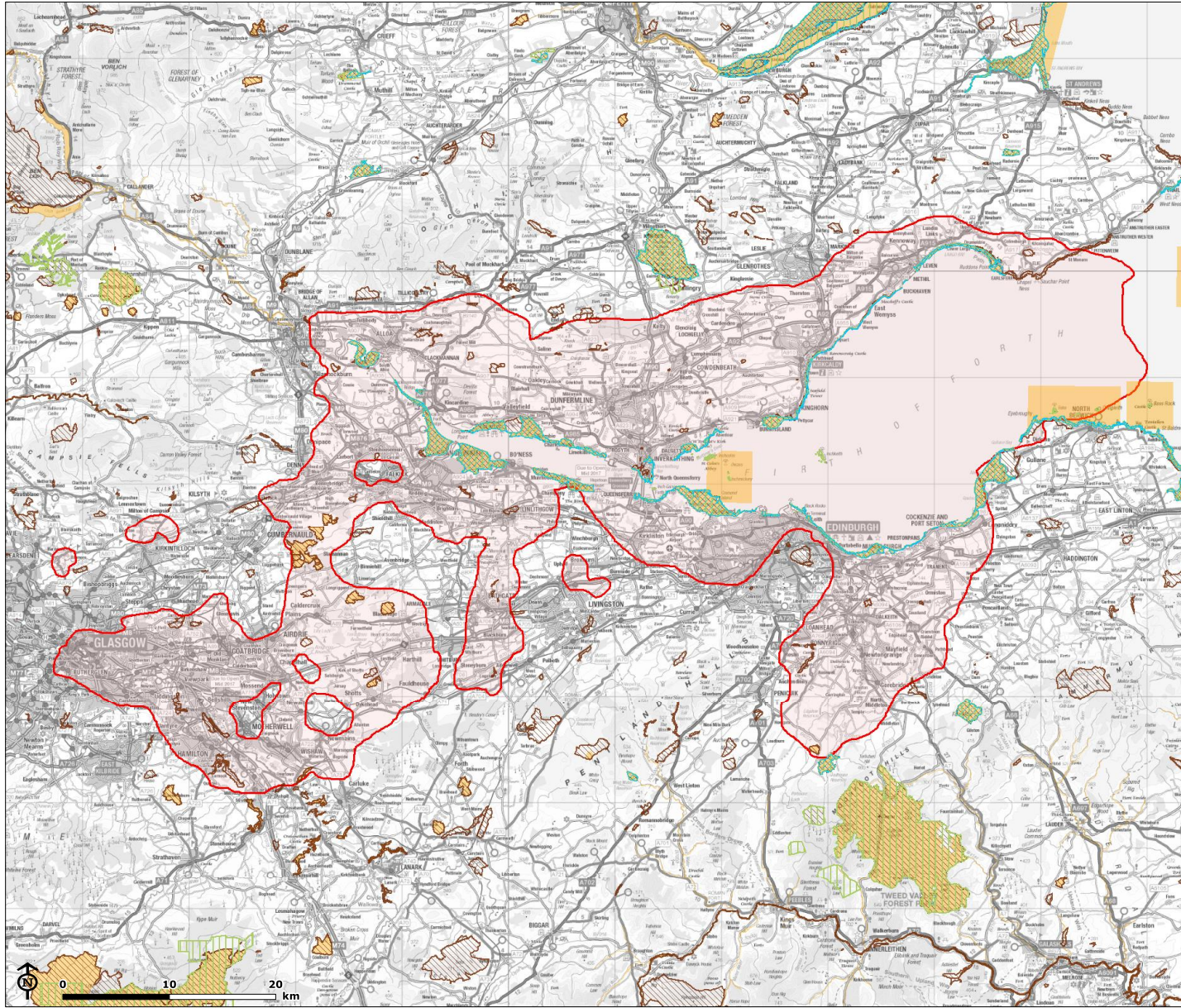
Figure 3a: Natural Heritage in Scotland

LUC
The Scottish
Government

Map Scale @A3: 1:2,150,000

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Figure 3b: Natural Heritage within Indicative Prospecting Area

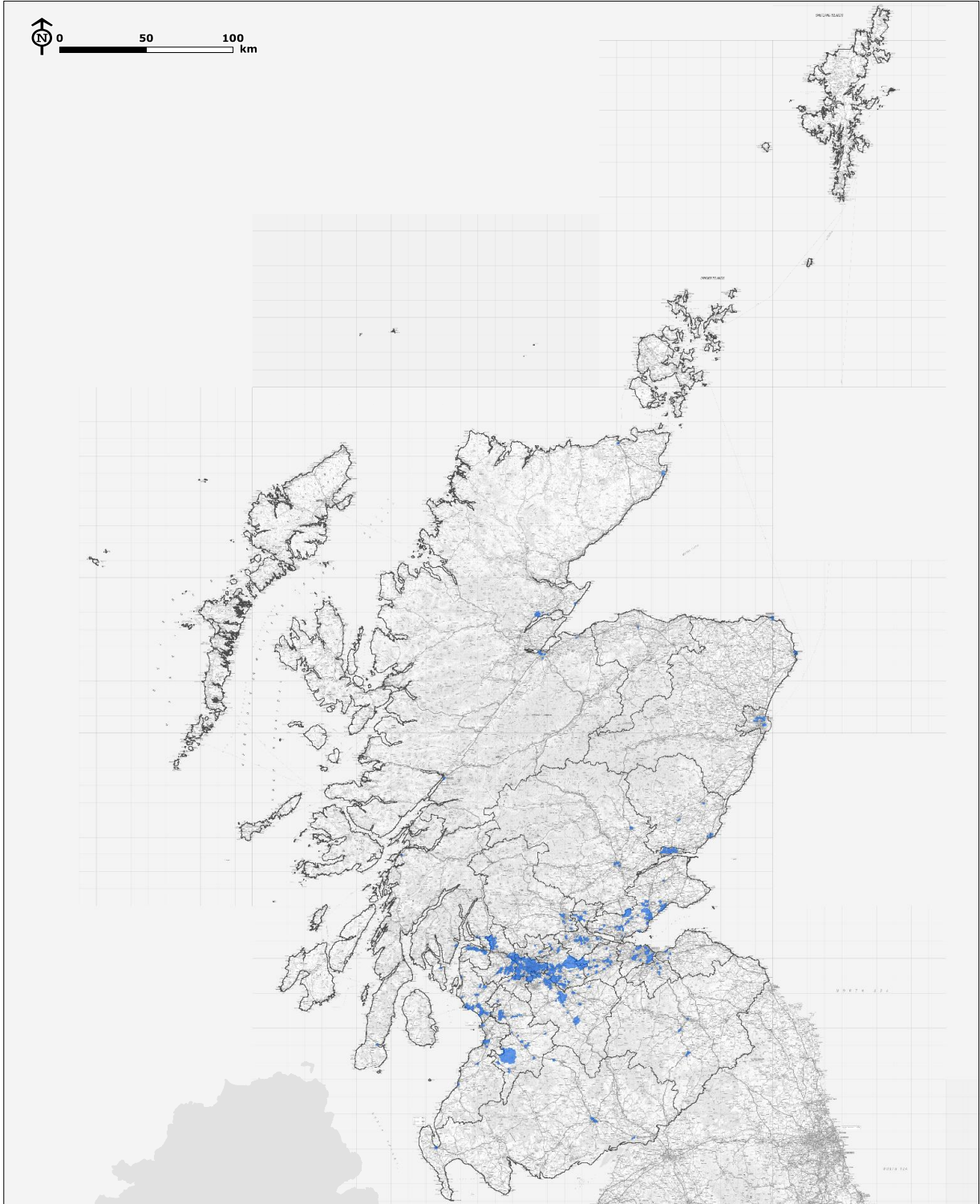
- Prospecting area (indicative)
- Ramsar site
- Natura 2000 sites (Special Area of Conservation and Special Protection Area)
- Important Bird Area
- National designations including National Nature Reserves and Sites of Special Scientific Interest



Map Scale @A3: 1:350,000



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CB:EL EB:Hendak_e LUC FIG3b_10225_r2_NaturalHrtgCntrl_A3P 03/09/2018 Source: SG, SNH, RSPB



-  Local Authority boundary
-  Index of multiple deprivation (20% most deprived areas)

SEA
Onshore Unconventional Oil and Gas

Figure 4a: Overall Deprivation in Scotland

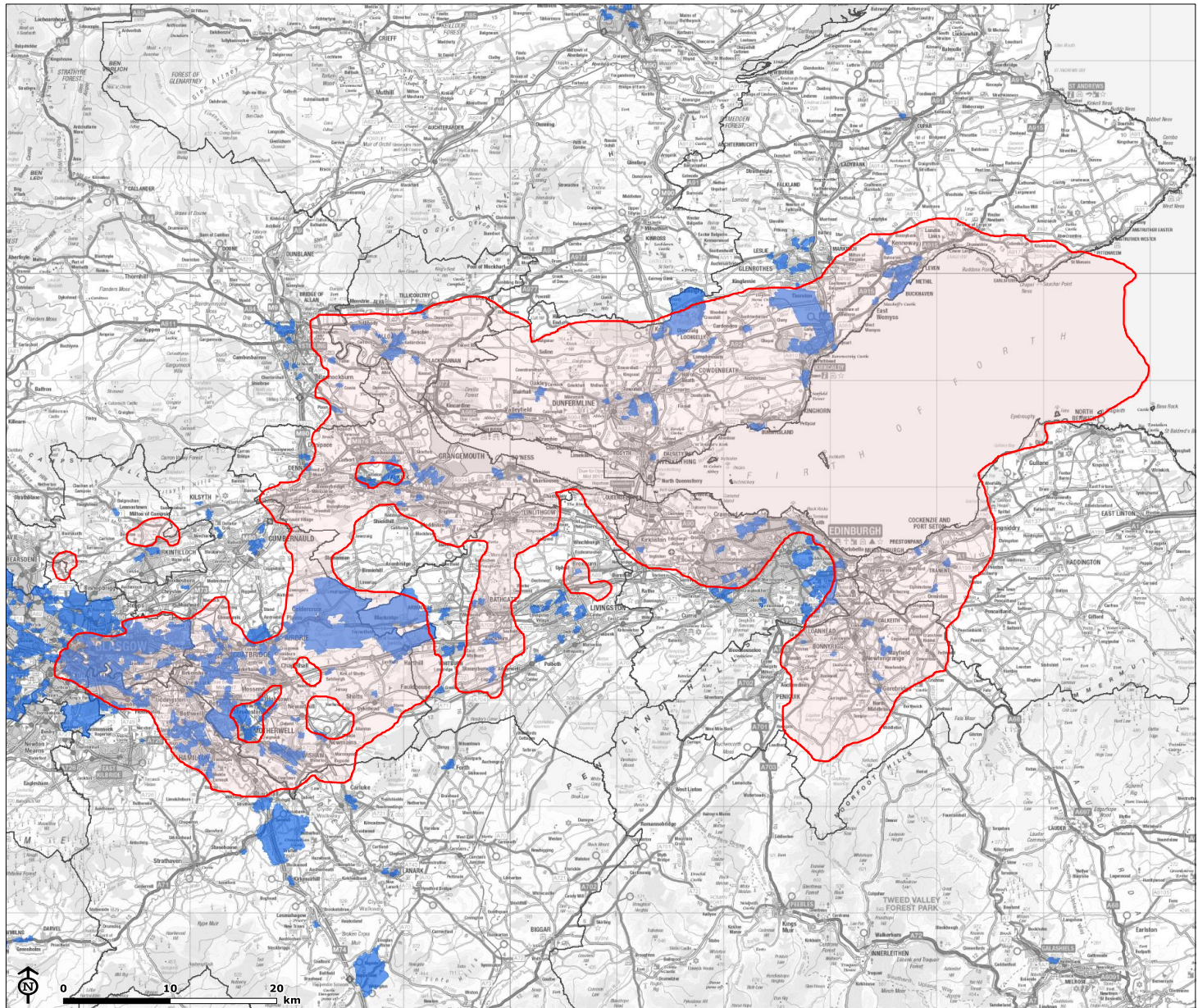
Source: SG (SIMD 2016)

Map Scale @A3: 1:2,150,000



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CB:EL EB:lendak_e LUC FIG4a_10225_r2_IMDsc_A3P 03/09/2018




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**Figure 4b: Overall Deprivation
within Indicative Prospecting Area**

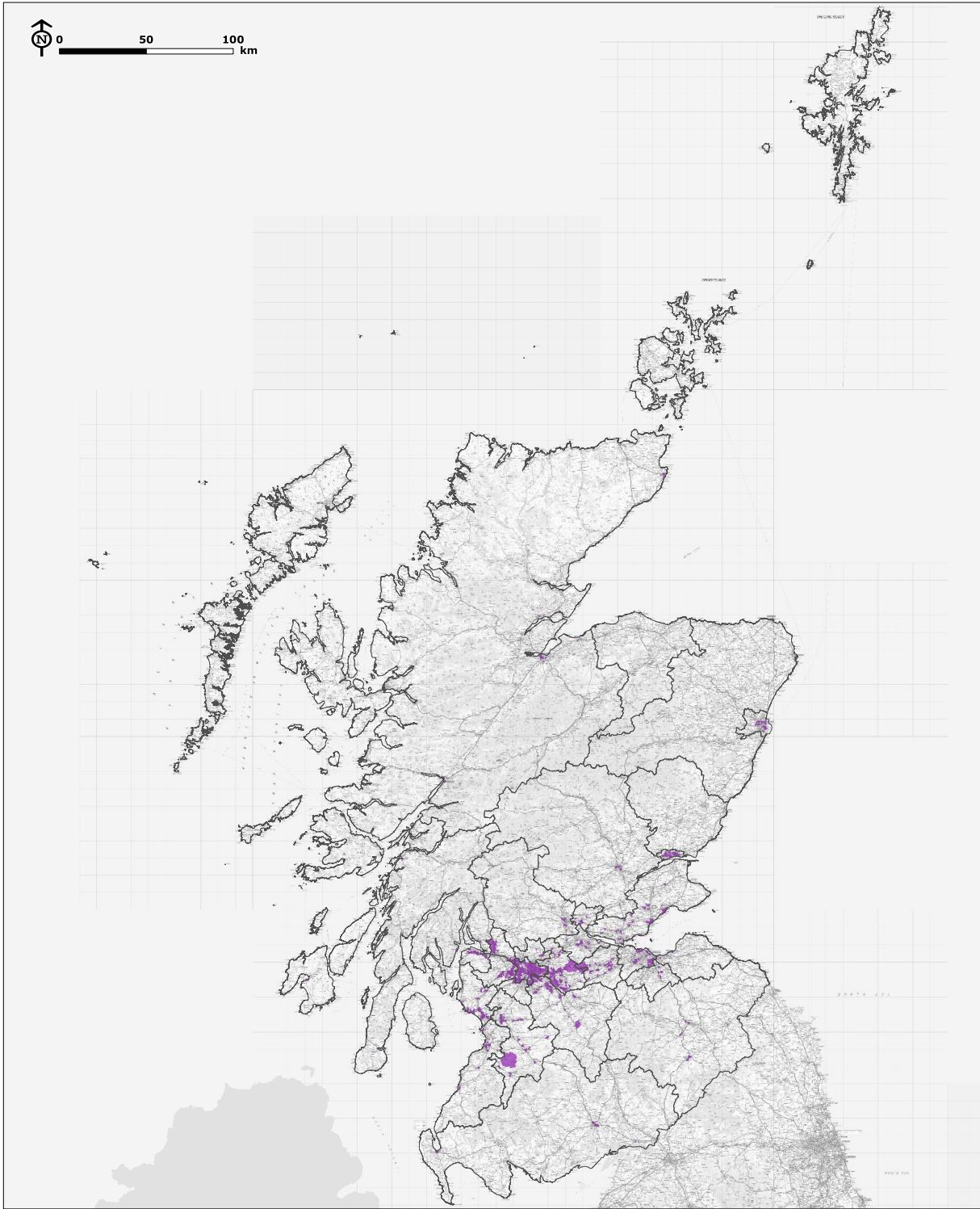
- Prospecting area (indicative)
- Local Authority boundary
- Index of multiple deprivation (20% most deprived areas)



Map Scale @A3: 1:350,000

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CB:EL EB:lendak_e_LUC FIG4b_10225_r2_IMDCntrl_A3P 03/09/2018 Source: SG (SIMD 2016)



-  Local Authority boundary
-  Index of health deprivation (20% most deprived areas)

SEA
Onshore Unconventional Oil and Gas

Figure 5a: Health Deprivation in Scotland

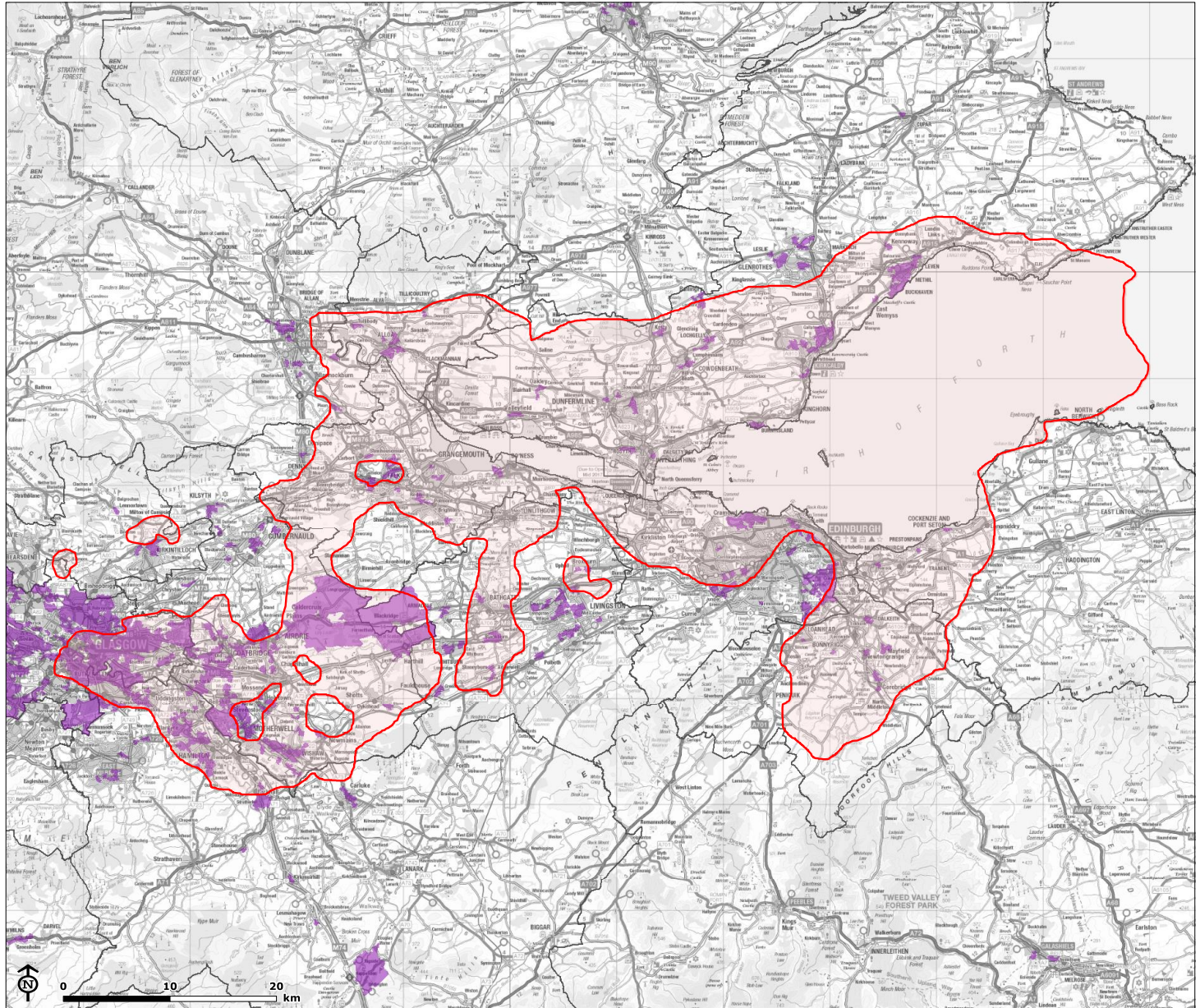
Source: SG (SIMD 2016)

Map Scale @A3: 1:2,150,000



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CB:EL EB:lenda_k_e LUC FIG5a_10225_r2_IMDHealthSco_A3P 03/09/2018



SEA
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Oil and Gas

**Figure 5b: Health Deprivation
within Indicative Prospecting Area**

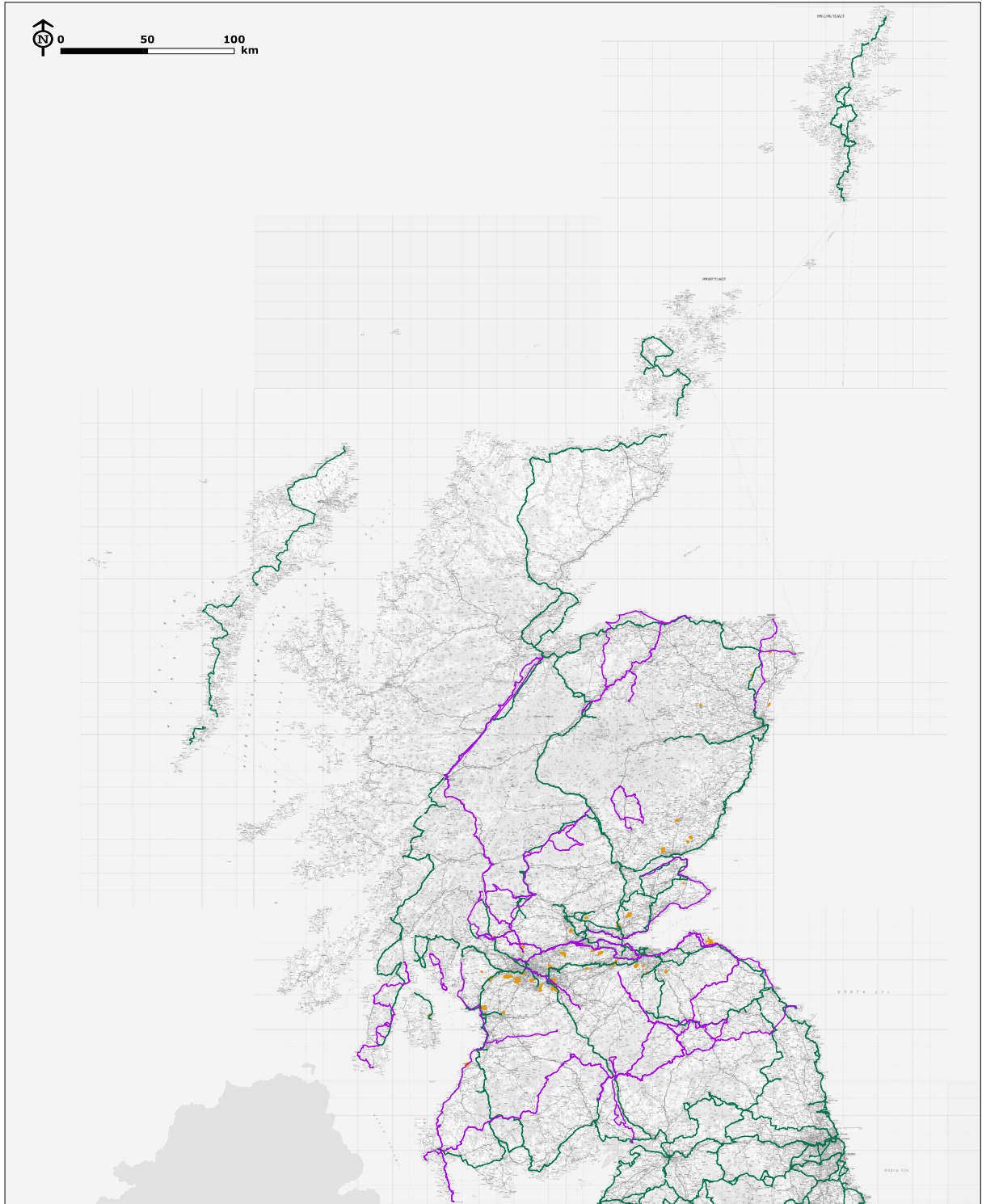
- Prospecting area (indicative)
- Local Authority boundary
- Index of health deprivation (20% most deprived areas)

Map Scale @A3: 1:350,000



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CB:EL:EB:lendak_e_LUC FIG5b_10225_r2 IMDHealthCntrl_A3P 03/09/2018 Source: SG (SIMD 2016)



- National Cycle Network
- Scottish Great Trails**
- Country Park

** Indicative data
 Source: NCN - Sustrans, SGT and CP - SNH

SEA
 Onshore Unconventional
 Oil and Gas

Figure 6a: Recreational Routes in Scotland

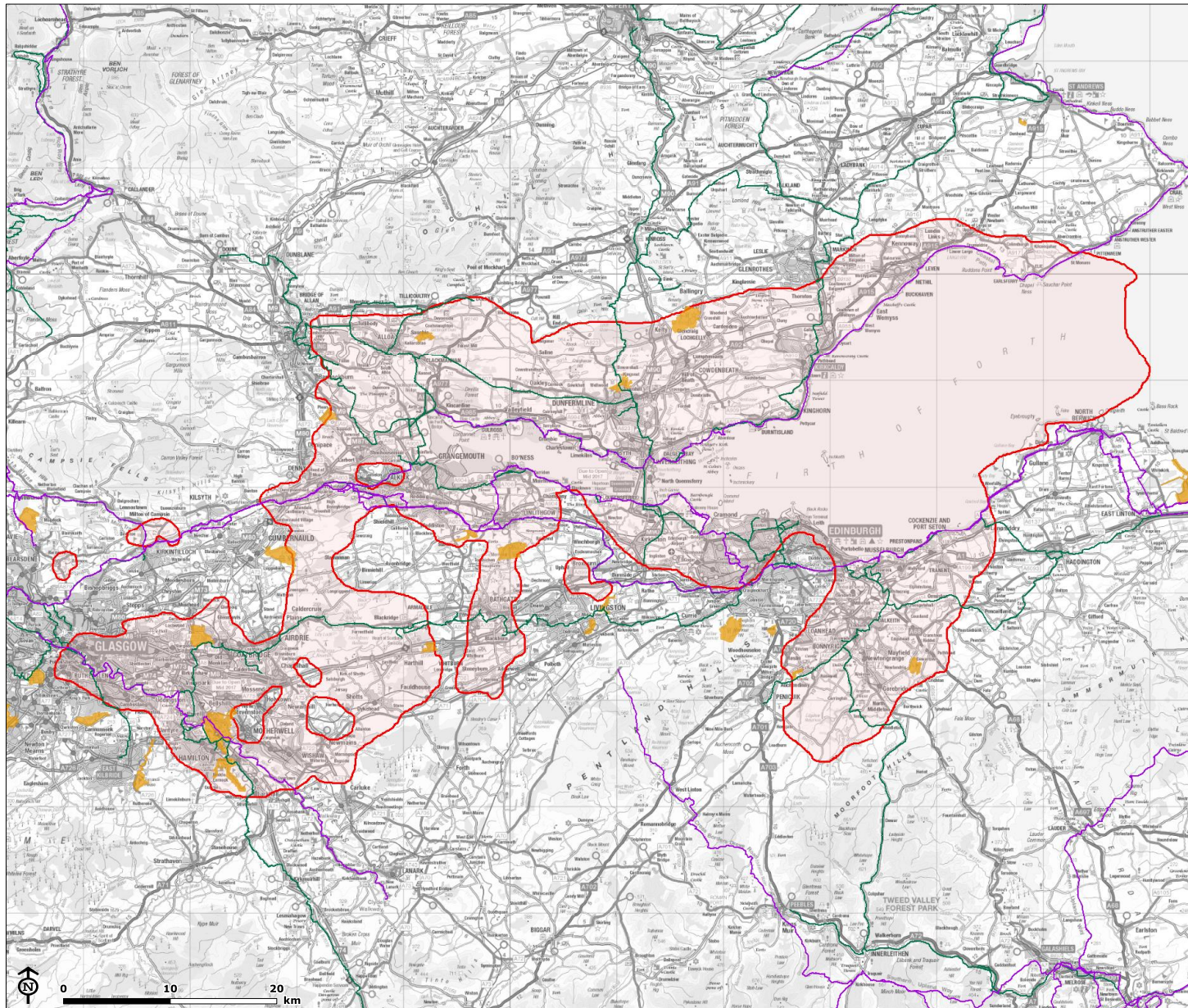
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Map Scale @A3: 1:2,150,000

CB:EL EB:lendak_e LUC FIG6a_10225_r2_RecreationSco_A3P 03/09/2018

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SEA
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**Figure 6b: Recreational Routes
within Indicative Prospecting Area**

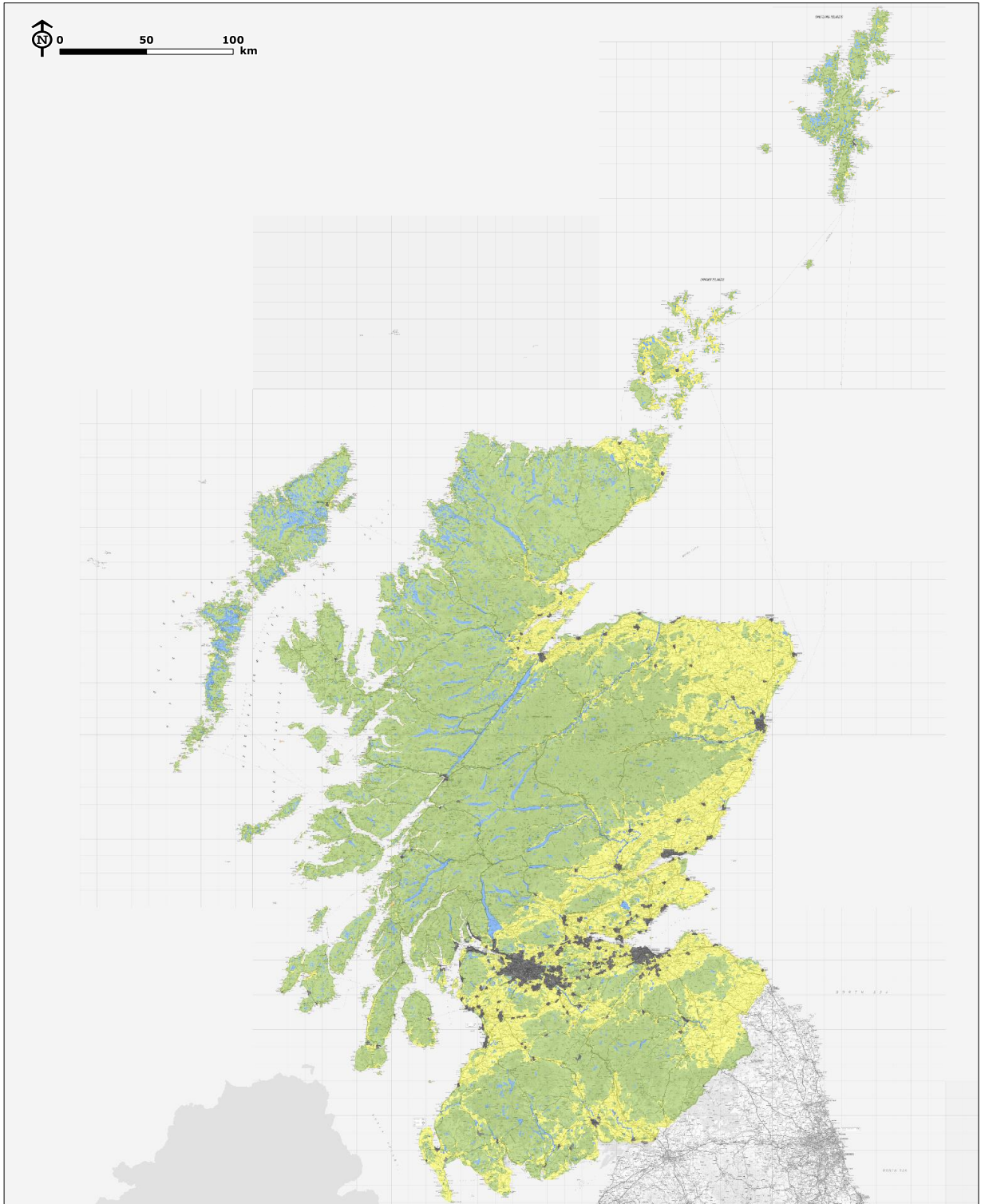
- ▭ Prospecting area (indicative)
- National Cycle Network
- Scottish Great Trails**
- ▭ Country Park

Map Scale @A3: 1:350,000



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Source: NCN - Sustrans, SGT and CP - SNH
** Indicative data



Land Capability for Agriculture

- Land suited to arable cropping (categories 1-4)
- Land suited only to improved grassland and rough grazing (categories 5-7)
- Built up area
- Inland water
- Undefined

Source: Land Capability for Agriculture 250K - Copyright James Hutton Institute.

SEA
Onshore Unconventional Oil and Gas

Figure 7a: Land Capability for Agriculture in Scotland

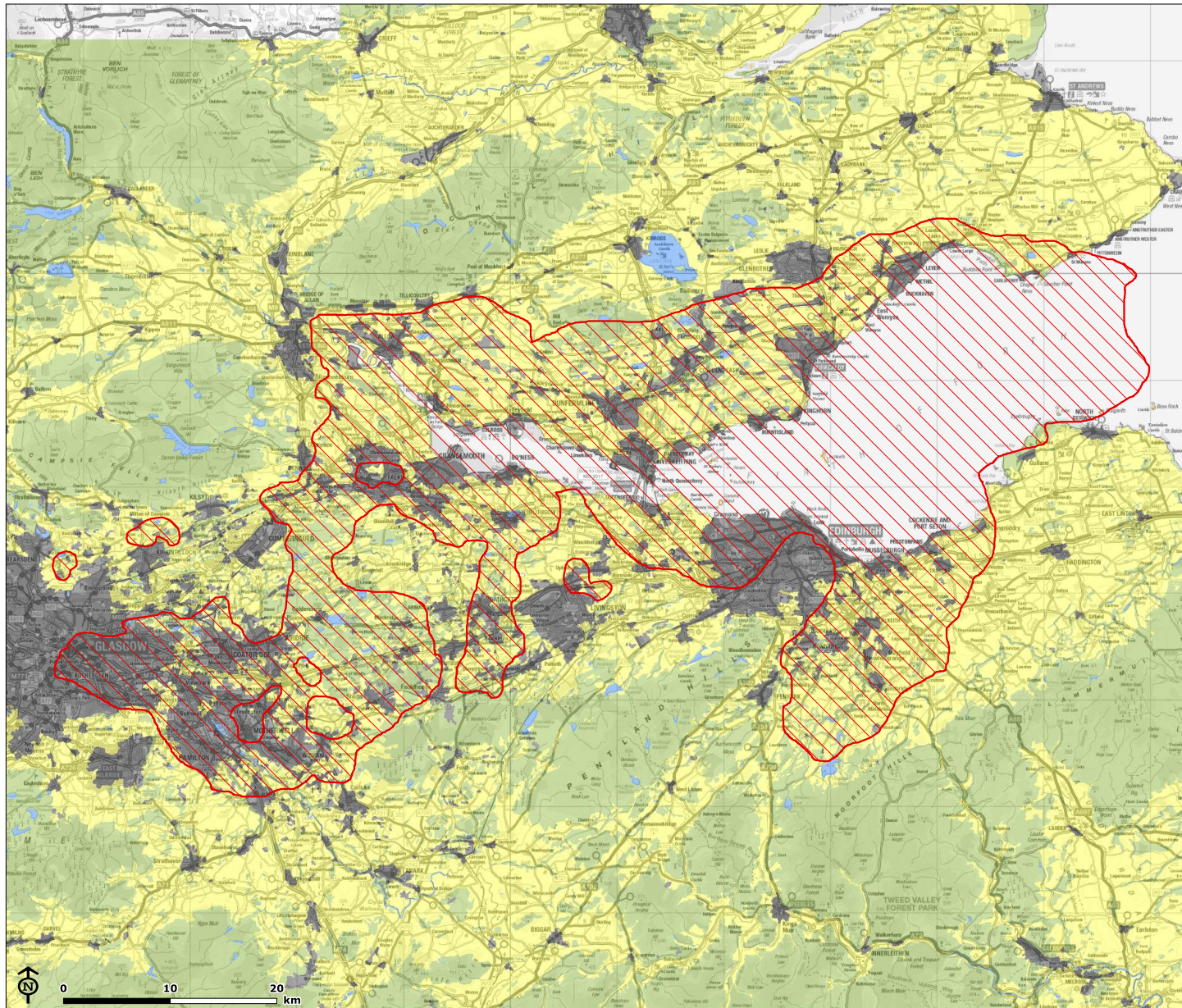
LUC



Map Scale @A3: 1:2,150,000

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CB:EL EB:lendaK_e LUC FIG7a_10225_r2_LCAgriSco_A3P 03/09/2018



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Oil and Gas

Figure 7b: Land Capability for Agriculture within Indicative Prospecting Area

Prospecting area (indicative)

Land Capability for Agriculture

- Land suited to arable cropping (categories 1-4)
- Land suited only to improved grassland and rough grazing (categories 5-7)
- Built up area
- Inland water
- Undefined

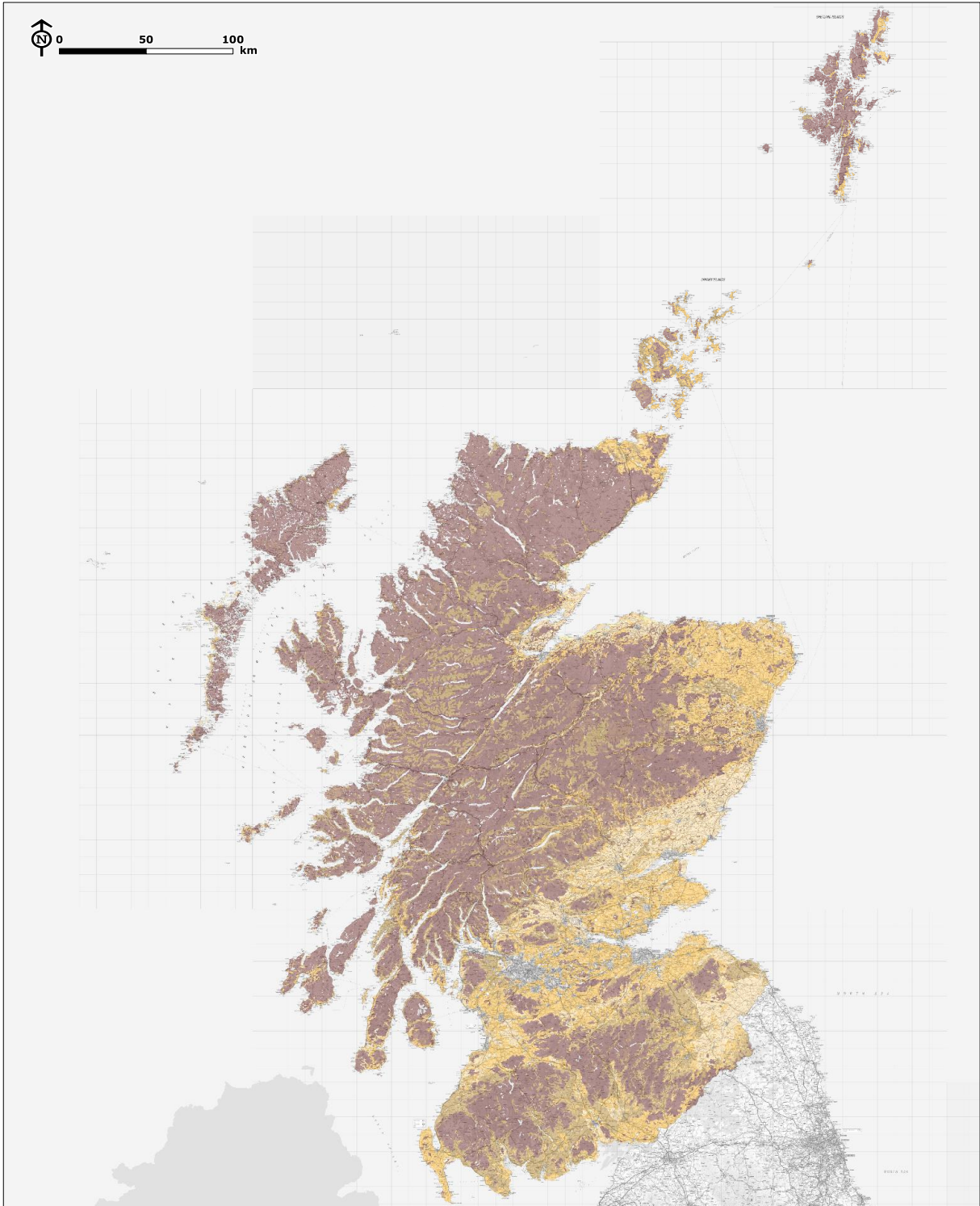
Map Scale @A3: 1:350,000



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CB:EL EB:lenda_k_e LUC FIG7b_10225_r2_LCAAgriCntr_A3P 03/09/2018

Source: SG, Land Capability for Agriculture 50K
Copyright James Hutton Institute.



Top soil organic carbon concentration

- Low (less than 1.5%)
- Moderate (between 1.5 and 3%)
- High (more than 3 to 5%)
- Humose (more than 5 to 12%)
- Organo-mineral (more than 12 to 35%)
- Organic (greater than 35%)

Source: Topsoil organic carbon concentration 250K - Copyright James Hutton Institute.

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Onshore Unconventional
Oil and Gas

**Figure 8a: Top Soil Organic
Carbon Concentration in Scotland**

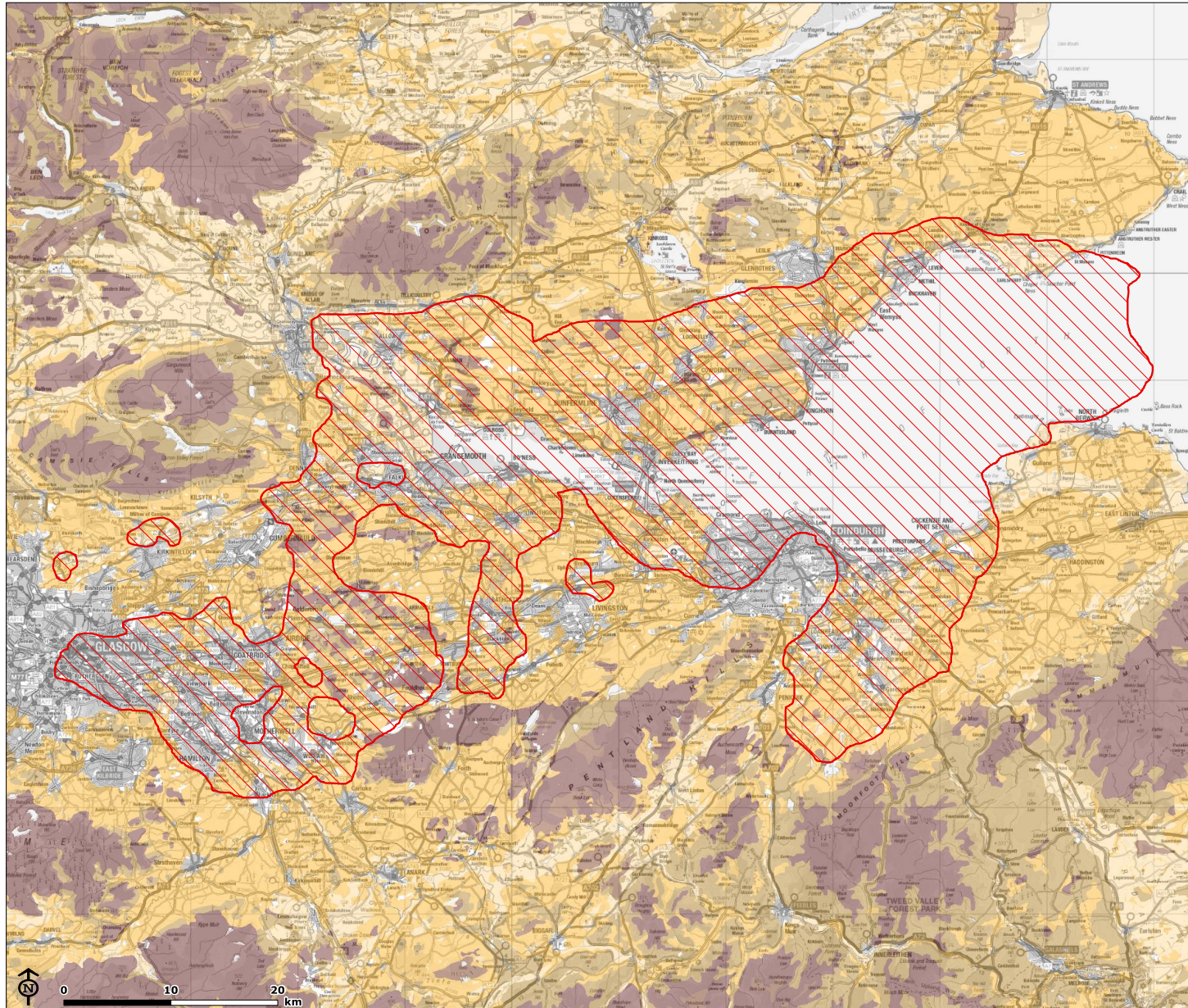
LUC



Map Scale @A3: 1:2,150,000








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CB:EL EB:lendak_e LUC FIG8a_10225_r2_OrgCarb5Co_A3P 03/09/2018



SEA
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Oil and Gas

Figure 8b: Top Soil Organic Carbon Concentration within Indicative Prospecting Area

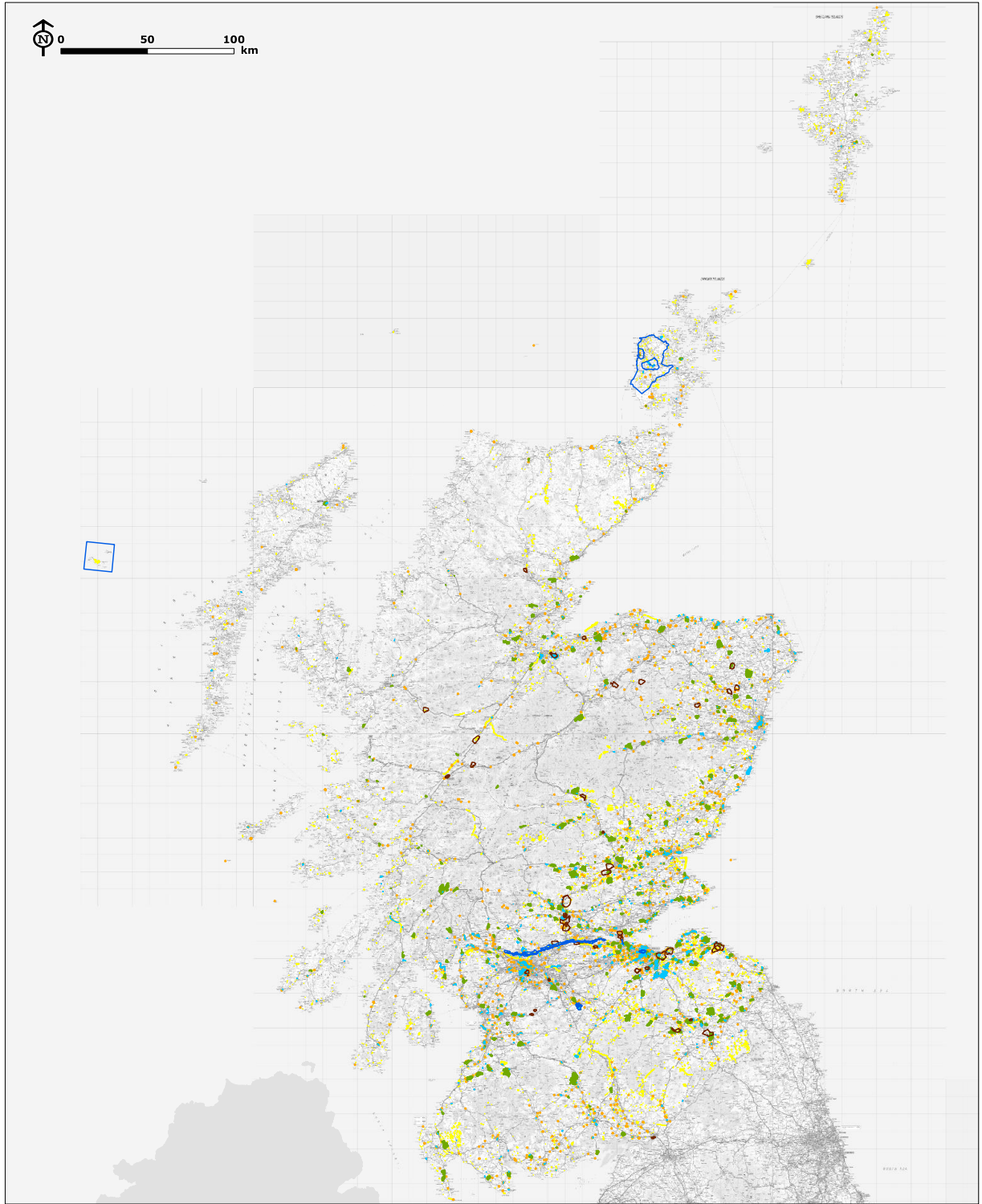
-  Prospecting area (indicative)
- Top soil organic carbon concentration**
-  Low (less than 1.5%)
-  Moderate (between 1.5 and 3%)
-  High (more than 3 to 5%)
-  Humose (more than 5 to 12%)
-  Organo-mineral (more than 12 to 35%)
-  Organic (greater than 35%)

Map Scale @A3: 1:350,000



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CB:EL EB:lendak_e LUC FIG8b_10225_r2_OrgCarbCtrl_A3P 03/09/2018 Source: SG, Topsoil organic carbon concentration 250K - Copyright James Hutton Institute.



- World Heritage Site
- Historic Battlefield
- Conservation Area
- Gardens and Designed Landscapes
- Scheduled Monument
- Listed Buildings (Grade A)

Source: Historic Scotland

Map Scale @A3: 1:2,150,000

SEA
Onshore Unconventional
Oil and Gas

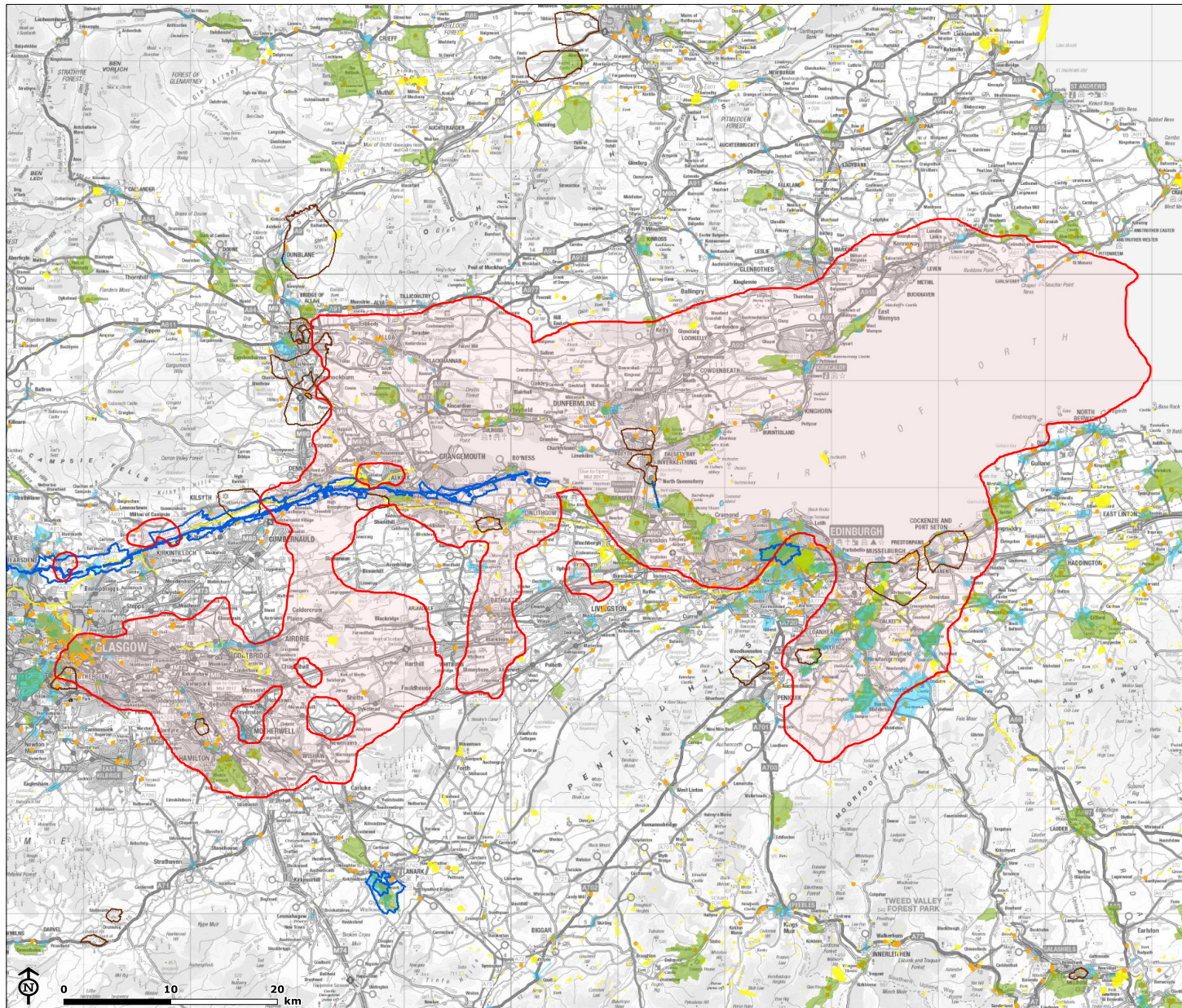
**Figure 9a: Cultural Heritage in
Scotland**

LUC



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CB:EL EB:lendak_e LUC FIG9a_10225_r2_CultHeritageSco_A3P 03/09/2018



SEA
Onshore Unconventional
Oil and Gas

Figure 9b: Cultural Heritage within Indicative Prospecting Area

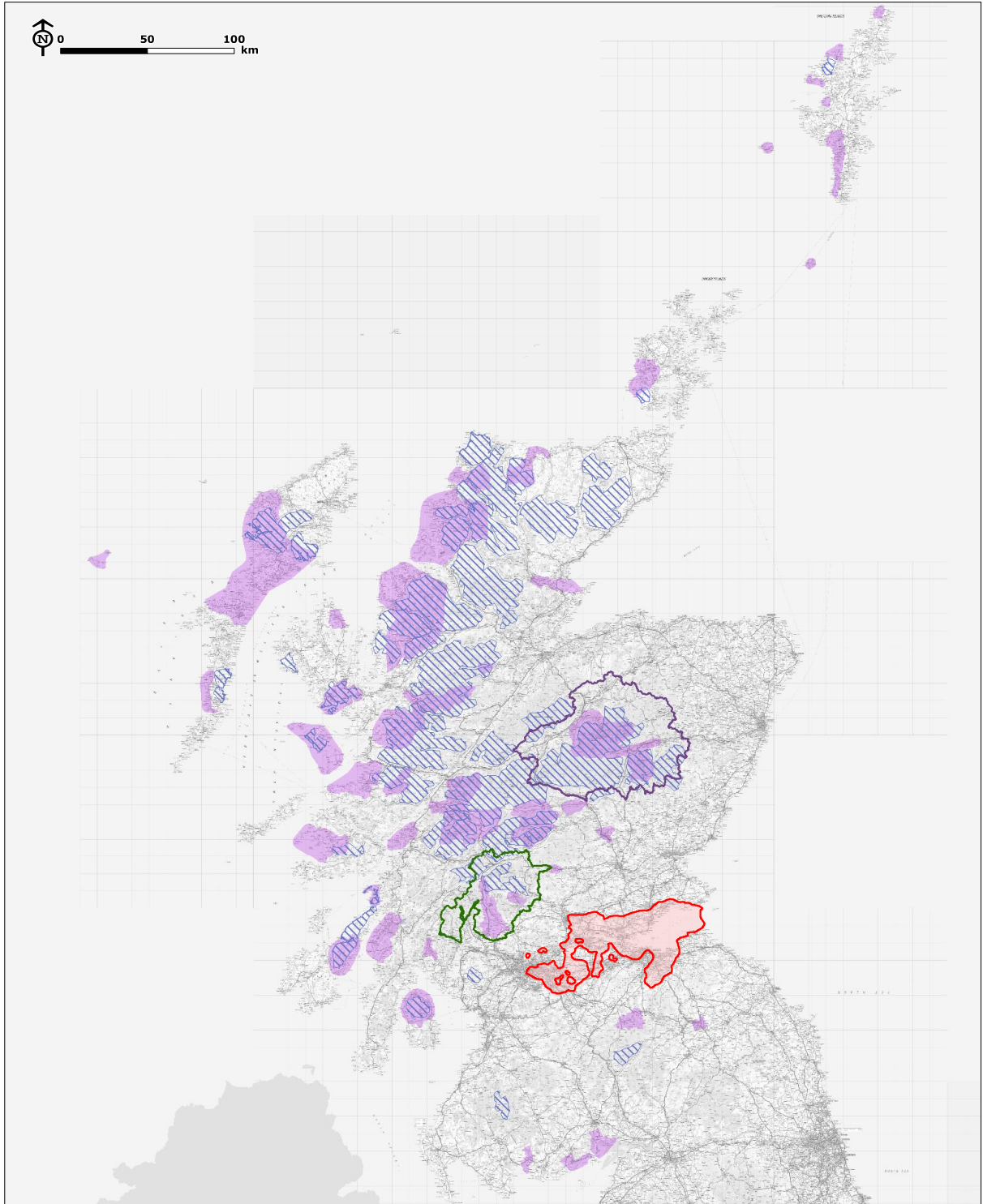
- Prospecting area (indicative)
- World Heritage Site
- Historic Battlefield
- Conservation Area
- Gardens and Designed Landscapes
- Scheduled Monument
- Listed Buildings (Grade A)

Map Scale @A3: 1:350,000



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CB:EL EB:lendak_e LUC FIG9b_10225_r1_CulHeritageCntrl_A3P 03/09/2018 Source: SG, Historic Scotland



- Prospecting area (indicative)
- Cairngorms National Park
- Loch Lomond and the Trossachs National Park
- National Scenic Area
- Wild Land Area

Source: SG, SNH

SEA
Onshore Unconventional
Oil and Gas

**Figure 10: Designated Landscape
in Scotland**

LUC



Map Scale @A3: 1:2,150,000

CB:EL EB:jendak_e LUC FIG10_10225_r2_LandscapeSco_A3P 03/09/2018

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Appendix 2

Review of Plans, Programmes and Strategies

Source	Key objectives	Implications / comments
GENERAL		
International		
Aarhus Convention (1998)	<p>To develop a number of rights of the public with regard to the environment. Local authorities should provide for:</p> <ul style="list-style-type: none"> • The right of everyone to receive environmental information • The right to participate from an early stage in environmental decision making • The right to challenge in a court of law public decisions that have been made without respecting the two rights above or environmental law in general 	Ensure that the public are involved and consulted at all relevant stages of SEA production.
Johannesburg Declaration on Sustainable Development (2002)	To make a significant commitment to building a humane, equitable and caring global society aware of the need for human dignity for all.	The SEA should reflect sustainability objectives to promote the principles of sustainable development
European		
EU Public Participation Directive Directive 2003/35/EC on providing for public participation in respect of the drawing up of certain plans and programmes relating to the environment and amending with regard to public participation and access to justice Council Directives 85/337/EEC and 96/61/EC	Provides a legal framework for community involvement by requiring public participation in decision-making and regulation, including through access to information and consultation.	Ensure that the public are involved and consulted at all relevant stages of drawing up certain plans and programmes relating to the environment.

Source	Key objectives	Implications / comments
<p>SEA Directive 2001</p> <p>Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment</p>	<p>The key objective of the SEA Directive is to provide for a high level of protection of the environment and contribute to the integration of environmental considerations into the preparation and adoption of plans and programmes with a view to promoting sustainable development.</p>	<p>Requirements of the SEA Directive must be met in Strategic Environmental Assessments.</p>
<p>National (Legislation)</p>		
<p>Town and Country Planning (Scotland) Act 1997 (as amended)</p>	<p>The Town and Country Planning (Scotland) Act governs the use and development of land within Scotland. The 1997 Act forms the basis of the Scottish planning system. It sets out the roles of Scottish Ministers and designates local authorities as ‘planning authorities’ with a responsibility for producing local development plans and handling most aspects of development management and enforcement.</p> <p>All planning applications in Scotland are required to be determined against the Town and Country Planning (Scotland) Act 1997. In this perspective, the planning authority is also responsible for granting planning permission for development related to the exploration and production of unconventional oil and gas.</p>	<p>The SEA should be mindful of the requirements set out in the 1997 Act.</p>
<p>Planning etc. (Scotland) Act 2006</p>	<p>The Planning etc. (Scotland) Act 2006 formed a central part of the reform of the Scottish planning system. One of its key effects was the creation of Strategic Development Planning Authorities, which comprise several local planning authorities and are charged with producing long-term development plans.</p>	<p>The SEA should be mindful of the requirements set out in the Planning etc. (Scotland) Act 2006</p>
<p>Town and Country Planning (Development Management Procedure) (Scotland) Regulations 2008 (as amended)</p>	<p>Sets out provisions for granting planning permission in accordance with the Town and Country Planning (Scotland) Act 1997.</p>	<p>The SEA should be mindful of the requirements of the Town and Country Planning</p>

Source	Key objectives	Implications / comments
		(Development Management Procedure) Scotland Regulations
Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017	Sets out criteria for determining whether an Environmental Impact Assessment would be required which also applies to unconventional oil and gas developments. Any application for planning permission to carry out unconventional oil and gas development involving hydraulic fracturing is likely to be accompanied by an Environmental Impact Assessment (EIA).	The SEA should reflect the objectives to minimise the potential environmental impacts of unconventional oil and gas developments
National (Policies, Plans, Programmes and Strategies)		
National Planning Framework 3 (the Scottish Government, 2014)	<p>The National Planning Framework 3 sets out the Scottish Government’s development priorities over the next 20-30 years and identifies national developments which support the spatial strategy. It is a long-term strategy to promote environmental sustainability, equality in opportunity, technological progress and human well-being and health.</p> <p>Key outcomes of the framework are as follows:</p> <ul style="list-style-type: none"> • Creating sustainable places • Reducing carbon emissions and adapting to climate change • Protecting and enhancing Scotland’s natural cultural assets as well as facilitating their sustainable use • Supporting better transport and digital connectivity 	The SEA should reflect the objectives to make Scotland a successful, sustainable place; a low carbon place; a natural, resilient place; and, a connected place.

Source	Key objectives	Implications / comments
<p><i>Scottish Planning Policy</i> (The Scottish Government, 2014)</p>	<p>The purpose of the Scottish Planning Policy is to set how nationally important land use planning matters should be addressed across the country.. It is non-statutory, however, it is in line with the Town and Country Planning (Scotland)</p> <ul style="list-style-type: none"> • Creating sustainable places • Reducing carbon emissions and adapting to climate change • Protecting and enhancing Scotland’s natural cultural assets as well as facilitating their sustainable use • Supporting better transport and digital connectivity 	<p>The SEA should reflect the objectives to make Scotland a successful, sustainable place; a low carbon place; a natural, resilient place; and, a connected place.</p>
<p>Local</p>		
<p>Proposed Strategic Development Plan for South East Scotland (2016)</p>	<p>The plan states that Local Development Plans will identify coal, oil and gas reserves to support a diverse energy mix, giving sufficient weight to the avoidance of long term environmental impacts and greenhouse gas emissions from their use.</p>	<p>The SEA should reflect the need to avoid environmental impacts.</p>
<p>Falkirk Local Development Plan (2015)</p>	<p>The Local Plan includes Policy RW03 Assessment of Mineral Proposals, which includes unconventional oil and gas extraction and sets out the criteria against which proposals will be assessed which includes:</p> <p>Impact on local communities, individual houses, and sensitive receptors, impact in terms of disturbance, disruption and noise, blasting and vibration; landscape and visual impact, impact on nature conservation and biodiversity, impact on the historic environment, impact on all land, including the potential for pollution, but</p>	<p>The SEA should reflect the requirements of the key assessment criteria.</p>

Source	Key objectives	Implications / comments
	especially for prime agricultural land and carbon rich and rare soils; impact on the water environment, impact on air quality, impact on the local road network.	
Clackmannanshire Local Development Plan (2015)	<p>The Local Plan does not include a policy for unconventional oil and gas, but includes Policy EP13 - Coal Bed Methane, which sets out criteria against which proposals will be assessed which includes:</p> <p>No significant adverse impacts on communities, the environment or the local economy; no significant adverse impacts on residential amenity or the built and natural environment or have an adverse effect on the integrity of the Firth of Forth SPA either alone or in combination with other projects and plans.</p>	The SEA should reflect requirements of the key policy criteria.

Source	Key objectives	Implications / comments
AIR		
International		
UNECE Convention on Long Range Transboundary Air Pollution (198	<p>The purpose of the UNECE Convention was to address the environmental consequences of air pollution. The main aim of the Convention was to reduce and prevent air pollution in order to improve air quality on the local, regional and national levels. To achieve this, the Convention sets out measures to be taken by parties to cut their emissions of air pollutions.</p> <p>The UNECE Convention has been extended by eight other protocols that identify measures to be undertaken by Parties to cut their emissions of air pollutants. These eight protocols include the following:</p> <ul style="list-style-type: none"> • EMEP Protocol on Long-Term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutions in Europe (1984) • Helsinki Protocol on the Reduction of Sulphur Emissions (1985) • Nitrogen Oxide Protocol (1988) • Volatile Organic Compounds Protocol (1991) • Oslo Protocol on Further Reduction of Sulphur Emissions (1994) • Protocol on Heavy Metals (1998) • Aarhus Protocol on Persistent Organic Pollutants (1998) 	<p>The SEA should reflect the objectives to protect and enhance air quality from factors such as eutrophication and acidification</p>

Source	Key objectives	Implications / comments
	<ul style="list-style-type: none"> Gothenburg Protocol on Abate Acidification, Eutrophication and Ground-level Ozone (1999) 	
European		
<p>The National Emissions Ceiling Directive 2001</p> <p>Directive 2001/81 EC on national emission ceilings for certain atmospheric pollutants</p>	<p>The Directives sets limits for the main causal factors of acidification, eutrophication and ground-level ozone.</p>	<p>The SEA should reflect the objectives to protect and enhance air quality from factors such as eutrophication and acidification.</p>
<p>The Air Quality Directive 2008</p> <p>Directive 2008/50/EC on ambient air quality and cleaner air for Europe</p>	<p>Avoid, prevent and reduce harmful effects of air pollution on human health and the environment. The Directive Brings together existing legislation (at the time) on air quality, including objectives for key pollutants such as SO₂, NO_x, particulates, lead, benzene and ozone.</p> <p>The Directive sets out statutory limits for the concentration of different pollutants (Annex XI) and thresholds for human and environmental health (Annex II).</p>	<p>The SEA should reflect the objectives to reduce harmful effects of air pollution.</p>
<p>The Industrial Emissions Directive 2010</p> <p>Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control)</p>	<p>This Directive lays down rules on integrated prevention and control of pollution arising from industrial activities. It also lays down rules designed to prevent or, where that is not practicable, to reduce emissions into air in order to achieve a high level of protection of the environment taken as a whole.</p>	<p>The SEA should reflect the objective for reducing air pollution caused by industrial emissions.</p>
<p>The Clean Air Policy Package and Clean Air Programme for Europe 2013</p>	<p>The Clean Air Policy Package and Clean Air Programme for Europe set targets up to 2030, and also introduces measures and proposals to reduce emissions and improve air quality across the EU.</p>	<p>The SEA should reflect the objectives to protect and enhance air quality.</p>

Source	Key objectives	Implications / comments
National (Legislation)		
The Environment Act 1995	<p>The Act requires the UK government and devolved administrations to produce a national air quality strategy. The most recent version of this national air quality strategy is The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, which defines the roles of the local and central government, as well as the Scottish Environment Protection Agency (SEPA), industry, business, transport, individuals and other groups.</p> <p>In addition, the Act sets objectives for specific emissions and measures for monitoring. Where limits are not met, the local authority must declare it an Air Quality Management Area (AQMA)</p>	The SEA should reflect the objective for reducing air pollution .
The Air Quality (Scotland) Regulations 2000 As amended by the Air Quality (Scotland) Amendment Regulations 2002 and the Air Quality (Scotland) Amendment Regulations 2016	Sets out air quality objectives for several substances in line with the Environment Act 1995. In contrast to EU requirement, Scotland has set stricter levels for specific pollutants including PM ₁₀ and PM _{2.5} .	The SEA should reflect the objective for reducing air pollution .
The Air Quality Standards (Scotland) Regulations (2010)	<p>Sets statutory targets for concentrations of pollutants in ambient air in accordance with EU Directives. The Act allows for Air Quality Management Zones to be identified and makes provision for the sharing of this information with the public.</p> <p>The Regulations were amended through The Air Quality Standards (Scotland) Amendment Regulations 2016.</p>	The SEA should reflect the objective for reducing air pollution .
Pollution Prevention and Control (Scotland) Regulations 2012	Implements the requirements of the EU Industrial Emissions Directive in Scotland. The Act states that emissions to air, water and land must be considered	The SEA should reflect the objective for reducing air pollution .

Source	Key objectives	Implications / comments
	<p>together, and permits are considered based on the nature of the activity.</p> <p>The Act has been amended several times since 2012.</p>	
National (Policies, Plans, Programmes and Strategies)		
The Air Quality Strategy for England, Scotland, Wales and Northern Ireland (2011)	The key objective of the strategy is to improve and protect ambient air quality in the UK, with the overall aim of health protection. The strategy sets out key objectives and monitoring recommendations for specific emissions.	The SEA should reflect the objective for reducing air pollution, particularly in relation to health protection.
Cleaner Air for Scotland – The Road to a Healthier Future (the Scottish Government, 2015)	<p>Presents a single framework which sets out further proposals for delivering improvements to air quality in Scotland.</p> <p>It summarises six broad types of key actions that could help to reduce air pollution and improve air quality;</p> <p>Transport – reducing transport emissions by promoting active travel and/or low and zero emission fuels</p> <p>Legislation and Policy – comply with European and Scottish legal requirements</p> <p>Communication – inform and engage citizens</p> <p>Health – protecting citizens from air pollution</p> <p>Placemaking – minimise air pollution through appropriate design</p> <p>Climate Change – achieve Scotland’s renewable targets</p>	The SEA should reflect the objective for reducing air pollution and promote active/sustainable travel.

Source	Key objectives	Implications/comments
BIODIVERSITY, FLORA AND FAUNA		
International		
Bern Convention (1979)	<p>To ensure conservation and protection of wild plant and animal species and their natural habitats (listed in Appendices I and II of the Convention), to increase cooperation between contracting parties, and to regulate the exploitation of those species) listed in Appendix III. To this end the Convention imposes legal obligations on contracting parties, protecting over 500 wild plant species and more than 1,000 wild animal species.</p>	<p>The SEA should consider the preservation and protection of the environment.</p>
Bonn Convention on the Conservation of Migratory Species of Wild Animals (1979)	<p>To ensure that contracting parties work together to conserve terrestrial, marine and avian migratory species and their habitats (on a global scale) by providing strict protection for endangered migratory species.</p> <p>The overarching objectives set for the Parties are:</p> <ul style="list-style-type: none"> • Promote, co-operate in and support research relating to migratory species • Endeavour to provide immediate protection for migratory species included in Appendix I • Endeavour to conclude Agreements covering the conservation and management of migratory species included in Appendix II 	<p>The SEA should reflect the objectives protecting biodiversity and the natural environment.</p>
Ramsar Convention (1971)	<p>To promote the wise use of wetlands and their resources.</p> <p>The Convention’s mission is “the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world”.</p>	<p>The SEA should take into account the conservation of wetlands and their resources.</p>

Source	Key objectives	Implications/comments
United Nations Convention on Biological Diversity (2010)	<p>The United Nations Convention on Biological Diversity (CBD) is a multilateral treaty which served three main goals, including:</p> <ul style="list-style-type: none"> • Conservation of biological diversity • Sustainable use of its components • Fair and equitable sharing of benefits arising from genetic 	The SEA should reflect objectives protecting biodiversity and sustainable use of its components.
European		
<p>The Habitats Directive 1992 Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora</p>	To promote the maintenance of biodiversity taking account of economic, social, cultural and regional requirements. Conservation of natural habitats and maintain landscape features of importance to wildlife and fauna.	The SEA should reflect objectives to protect and maintain the natural environment and important landscape features.
<p>The Birds Directive 2009 Directive 2009/147/EC is a codified version of Directive 79/409/EEC as amended</p>	<p>The preservation, maintenance, and re-establishment of biotopes and habitats shall include the following measures:</p> <ul style="list-style-type: none"> • Creation of protected areas. • Upkeep and management in accordance with the ecological needs of habitats inside and outside the protected zones. • Re-establishment of destroyed biotopes. • Creation of biotopes. 	The SEA should reflect objectives for the protection of birds.
Our Life Insurance, Our Natural Capital: an EU Biodiversity Strategy to 2020	The European Commission has adopted an ambitious new strategy to halt the loss of biodiversity and ecosystem services in the EU by 2020. The six targets	The SEA should reflect objectives to value, protect and enhance biodiversity.

Source	Key objectives	Implications/comments
	<p>cover:</p> <ul style="list-style-type: none"> • Full implementation of EU nature legislation to protect biodiversity • Better protection for ecosystems, and more use of green infrastructure • More sustainable agriculture and forestry • Better management of fish stocks • Tighter controls on invasive alien species • A bigger EU contribution to averting global biodiversity loss 	
EU Seventh Environmental Action Plan to 2020	<p>The EU's objectives in implementing the programme are:</p> <p>(a) to protect, conserve and enhance the Union's natural capital;</p> <p>(b) to turn the Union into a resource-efficient, green and competitive low-carbon economy;</p> <p>(c) to safeguard the Union's citizens from environment-related pressures and risks to health and wellbeing;</p> <p>(d) to maximise the benefits of the Union's environment legislation;</p> <p>(e) to improve the evidence base for environment policy;</p> <p>(f) to secure investment for environment and climate policy and get the prices right;</p> <p>(g) to improve environmental integration and policy coherence;</p>	The SEA should reflect objectives to protect and enhance the natural environment and promote energy efficiency.

Source	Key objectives	Implications/comments
	<p>(h) to enhance the sustainability of the Union's cities;</p> <p>(i) to increase the Union's effectiveness in confronting regional and global environmental challenges.</p>	
EU Biodiversity Strategy to 2020	<p>The European Commission has adopted an ambitious new strategy to halt the loss of biodiversity and ecosystem services in the EU by 2020. The six targets cover:</p> <ul style="list-style-type: none"> • Full implementation of EU nature legislation to protect biodiversity • Better protection for ecosystems, and more use of green infrastructure • More sustainable agriculture and forestry • Better management of fish stocks • Tighter controls on invasive alien species • A bigger EU contribution to averting global biodiversity loss 	The SEA should reflect objectives to value, protect and enhance biodiversity.
National (Legislation)		
Wildlife and Countryside Act 1981 (as amended)	<p>The Act implements the principles of the Bern Convention and the EU Birds Directive in the UK. Since it came into force, the Act has been amended several times. The act applies to the terrestrial environment and inland waters.</p> <p>According to the Act, Scottish Natural Heritage (SNH) is a regulator of the Wild and Countryside Act and is legally responsible for Sites of Special Scientific Interest (SSSIs) and to enforce law when necessary.</p> <p>It is important to note that specific amendments, which</p>	The SEA should reflect objectives to value, protect and enhance biodiversity.

Source	Key objectives	Implications/comments
	only apply in Scotland due to devolution, have been made to the Act.	
Natural Habitats (Conservation etc) Regulations 1994	The Act amends the Wildlife and Countryside Act 1981 for Scotland. The Act, together with the Nature Conservation (Scotland) Act 2004, implements the EU Birds and Habitats Directives.	The SEA should reflect objectives to value, protect and enhance biodiversity.
Nature Conservation (Scotland) Act 2004	The Act amends the Wildlife and Countryside Act 1981 for Scotland, and makes provision for the further conservation of biodiversity. The Act requires the Scottish Government to report on progress in relation to the Scottish Biodiversity Strategy	The SEA should reflect objectives to protect biodiversity and the natural environment.
Wildlife and Natural Environment (Scotland) Act 2011 (as amended)	The Act amends the Wildlife and Countryside Act 1981 for Scotland. The Act mainly changed the way land and the environment is managed in Scotland e.g. it made operational changes to how SSSIs are managed.	The SEA should reflect objectives to protect and enhance designated biodiversity areas.
National (Policies, Plans, Programmes and Strategies)		
Scotland's Biodiversity: It's in Your Hands (Scottish Executive, 2004)	<p><i>Scotland's Biodiversity: It's in Your Hands</i> presents a 25 year strategy (until 2030) for the conservation and enhancement of Scotland's biodiversity. It sets out a number of outcomes in relation to;</p> <ul style="list-style-type: none"> • Species and habitats • People • Landscapes and Ecosystems • Integration and Co-ordination • Knowledge 	The SEA should reflect objectives to value, protect and enhance biodiversity.
2020 Challenge for Scotland's Biodiversity – A Strategy for the conservation and	The aims of the <i>2020 Challenge</i> are in line with the targets set by the aforementioned United Nations	The SEA should reflect objectives to value, protect

Source	Key objectives	Implications/comments
enhancement of biodiversity in Scotland (The Scottish Government, 2013)	<p>Convention on Biological Diversity (2010) and the European Union's Biodiversity Strategy for 2020, and include:</p> <ul style="list-style-type: none"> • Protect and restore biodiversity on land and in Scotland's SAs • Involve and engage people in decisions about the environment • Promote sustainable economic growth <p>The 2020 Challenge and the 'Scotland's Biodiversity: It's in Your Hands' together make up the Scottish Biodiversity Strategy.</p>	and enhance biodiversity.

Source	Key objectives	Implications/comments
CLIMATIC FACTORS		
International		
IPCC's Fifth Assessment Report on Climate Change (2014)	To limit and/or reduce all greenhouse gas emissions which contribute to climate change	The SEA should reflect objectives to support reduction in emissions of greenhouse gases.
<i>Paris Agreement</i> (United Nations 2015)	The main aim of the Paris Agreement centres on keeping global temperature rise this century well below 2°C above preindustrial levels. Frameworks are to be put in place to help achieve these goals.	The SEA should reflect objectives to adapt and mitigate climate change .
European		
Emissions Trading System Directive 2009	The main aim of the Directive is to improve and extend	The SEA should reflect

Source	Key objectives	Implications/comments
Directive 2009/29/EC to improve and extend the greenhouse gas emission allowance trading scheme of the Community	the greenhouse gas emission allowance trading scheme of the Community	objectives to promote energy efficiency and reduce the emission of greenhouse gases.
Renewable Energy Directive 2009 Directive 2009/28/EC on the use of energy from renewable sources	The Directive sets targets for renewable energy use within the EU, which requires that 20% of the energy consumed within the EU is renewable.	The SEA should reflect objectives to promote renewable energy .
Energy Efficiency Directive 2012 Directive 2012/30/EU on energy efficiency	The purpose of the Directive is to promote energy efficiency by establishing a set of binding measures to help the EU reach its 20% energy efficiency target by 2020.	The SEA should reflect objectives to promote energy efficiency and prudent use of resources.
National (Legislation)		
Climate Change (Scotland) Act 2009	<p>The Act sets statutory targets for the reduction of greenhouse gas emissions. The Act sets an interim 42 percent reduction target by 2020 and an 80 percent reduction target for 2050.</p> <p>Secondary legislation has been made under the Climate Change (Scotland) Act 2009, including:</p> <ul style="list-style-type: none"> • The Climate Change (Annual Targets) (Scotland) Order 2010: sets emission reduction targets for 2010-2022 • <i>The Climate Change (Limit on Carbon Units) (Scotland) Order 2010</i>: places a limit on the amount of carbon units that may be credited to net Scottish Emissions for the period 2010-2012 • <i>The Carbon Accounting Scheme (Scotland) Regulations 2010</i>: establish a scheme for 	The SEA should reflect the objective to reduce the emission of greenhouse gases and mitigate climate change

Source	Key objectives	Implications/comments
	<p>monitoring compliance with annual reduction targets for 2010-22 (as amended in 2015 and 2016)</p> <ul style="list-style-type: none"> • The Climate Change (Annual Targets) (Scotland) Order 2011: sets emission reduction targets for 2023-2027 • <i>The Climate Change (Limit on Carbon Units) (Scotland) Order 2011</i>: places a limit on the amount of carbon units that may be credited to net Scottish Emissions for the period 2023-2027 • <i>The Climate Change (Limit on Carbon Units) (Scotland) Order 2010</i>: places a limit on the amount of carbon units that may be credited to net Scottish Emissions for the period 2013-2017 • <i>The Climate Change (Additional Greenhouse Gas) (Scotland) Order 2015</i>: adds nitrogen trifluoride as an additional greenhouse gas listed in the Climate Change (Scotland) Act 2009 • The Climate Change (Annual Targets) (Scotland) Order 2016: sets annual reduction targets for 2028-2032 • <i>The Climate Change (Limit on Carbon Units) (Scotland) Order 2016</i>: places a limit on the amount of carbon units that may be credited to net Scottish Emissions for the period 2018-2022 	

Source	Key objectives	Implications/comments
National (Policies, Plans, Programmes and Strategies)		
A Low Carbon Economic Strategy for Scotland – Scotland, A Low Carbon Society (The Scottish Government, 2010)	<p>The main purpose of the Low Carbon Economic Strategy is to achieve the targets as set out in the Climate Change (Scotland) Act 2009.</p> <p>The document provides a comprehensive framework for developing a low carbon economy across Scotland. The strategy sets out measures that could be undertaken by Parties to cut their greenhouse gas emissions. This vision relates to the energy sector, the built environment, Scotland’s resources and businesses.</p>	The SEA should reflect objectives to support the reduction of greenhouse gas emissions
Towards a Low Carbon Scotland – Smart Cities (The Scottish Government, 2012)	The purpose of the document is to highlight the ways in which Scotland can become a low carbon society by presenting a number of case studies about sustainable urban development in Scottish cities such as district heating development and a hydrogen bus project in Aberdeen, renewable energy projects in Edinburgh and the ‘Energy from Waste’ project in Glasgow.	The SEA should support the reduction of greenhouse gas emissions.
Climate Change Bill (The Scottish Government, 2018)	The Climate Change Bill contains proposals to amend the framework of emissions reduction targets in the Climate Change (Scotland) Act 2009, including increasing the 2050 target from an 80% to a 90% reduction.	The SEA should reflect objectives to support the reduction of greenhouse gas emissions.
A nation with ambition: The Government’s Programme for Scotland 2017-18	One of the key objectives of the Programme is to promote further investments in renewable energies, renewable technologies and sustainable modes of transport in order to tackle climate change.	The SEA should reflect objectives to support renewable technologies, sustainable modes of transport.
The Climate Change Delivery Plan (The Scottish Government, 2018)	The Climate Change (Scotland) Act 2009 requires that Ministers publish a report setting out policies and proposals to meet annual targets. The current Climate	The SEA should reflect objectives to adapt and

Source	Key objectives	Implications/comments
	Change Plan sets out policies and proposals to meet targets over the period to 2032.	mitigate climate change.
<i>The Scottish Energy Strategy</i> (The Scottish Government, 2017)	<p>Scotland's Energy Strategy sits alongside the aforementioned Climate Change Delivery Plan.</p> <p>Three key themes underpin the Strategy;</p> <ul style="list-style-type: none"> • A whole-system view in which energy supply and consumption are seen as equal priorities • A stable energy transition towards renewable energies and sustainable transport • A smarter model of local energy provision which promotes local energy, community involvement and community ownership of energy generation 	The SEA should reflect objectives to adapt to and mitigate climate change.
<i>Reducing emissions in Scotland 2017 Progress Report to Parliament (Committee on Climate Change, 2017)</i>	<p>Sets out recommendations by the Committee on Climate Change which involves the following;</p> <ul style="list-style-type: none"> • Policies and proposals • Balance of effort across sectors • Ambition on electric vehicles • Low-carbon heating • Power sector • Carbon capture and storage (CCS) • Forestry • Agriculture 	The SEA should reflect objectives to reduce greenhouse gas emissions.
Climate Ready Scotland: Scottish Climate	Addresses the impacts identified for Scotland in the UK	The SEA should reflect

Source	Key objectives	Implications/comments
Change Adaptation Programme (The Scottish Government, 2014)	Climate Change Risk Assessment (CCRA) published under section 56 of the UK Climate Change Act 2008. It aims to increase the resilience of Scotland's people, environment and economy to the impacts of a changing climate.	objectives to mitigate the effects of climate change.

Source	Key objectives	Implications/comments
CULTURAL HERITAGE		
International		
European Convention on the Protection of the Archaeological Heritage (Valletta, 1992) Revision of the 1985 Granada Convention	Protection of the archaeological heritage, including any physical evidence of the human past that can be investigated archaeologically both on land and underwater. Creation of archaeological reserves and conservation of excavated sites.	The SEA should reflect objectives to protect the archaeological heritage .
European		
European Spatial Development Perspective (1999)	Economic and social cohesion across the community. Conservation of natural resources and cultural heritage. Balanced competitiveness between different tiers of government.	The SEA should reflect objectives to conserve natural resources and cultural heritage.
National (Legislation)		
Planning (Listed Buildings and Conservation Areas) (Scotland) Act 1997	Provides main legislation to: <ul style="list-style-type: none"> list buildings of special architectural or historic interest 	The SEA should reflect objectives to conserve cultural heritage, particularly in relation to Listed Buildings,

Source	Key objectives	Implications/comments
	<ul style="list-style-type: none"> • providing requirements in relation to changes affecting listed buildings and conservation areas • setting out a framework for designating and managing Conservation Areas 	Conservation Areas and buildings of special architectural or historic interest.
National Parks (Scotland) Act 2000	<p>Sets out for main aims for the National Parks of Scotland:</p> <ul style="list-style-type: none"> • Conserving and enhancing the natural and cultural heritage of the area • Promoting sustainable use of the natural resources of the area • Promoting understanding and enjoyment of the area by the public • Promoting sustainable economic and social development of the area's communities 	The SEA should reflect objectives to conserve cultural heritage in National Parks.
Historic Environment Scotland Act 2014	<p>The Act established Historic Environment Scotland (HES) as a Non Departmental Public Body (NDPB). Under the Act, HES will be a statutory consultee in relation to listed buildings and conservation area consents, as well as in relation to EIA.</p> <p>The Act also amended statutory processes in relation to the historic environment by changing the processes for the designation of sites and buildings (by scheduling and listing) and for consents relating to scheduled monuments, listed buildings and conservation areas.</p>	<p>The SEA should reflect objectives to conserve cultural heritage and the wider historic environment.</p> <p>In addition, the role of Historic Environment Scotland should be taken into account.</p>
The Town and Country Planning (Development Management Procedure) (Scotland) Regulations 2013	Both Acts state that Historic Environment Scotland must be consulted on any development affecting a UNESCO World Heritage Site in Scotland.	The SEA should reflect objectives to conserve cultural heritage and the wider historic

Source	Key objectives	Implications/comments
The Town and Country Planning (Neighbouring Planning Authorities and Historic Environment) (Scotland) Direction 2015		environment.
National (Policies, Plans, Programmes and Strategies)		
Our Place in Time – The Historic Environment Strategy for Scotland (The Scottish Government, 2014)	<p>The Strategy provides a high level framework which sets out a 10-year vision for safeguarding the cultural, social, environmental and economic value of Scotland’s heritage assets.</p> <p>The Strategy sets out three main aims:</p> <ul style="list-style-type: none"> • Investigating and recording the assets that make up Scotland’s historic environment • Protecting Scotland’s historic environment • Sharing information on the significance of Scotland’s historic environment <p>Each ambition is underpinned by a number of strategic priorities e.g. application of new technologies.</p>	The SEA should reflect objectives to conserve the historic environment.
Scottish Historic Environment Policy Statement (2016)	The policy statement supports the protection and enhancement of the historic environment, and sets out the principles for designation.	The SEA should reflect the principles of the protection and enhancement of the historic environment.

Source	Key objectives	Implications / comments
POPULATION AND HEALTH		
International		
International Health Regulations, 2007	The International Health Regulations provide a legal instrument for upholding global public health security by preventing and responding to acute public health risks. The Regulations require countries to report certain disease outbreaks and public health risks to the World Health Organisation.	The SEA should reflect the objective that acknowledges the potential health hazards that could be caused by the different development types.
European		
The Bathing Water Quality Directive 2006 Directive 2006/7/EC on the quality of water intended for human consumption	The overall objective of the revised Directive remains the protection of public health whilst bathing.	The SEA should reflect the Directive requirements and protect the quality of bathing waters.
The Drinking Water Directive 1998 Directive 98/83/EC on the quality of water intended for human consumption	Protect human health from the adverse effects of any contamination of water intended for human consumption by ensuring that it is wholesome and clean.	The SEA should reflect objectives to protect and enhance drinking water quality.
The Noise Directive 2000/14/EC	<ul style="list-style-type: none"> • Monitor the environmental problem by drawing up strategic noise maps. • Informing and consulting the public about noise exposure, its effects and the measures considered to address noise. 	The SEA should reflect objectives to reduce noise pollution.

Source	Key objectives	Implications / comments
	<ul style="list-style-type: none"> Addressing local noise issues by requiring authorities to draw up action Plans to reduce noise where necessary and maintain environmental noise where it is good. 	
<p>Seveso Directive III Directive 2012/18/EU on the control of major-accident hazards involving dangerous substances</p>	<ul style="list-style-type: none"> The Seveso Directive (III) lays down rules for the prevention of major accidents which involve dangerous substances, and the limitation of their consequences for human health and the environment, with a view to ensuring a high level of protection throughout the Union in a consistent and effective manner. 	<p>The SEA should reflect objectives to protect human health and the environment.</p>
National (Legislation)		
<p>Public Health etc. (Scotland) Act 2008</p>	<ul style="list-style-type: none"> The Act updates the law on public health, enabling Scottish Ministers to protect public health. It also makes provision for law on statutory nuisances. 	<p>The SEA should reflect objectives to protect public health.</p>
<p>The Control of Major Accident Hazards Regulations 2015 (COMAH)</p>	<ul style="list-style-type: none"> Sets out regulations to reduce the risks of potential major accident hazards that are associated with storing or handling large quantities of industrial chemicals of a hazardous nature. 	<p>The SEA should reflect objectives to minimise the risks of accident hazards that are associated with the handling of hazardous substances.</p>

Source	Key objectives	Implications / comments
National (Policies, Plans, Programmes and Strategies)		
National Performance Framework (The Scottish Government, 2016)	<ul style="list-style-type: none"> • The main purpose of the National Performance Framework is to promote sustainable economic growth by setting out a measurement set that can be used to determine the extent to which key targets are being fulfilled. It sets seven broad targets in relation to: • Growth – stimulating economic growth • Productivity – improving productivity • Participation – improving economic participation • Population – increase population growth • Solidarity – reduce income equality • Cohesion – reduce inequalities in economic participation • Sustainability – reduce greenhouse gas emissions 	The SEA should reflect objective to promote the principles of sustainable economic growth.
Let's make Scotland more active A Strategy for Physical Activity (Physical Activity Task Force 2003)	<ul style="list-style-type: none"> • The strategy seeks to improve the levels of physical activity in Scotland in order to achieve health benefits. The strategy includes a number of objectives to improve physical activity including the need to improve 	The SEA should reflect objectives which support opportunities for physical activity.

Source	Key objectives	Implications / comments
	environments to support inactive people to become active, alongside education and information.	
Cycling Action Plan for Scotland More people cycling more often (Scottish Government, 2010) http://www.gov.scot/resource/doc/316212/0100657.pdf	<ul style="list-style-type: none"> The action plan includes the vision that by 2020, 10% of all journeys taken in Scotland will be by bike. It supports skills development, improvements to the cycle network, and active travel. 	The SEA should reflect objectives which support opportunities for active travel.

Source	Key objectives	Implications / comments
SOIL		
European		
EU Management of Waste from Extractive Industries (2006/21/EC)	<p>The purpose of the Directive is to prevent water and soil pollution from the deposition of waste into heaps or ponds and puts emphasis on the long-term stability of waste facilities to help avoid major accidents.</p> <p>The main elements of the Directive are:</p> <ul style="list-style-type: none"> Conditions for operating permits. General obligations concerning waste management. The obligation to characterise waste before disposing of it or treating it. 	The SEA should reflect objectives to protect soil quality and minimise soil pollution from installations.

Source	Key objectives	Implications / comments
	<ul style="list-style-type: none"> Measures to ensure the safety of waste management facilities. A requirement to draw up closure plans. An obligation to provide for an appropriate level of financial security. 	
<p>The Industrial Emissions Directive 2010 Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control)</p>	<p>This Directive lays down rules on integrated prevention and control of pollution arising from industrial activities. It also lays down rules designed to prevent or, where that is not practicable, to reduce emissions into land and to prevent the generation of waste, in order to achieve a high level of protection of the environment taken as a whole.</p>	<p>The SEA should reflect objectives to protect soil quality and minimise soil pollution from installations.</p>
<p>EU Soil Thematic Strategy 2006</p>	<p>Includes a thematic strategy which aims to:</p> <ul style="list-style-type: none"> Establish common principles for the protection and sustainable use of soils Mitigate potential threats to soils Preserve soil functions Restore degraded and contaminated soils 	<p>The SEA should reflect objectives to protect soils and minimise soil pollution from installations.</p>
<p>National Legislation</p>		
<p>Environmental Protection Act 1990 (as amended)</p>	<p>Sets out legislation for the management and remediation of contaminated land that, in its current states, is causing or has the potential to cause significant pollution of the environment.</p>	<p>The SEA should reflect objectives to protect soil quality.</p>
<p>Contaminated Land (Scotland) Regulations 2000</p>	<p>Provides a detailed framework for the definition, identification and remediation of contaminated land.</p>	<p>The SEA should reflect objectives to protect soil quality.</p>

Source	Key objectives	Implications / comments
National (Policies, Plans, Programmes and Strategies)		
<p><i>The Scottish Soil Framework</i> (The Scottish Government, 2009)</p>	<p>The Soil Framework sets out a vision for the enhancement and protection of soil consistent with the economic, social and environmental needs of Scotland.</p> <p>The Framework identifies 13 key outcomes, as follows:</p> <ul style="list-style-type: none"> • Protecting and enhancing soil organic matter • Reducing soil erosion • Maintaining soil structure • Reduce greenhouse gas emissions from soils • Protecting soil biodiversity • Ensuring that soils contribute to sustainable flood management • Enhancing water quality through sustainable soil management • Enhancing soil's productive capacity • Reducing soil contamination • Reducing pressure on greenfield land and redirect development to brownfield sites where appropriate • Protecting soils with significant historical and cultural features • Enhancing knowledge base • Promoting effective coordination between stakeholders 	<p>The SEA should reflect objectives to protect soils and minimise soil pollution from installations.</p>

Source	Key objectives	Implications / comments
LANDSCAPE AND GEODIVERSITY		
European		
European Landscape Convention (Florence, 2002)	The convention promotes landscape protection, management and planning.	The SEA should reflect objectives to protect, manage and plan for landscape provision.
National (Policies, Plans, Programmes and Strategies)		
Natural Heritage Futures Eastern Lowlands	The documents seek to guide the future management of the natural heritage towards 2025 within the context of sustainable development. This includes the need to create a strategic approach to all land uses. Relevant objectives include: <ul style="list-style-type: none"> To allow river systems to function naturally wherever possible 	The SEA should reflect objectives for sustainable land use.
Natural Heritage Futures West Central Belt	The documents seek to guide the future management of the natural heritage towards 2025 within the context of sustainable development. This includes the need to create a strategic approach to all land uses. Relevant objectives include: <ul style="list-style-type: none"> Ensure that developments complement and enhance local landscapes and wildlife, and use open space to create environments of value to the natural heritage Improve the biodiversity and landscape quality of the managed countryside Promote sustainable use of natural resources and reduce contribution to the causes of climate change. 	The SEA should reflect objectives for sustainable land use.
Getting the best from our land A Land	The Strategy supports sustainable land use, and recognises the	The SEA should reflect

Source	Key objectives	Implications / comments
Use Strategy for Scotland 2016-2021	<p>interactions between different interests and land use. The objectives of the strategy include:</p> <ul style="list-style-type: none"> • Land-based businesses working with nature to contribute more to Scotland's prosperity. • Responsible stewardship of Scotland's natural resources delivering more benefits to Scotland's people. • Urban and rural communities better connected to the land, with more people enjoying the land and positively influencing land use. 	the need to support sustainable land use .

Source	Key objectives	Implications/comments
WATER		
European		
<p>The Water Framework Directive 2000</p> <p>Directive 2000/60/EC establishing a framework for community action in the field of water policy</p>	<p>The main aim of the Directive is to protect of inland surface waters, transitional waters, coastal waters and ground waters.</p>	<p>The SEA should reflect objectives to protect and minimise the impact on water quality.</p>
<p>The Bathing Water Quality Directive 2006</p> <p>Directive 2006/7/EC on the quality of water intended for human consumption</p>	<p>The overall objective of the revised Directive remains the protection of public health whilst bathing.</p>	<p>The SEA should reflect the Directive requirements and protect the quality of bathing waters.</p>

Source	Key objectives	Implications/comments
The Floods Directive 2007 Directive 2007/60/EC on the assessment and management of flood risks	Establish a framework for the assessment and management of flood risks, aiming at the reduction of the adverse consequences for human health, the environment, cultural heritage and economic activity associated with floods.	The SEA should reflect objectives that relate to flood management and reduction of risk.
EU Management of Waste from Extractive Industries (2006/21/EC)	<p>The purpose of the Directive is to prevent water and soil pollution from the deposition of waste into heaps or ponds and puts emphasis on the long-term stability of waste facilities to help avoid major accidents.</p> <p>The main elements of the Directive are:</p> <ul style="list-style-type: none"> • Conditions for operating permits. • General obligations concerning waste management. • The obligation to characterise waste before disposing of it or treating it. • Measures to ensure the safety of waste management facilities. • A requirement to draw up closure plans. <p>An obligation to provide for an appropriate level of financial security.</p>	The SEA should reflect objectives to protect soil /water quality and minimise soil/water pollution from installations.
National (Legislation)		
Bathing Waters (Scotland) Regulations 2008	The Act implements the EU Bathing Water Quality Directive.	The SEA should reflect objectives to protect and improve the quality of the water environment.
Flood Risk Management (Scotland) Act 2009	The Act requires local authorities to assess bodies of water to determine potential flood risk and carry out measures if required. The Act implements the EU	The SEA should reflect objectives that relate to flood management and reduction of risk.

Source	Key objectives	Implications/comments
	Floods Directive.	
Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended)	Provides a regulatory framework for controlling activities which could have an adverse effect on Scotland's water environment including abstraction, impoundments, dredging, impoundments, surface water drainage and pollution. The primary objective of the Regulations is to protect and restore Scotland's water environment.	The SEA should reflect objectives to protect and restore the water environment.
Water Environment (Miscellaneous) (Scotland) Regulations 2017	The Regulations amend existing general binding rules and introduces requirements for particular projects to have a construction license in place before works can commence.	The SEA should reflect sustainability objectives to protect the natural environment .
National (Policies, Plans, Programmes and Strategies)		
SEPA Draft River Basin Management Plans Scotland River Basin District / Solway Tweed River Basin District 2008	Identifies key pressures and environmental impacts on Scottish water bodies, which may be exacerbated by climate change.	The SEA should reflect objectives to protect and improve the quality of the water environment .

Source	Key objectives	Implications/comments
MATERIAL ASSETS – WASTE		
European		
The Landfill Directive 1999 Directive 99/31/EC on the landfill of waste	Prevent or reduce negative effects on the environment from the landfilling of waste by introducing stringent technical requirements for waste and landfills.	The SEA should reflect objectives to increase recycling and reduce the amount of waste.
The Waste Framework Directive	Prevention or reduction of waste production	The SEA should reflect objectives that minimise

Source	Key objectives	Implications/comments
2008 Directive 2008/98/EC on waste	and its harmfulness. The recovery of waste by means of recycling, re-use or reclamation. Recovery or disposal of waste without endangering human health and without using processes that could harm the environment.	waste production as well as promote recycling.
The Urban Waste Water Directive 1991 Directive 91/271/EEC concerning urban waste water treatment	Protect the environment from the adverse effects of urban waste water collection, treatment and discharge, and discharge from certain industrial sectors.	The SEA should reflect objectives to reduce water pollution .
The Packaging and Packaging Waste Directive 1994 Directive 94/62/EC on packaging and packaging waste	Harmonise the packaging waste system of Member States and promote recycling.	The SEA should reflect objectives to minimise the environmental impact of waste and promote recycling.
National (Legislation)		
Environmental Protection Act 1990	<p>The Act implements the EU Waste Framework Directive (2008) and includes provisions for improved control of pollution and waste generation arising from certain industrial processes</p> <p>Moreover, the Act places a duty on local authorities, as the primary regulators, to identify and secure the remediation of contaminated land in their respective areas.</p> <p>The Environmental Protection Act comprises the following parts:</p> <p>Part I: Integrated Pollution and Control</p> <p>Part II: Waste Management Licencing</p>	The SEA should reflect objectives to reduce pollution associated with industrial processes.

Source	Key objectives	Implications/comments
	Part III: Statutory Nuisances Part IV: Criminal Offences Concerning Litter Part VI: Statutory Notification and Risk Assessment for Genetically Modified Organisms (GMOs) Part VII: Creation of Nature Conservancy Council for England, the Nature Conservancy Council for Scotland and the Countryside Council for Wales.	
The Management of Extractive Waste (Scotland) 2010 Regulations	EU directive 2006/21/EC was transposed in the form of the Management of Extractive Waste (Scotland) 2010 Regulations, also known as 'MEW'. It sets out conditions for granting planning permission for extractive waste areas and waste facilities, along with additional requirements for category A (high risk) waste facilities.	The SEA should reflect objectives to minimise the environmental impact of waste.
Waste Management Licencing (Scotland) Regulations 2011 (as amended)	Sets out requirements for the management of waste and related activities with regard to granting site licences and consolidating existing licences.	The SEA should reflect objectives to minimise the environmental impact of waste.
The Waste (Scotland) Regulations 2011	The Waste (Scotland) Regulations 2011 are designed to enhance waste management through a number of requirements relating to: <ul style="list-style-type: none"> • Source segregation • Restricting input to landfill • Restricting inputs to Energy from Waste Facilities 	The SEA should reflect objectives to minimise the environmental impact of waste.

Source	Key objectives	Implications/comments
National (Policies, Plans, Programmes and Strategies)		
Scotland's Zero Waste Plan (2010)	The Zero Waste Plan presents a vision to minimise waste transport to landfills, promote recycling and enhancing collection methods. The key objective of the Plan is to maximise the economic and environmental opportunities of waste reduction and reuse.	The SEA should reflect objectives to minimise the environmental impact of waste and promote recycling.
Planning Advice Note 63: energy from waste (2013)	Sets out guidance for planning authorities on proactively planning for waste management	The SEA should reflect objectives to minimise the environmental impact of waste and promote recycling.
A strategy for improving waste data in Scotland (2017)	Sets out a strategy to improve the relevance, quality and availability of data on waste from all sources (e.g. households, commerce and industry). The primary objective of the strategy is to improve waste data strategies in order to enhance Scotland's waste and resources sector.	The SEA should reflect objectives to minimise the environmental impact of waste and promote recycling.
MATERIAL ASSETS – EXTRACTION INDUSTRIES		
European		
European Directive on Boreholes Directive 92/91/EEC concerning the minimum requirements for improving the safety and health protection of workers in the mineral extracting industries through drilling.	The European Directive on Boreholes sets out the minimum requirements for improving the safety and health protection of workers in the mineral-extracting industries through drilling i.e. extraction of minerals (onshore and offshore), preparation of extracted materials for sale etc.	The SEA should reflect objectives to protect the safety and health of workers
European Directive on Mines and Quarries	The European Directive on Boreholes sets out the minimum requirements for improving the	The SEA should reflect objectives to protect the safety and health of workers

Source	Key objectives	Implications/comments
Directive 92/104/EEC on the minimum health and safety requirements for improving the safety and health protection of workers in surface and underground mineral extracting industries	safety and health protection of workers in surface and underground mineral extracting industries	
European Directive on Hydrocarbons (1994) Directive 94/22/EC on the conditions for granting and using authorisations for the prospection, exploration and production of hydrocarbons	Directive 94/22/EC sets out framework rules for all stages of petroleum operations and aims to ensure fair competition in relation to the prospection, exploration and production of hydrocarbons – reinforcing the integration of the energy market within Member States. The Directive aims to create a level playing field, meaning that hydrocarbon exploration and production is subject to the same conditions in each Member State (i.e. national security, public health, public safety, security of transport, protection of environmental resources and financial contributions).	The SEA should reflect objectives to promote environmental sustainability .
Commission Recommendation on minimum principles for the exploration and production of hydrocarbons (such as shale gas) using high-volume hydraulic fracturing (2014/70/EU)	The 2014/70/EU Commission Recommendation invites EU member states that follow minimum principles when applying or adapting their legislation applicable to hydrocarbons exploration or production using high volume hydraulic fracturing. The Recommendation is intended to complement existing EU legislation.	The SEA should reflect objectives to minimise environmental impacts associated with the exploration and production of hydrocarbons using high-volume hydraulic fracturing
National (Legislation)		
Borehole Sites and Operations	Provides a main set of Health and Safety legislation for onshore drilling for petroleum to	The SEA should reflect objectives to minimise environmental impacts associated with drilling

Source	Key objectives	Implications/comments
Regulations 1995	ensure that drilling will be carried out to the highest standards available.	operations for petroleum.
Hydrocarbon Licencing Directive Regulations 1995	The Hydrocarbon Licencing Directive Regulations 1995 implement the EU Hydrocarbons Directive (94/22/EC).	The SEA should reflect objectives to minimise the environmental impacts associated with hydrocarbon exploration and productions.
The Offshore Installations and Wells (Design and Construction, etc.) Regulations 1996	Provides a main set of provisions with regard to the design, construction and commissioning of wells as well as the assessments and supervision involved in their operation. With the exception of Regulation 17 (which deals with well control equipment), the Regulations apply to wells offshore and on land.	The SEA should reflect objectives to ensure that the environmental impacts of the construction and commissioning of wells are minimised.
Petroleum Act 1998	Sets out restrictions on the exploration for and production of petroleum in the UK. The Act sets out the terms and conditions of licenses issues by the Oil & Gas Authority (OGA)	The SEA should reflect the objective to minimise environmental impacts associated with oil and gas developments.
Offshore Installations (Safety Case) Regulations 2005	The aim of the Offshore Installations (Safety Case) Regulations 2005 is to reduce the risk from major accident hazards. The Regulations set out a number of statutory requirements in relations to submitting safety cases and notifications for installations.	The SEA should reflect objectives in relation to human health and safety .
Petroleum (Production) (Landward Areas) Regulations 2014	Sets out regulations for the licencing process in relation to the exploration and production of petroleum in the UK.	The SEA should reflect objectives to minimise environmental impacts associated with oil and gas developments.
National (Policies, Plans, Programmes and Strategies)		
Planning Advice Note (PAN) 33 – Development of Contaminated Land	PAN 33 provides guidance on the management and remediation of contaminated land. The objectives of PAN 33 is to provide	The SEA should reflect objectives to reduce soil pollution and promote the remediation of contaminated land.

Source	Key objectives	Implications/comments
	<p>advice on:</p> <ul style="list-style-type: none"> • The implications of the new contaminated land regime for the planning system • The development of contaminated land • The approach to contaminated land in development plans • The determination of planning applications when the site is or may be contaminated; and • Where further information and advice can be found 	
<p>Planning Advice Note (PAN) 64 – Reclamation of Surface Mineral Workings (2003)</p>	<p>PAN 64 provides guidance for local authorities and operators to ensure that mineral workings are reclaimed to a high standard as soon as possible after working has ceased.</p>	<p>The SEA should reflect objectives to minimise the environmental effects associated with the decommissioning of mineral workings.</p>
<p>MATERIAL ASSETS – INDUSTRIAL HAZARDS AND ACCIDENTS</p>		
<p>European</p>		
<p>European Directive Directive 2004/35/CE on environmental liability with regard to the prevention and remedying of environmental damage (as amended)</p>	<p>Directive 2004/35/CE establishes a framework based on the ‘polluter pays principle’ to prevent and remedy environmental damage which is defined as damage to protected species and habitats, damage to water and damage to soil.</p> <p>Since its implementation, Directive 2004/35/CE has been amended three times</p>	<p>The SEA should reflect objectives to prevent and minimise environmental damage caused by extractive industries</p>

Source	Key objectives	Implications/comments
	through the following directives: <ul style="list-style-type: none"> • EU Directive on the management of waste from extractive industries (Directive 2006/21/EC) • EU Directive on the geological storage of carbon dioxide (Directive 2009/31/EC) • EU Directive on safety of offshore oil and gas operations (2013/30EU) 	
National (Legislation)		
Radioactive Substances Act 1993	The Radioactive Substances Act 1993 sets out regulations for the control of radioactive material and the disposal of radioactive waste in the UK. The production of oil and gas is classed as a NORM Industrial Activity.	The SEA should reflect objectives to minimise environmental impacts associated with unconventional oil and gas developments.
Offshore Installations (Prevention of Fire and Explosion and Emergency Response) Regulations 1995	The Act sets out provisions for the assessment and management of hazards associated with wells and their control.	The SEA framework should include sustainability objectives to minimise the risks of potential hazards associated with wells and their control.
The Environmental Liability (Scotland) Regulations 2009 (as amended)	Sets out an environmental protection legislative framework which is based on the 'polluter pays principle'. The Environmental Liability (Scotland) Regulations 2009 do not apply to all types of damage to the environment. Instead, the types of significant damage addressed in the Regulations are the following: <ul style="list-style-type: none"> • Damages to protected species or 	The SEA should reflect objectives to minimise the potential environmental impacts caused by oil and gas operators.

Source	Key objectives	Implications/comments
	<p>habitats</p> <ul style="list-style-type: none"> • Impacts on surface water or ground water • Impacts on land 	
Pollution Prevention and Control (Scotland) Regulations 2012 (as amended)	<p>Implements the requirements of the EU Industrial Emissions Directive in Scotland. The Act states that emissions to air, water and land must be considered together, and permits are considered based on the nature of the activity.</p> <p>The Act has been amended several times since 2012.</p>	The SEA should reflect objectives for reducing air/water/soil pollution.
National (Policies, Plans, Programmes and Strategies)		
Scotland's Higher Activity Radioactive Waste Policy (2011)	Sets out guidance on the long-term management of higher-activity radioactive waste i.e. design, safety measures, monitoring and regulatory control.	The SEA should reflect objectives to minimise the risks of accident hazards associated with the handling of hazardous substances.
Planning Circular 3/2015: Planning controls for hazardous substances	Provides guidance on the planning procedures around hazardous substances consent, relevant applications for planning permission and planning policies.	The SEA should reflect objectives to minimise the risks of accident hazards associated with the handling of hazardous substances.
Higher-activity waste implementation strategy (2016)	<p>Provides an implementation strategy for Scotland's policy on higher-activity radioactive waste (NB: the production of oil and gas is classed as a NORM Industrial Activity).</p> <p>The strategy has been prepared to support Scotland's Higher Activity Radioactive Waste Policy (2011).</p>	The SEA should reflect objectives to minimise the risks of accident hazards that are associated with the handling of hazardous substances.

Appendix 3

Consultation authority responses

Table A3.1 Summary of Consultation authority comments on the Scoping Report and how these have been addressed in the Environmental Report

Consultation authority	Topic	Comment	Action (how the comments have been addressed in the Environmental Report)
SNH	Environmental baseline	Consideration of the Environmental Baseline in Section 5 focusses on 'Potential pressures associated with unconventional oil and gas development' for each SEA topic. It will be important to ensure that the preferred policy option is the focus of the assessment and is not lost in consideration of the alternative scenarios. For example, it will be interesting to note the effect of the preferred position on the potential pressures on biodiversity detailed in section 5.15.	The environmental baseline sets out the current trends and pressures on each SEA topic area, in the absence of unconventional oil and gas development, it also includes a summary of additional pressures which could result from unconventional oil and gas. This approach provides the required baseline to inform the assessment.
HES		We are broadly content with the summary baseline provided for the historic environment, but consider that subjective phrases such as 'iconic' or 'landmark' are not helpful in this context. Given the nature of	Historic baseline language has been

Consultation authority	Topic	Comment	Action (how the comments have been addressed in the Environmental Report)
		the assessment, we are content that assessment will focus on more generic (in terms of heritage asset type and/or location) historic environment baseline, but recommend that you ensure that where varying levels of detail occur across the assessment, the baseline is tailored accordingly.	updated.
SEPA		We are generally content with the gathering and presentation of the baseline information; however, the section on material assets appears inconsistent. Sections 5.77 includes mineral resources, environmental pollution, the treatment of waste products, and land use change. This description does not appear to be consistent with the issues which appear in the latter sections. For example the <i>current state</i> and <i>existing pressures</i> sections refer to peat and mineral resources but do not refer to waste or pollution issues.	Additional data included on waste trends and water quality trends.
SNH	Reasonable alternatives	We are content with the KPMG scenario approach taken in the 'Reasonable alternatives' section. However, we would reiterate that we consider the focus of the assessment should be on the preferred policy option with comparisons drawn across the three alternative scenarios. This does not necessarily come across clearly in the scoping report, particularly where the emphasis is on the 'environmental effects of unconventional oil and gas development avoided' rather than on positive or negative effects of the position statement.	The approach to the assessment is described in Section 2, Methodology. This describes the approach to the assessment and explains the approach to the assessment of the alternatives, including the emphasis on

Consultation authority	Topic	Comment	Action (how the comments have been addressed in the Environmental Report)
			environmental effects of unconventional oil and gas avoided.
HES		<p>The diagram at 4.10 suggests that assessment of the PPP will be defined by the findings of the assessment of the other alternatives, rather than considering the effects that the PPP may have in its own right. We recommend that for transparency and clarity, all four alternatives should be assessed on their own merits, to the same level, and that there should be parity in terms of the consideration of 'avoided' effects.</p>	<p>The approach to the assessment is described in Section 2, Methodology. This describes the approach to the assessment and explains the approach to the assessment of the alternatives, including the emphasis on environmental effects of unconventional oil and gas avoided.</p>
SEPA		<p>We note that the three alternatives described in the KPMG 2016 report i.e. the Central, Low and High development scenarios (section 2.9) will be used as the alternative scenarios required for the SEA. We would expect to see the same rigour applied to the assessment of potential environmental effects for the preferred policy option as to each of the three other alternatives.</p> <p>It is unclear what the diagram in section 4.10 depicts - particularly the box containing the words <i>environmental impacts of unconventional oil</i></p>	<p>The approach to the assessment is described in Section 2, Methodology. This describes the approach to the assessment and explains the</p>

Consultation authority	Topic	Comment	Action (how the comments have been addressed in the Environmental Report)
		<p>and gas <i>scenarios avoided</i>. We would suggest that a straightforward approach would be to simply assess the environmental impacts of the preferred policy option. This would be on an equitable basis with the consideration given to the other three alternatives. The overarching narrative could then draw out and discuss the environmental benefits / dis-benefits of the preferred policy option in comparison to the environmental effects which would result from pursuing any of the other three alternatives.</p> <p>We would expect to see the potential environmental effects of each of the three alternatives (i.e. central, low, and high development scenarios) and the preferred policy option to be identified and discussed in turn in relation to impacts on the current environmental baseline. We are content with the proposal to report these assessments in narrative form and would expect to see a separate narrative for each of the three alternatives and the preferred policy option presented.</p>	<p>approach to the assessment of the alternatives, including the emphasis on environmental effects of unconventional oil and gas avoided.</p>
SNH	Methodology	<p>We agree with Section 4. Methodology for all the SEA topics to be scoped in, but would ask that you also consider environmental effects on access and recreation. This is due to the potential implications from any of the likely scale of development scenarios adding to existing pressures on access and recreation opportunities in the highly developed 'central belt' area of Scotland. This is often included within the Population and/or Human Health topics.</p>	<p>Recreation and access added to baseline and included in assessment for population and human health.</p>
SNH	Cumulative effects	<p>Section 4.14 proposes consideration of the cumulative effects of the alternative scenarios across each SEA topic, and between topics. However, with consideration of the comments above and the focus of the Environmental Report being on the preferred position, in the</p>	<p>Noted</p>

Consultation authority	Topic	Comment	Action (how the comments have been addressed in the Environmental Report)
		interests of proportionality, we suggest this element of the assessment could be reasonably focussed.	
HES		We welcome that you intend to consider the potential for cumulative effects, but note that you have not referred to secondary or synergistic effects. We would expect the assessment to consider such effects within Scotland, and this should be clearly presented in the ER.	Reference to secondary or synergistic effects is included.
SNH	Potential effects of sourcing oil and gas products from other countries	We note that detailed consideration of potential effects of sourcing oil and gas products from other countries is beyond the scope of the proposed policy position (4.12). However, it would be helpful if the assessment could include a general narrative and give direction to areas of further consideration as part of possible mitigation from the environmental effects from the existing preferred position scenario. Existing plans, programmes and strategies should be referred to as offering potential mitigation options in their ambitions and desired outcomes, for instance, as outlined in the Energy Strategy (2017), the renewed emphasis on energy efficiency and the overall approach to energy being driven by the need to decarbonise the whole energy system, in line with emissions levels set out in the Climate Change (Scotland) Act.	Narrative on this issue is included.
SEPA		We agree with the statement at section 4.12 that detailed consideration of potential effects of sourcing oil and gas products from other countries is beyond the scope of the current policy. However, we note that the introduction to the policy statement published in December 2017 states that <i>the future of unconventional oil and gas in Scotland is relevant to wider energy issues and our climate change ambitions</i> . As such we would recommend that the assessment, ER and / or Post Adoption Statement (PAS) acknowledge the issue of out-sourcing as an area for further consideration and also establishes	Narrative on this issue is included.

Consultation authority	Topic	Comment	Action (how the comments have been addressed in the Environmental Report)
		<p>appropriate monitoring mechanisms to ensure that meaningful data on activity in this area can be gathered. Such monitoring will contribute to building an essential evidence base which can be used to inform related policy (e.g. energy, planning, or climate change) in the future.</p> <p>Section 6.3 states that it is anticipated that the preferred policy position will become part of the revised National Planning Framework (NPF4); this together with the revised Scottish Planning Policy (SPP) will have a great deal of influence on future social and economic activity. Some of this activity will require oil and gas related products either as a source of materials or a source of energy; a portion of this need may be met from non-domestic oil and gas supplies. In terms of Scotland's contribution to global sustainable development goals it is important that the potential effects of the preferred policy option and its alternatives are seen within this wider context (e.g. will there be an increase in imports, or will related domestic policy ensure that alternatives are established). It is therefore important that cognisance is given in this current environmental assessment to the effects which our domestic policy can have in the global context.</p>	
SNH	Relationship of Plans, Programmes and Strategies and Environmental Protection Objectives	<p>Section 3.11 notes SNH as a statutory consultee for decommissioning plans. This is not a statutory requirement for SNH. Further, as of April 2017, we also deal with development proposals at sea beyond 12 nautical miles.</p>	<p>Reference to statutory consultee for decommissioning plans deleted.</p> <p>SNH involvement in development proposals at sea beyond 12 nautical</p>

Consultation authority	Topic	Comment	Action (how the comments have been addressed in the Environmental Report)												
			miles noted.												
SEPA	Mitigation and enhancement	<p>We would encourage you to be very clear in the Environmental Report about mitigation and enhancement measures which are proposed as a result of the assessment. Section 4.16 states that mitigation will be proposed for the <i>pre-moratorium scenarios</i>. We understand this to mean the three alternative scenarios identified by KPMG. We would recommend that proposed mitigation and enhancement measures are set out in a way that clearly identifies: (1) the measures required, (2) when they would be required and (3) who will be required to implement them. The inclusion of a summary table in the Environmental Report such as that presented below would be useful to help track progress on mitigation through the monitoring process.</p> <table border="1" data-bbox="768 858 1762 1206"> <thead> <tr> <th data-bbox="768 858 976 1023">Issue / Impact Identified in ER</th> <th data-bbox="976 858 1256 1023">Mitigation / Enhancement Measure</th> <th data-bbox="1256 858 1512 1023">Lead Authority</th> <th data-bbox="1512 858 1762 1023">Proposed Timescale</th> </tr> </thead> <tbody> <tr> <td data-bbox="768 1023 976 1150">Insert effect recorded in ER</td> <td data-bbox="976 1023 1256 1150">Insert mitigation measure to address effect</td> <td data-bbox="1256 1023 1512 1150">Insert as appropriate</td> <td data-bbox="1512 1023 1762 1150">Insert as appropriate</td> </tr> <tr> <td data-bbox="768 1150 976 1206">etc.</td> <td data-bbox="976 1150 1256 1206">etc.</td> <td data-bbox="1256 1150 1512 1206">etc.</td> <td data-bbox="1512 1150 1762 1206">etc.</td> </tr> </tbody> </table> <p>We note from section 4.17 that mitigation of environmental effects from the preferred policy position will be related to the wider policy implications, and will draw on the mitigation provided by existing policies and strategies. We would again recommend the use of a table such as that above to record these mitigation measures. In this case</p>	Issue / Impact Identified in ER	Mitigation / Enhancement Measure	Lead Authority	Proposed Timescale	Insert effect recorded in ER	Insert mitigation measure to address effect	Insert as appropriate	Insert as appropriate	etc.	etc.	etc.	etc.	Noted.
Issue / Impact Identified in ER	Mitigation / Enhancement Measure	Lead Authority	Proposed Timescale												
Insert effect recorded in ER	Insert mitigation measure to address effect	Insert as appropriate	Insert as appropriate												
etc.	etc.	etc.	etc.												

Consultation authority	Topic	Comment	Action (how the comments have been addressed in the Environmental Report)
		<p>this could include details of “assumed” mitigation e.g. that provided by existing planning or environmental regulation as well as required mitigation e.g. that which may be achieved through a review of existing regulation or the creation of new policy.</p> <p>We would highlight the importance of considering any issues that may fall outwith the scope of existing regulation due to their nature or scale. For example many regulations only cover certain scales of development however, a number of small-scale activities which are not regulated can result in significant cumulative effects. In such cases we would expect to see detailed mitigation proposals established.</p>	
SEPA	Monitoring	<p>We would recommend that monitoring proposals also include reference to the need to consider transboundary effects, and would refer you back to our comments in section 2 above. Although detailed consideration of the effects from activities such as the importation of oil and gas products is beyond the scope of this current policy it is important to record the potential interactions this has with other policy areas, not least because the approach proposed for mitigation is closely tied to the existing wider policy context, much of which includes ambitions which are set in the global context e.g. climate change targets and their close link with energy policy.</p>	Noted and included.
SNH	Indicative timetable of SEA stages	<p>The eight week consultation period is acceptable, but it would help better resource planning if this could allow for the usual time taken over summer/school holidays.</p>	Noted.
HES		<p>We are content with the eight week period proposed for consultation on the Environmental Report and Preferred Policy Position</p>	Noted.
SEPA		<p>We are satisfied with the proposal for an eight week consultation period for the ER.</p>	Noted.

Appendix 4

Meeting the requirements of the SEA Act

This Environmental Report includes all of the required elements of the final 'Environmental Report' (the output required by the Environmental Assessment (Scotland) Act 2005).

Table A.4.1 signposts the relevant sections of the Environmental Report that are considered to meet the Environmental Assessment (Scotland) Act 2005 requirements.

Table A.4.1 Meeting the requirements of the Environmental Assessment (Scotland) Act 2005

Requirements of the Environmental Assessment (Scotland) Act 2005	Covered in this Environmental Report?
Environmental Report	
<p>In relation to any qualifying plan or programme, the responsible authority shall secure the preparation of an Environmental Report. The report shall identify, describe and evaluate the likely significant effects on the environment of implementing—</p> <p>(a) the plan or programme; and</p> <p>(b) reasonable alternatives to the plan or programme, taking into account the objectives and the geographical scope of the plan or programme. (Section 14(1) and (2) and Schedule 3).</p>	
<p>1) An outline of the contents and main objectives of the plan or programme, and of its relationship (if any) with other qualifying plans and programmes.</p>	<p>Sections 1, 3, 4 and Appendix 2.</p>
<p>2) The relevant aspects of the current state of the environment and the likely evolution thereof without implementation of the plan or programme.</p>	<p>Sections 4 - 13 and Appendix 1.</p>
<p>3) The environmental characteristics of areas likely to be significantly affected.</p>	<p>Sections 4 - 13 and Appendix 1.</p>
<p>4) Any existing environmental problems which are relevant to the plan or programme including, in particular, those relating to any areas of a particular environmental importance, such as areas designated pursuant to Council Directive 79/409/EEC on the conservation of wild birds and Council Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna (as last amended by Council Directive 97/62/EC).</p>	<p>Sections 4 -13 and Appendix 1.</p>
<p>5) The environmental protection objectives, established at international, Community or Member State level, which are relevant to the plan or programme and the way those objectives and any environmental considerations have been taken into account during its preparation.</p>	<p>Section 3 and Appendix 2</p>

Requirements of the Environmental Assessment (Scotland) Act 2005	Covered in this Environmental Report?
<p>6) The likely significant effects on the environment, including—</p> <p>(a) on issues such as (i) biodiversity; (ii) population; (iii) human health; (iv) fauna; (v) flora; (vi) soil; (vii) water; (viii) air; (ix) climatic factors; (x) material assets;</p> <p>(xi) cultural heritage, including architectural and archaeological heritage; (xii) landscape; and (xiii) the inter-relationship between the issues referred to in heads (i) to (xii);</p> <p>(b) short, medium and long-term effects; (c) permanent and temporary effects; (d) positive and negative effects; and (e) secondary, cumulative and synergistic effects.</p>	Sections 4 - 13
<p>7) The measures envisaged to prevent, reduce and as fully as possible offset any significant adverse effects on the environment of implementing the plan or programme.</p>	Section 15
<p>8) An outline of the reasons for selecting the alternatives dealt with, and a description of how the assessment was undertaken including any difficulties (such as technical deficiencies or lack of expertise) encountered in compiling the required information.</p>	Section 2
<p>9) A description of the measures envisaged concerning monitoring in accordance with section 19.</p>	Section 16.
<p>10) A non-technical summary of the information provided under paragraphs 1 to 9.</p>	Non – technical summary
<p>The report shall include such of the information specified in schedule 3 as may reasonably be required, taking account of—</p> <p>(a) current knowledge and methods of assessment of environmental matters;</p> <p>(b) the contents of, and level of detail in, the plan or programme;</p> <p>(c) the stage of the plan or programme in the decision-making process; and</p> <p>(d) the extent to which any matters to which the report relates would be more appropriately assessed at different levels in that process in order to avoid duplication of the assessment (Section 14 (3))</p>	The Environmental Report adheres to this requirement.
<p>Consultation</p>	
<p>Before deciding on—(a) the scope and level of detail of the information to be included in the Environmental Report to be prepared in accordance with section 14; and (b) the consultation period it intends to (i)specify under section 16(1)(b); and (ii)notify under section 16(2)(a)(iv), the</p>	<p>Consultation on this Environmental Report will be undertaken for a 8 week period from 23 October 2018 to 18</p>

Requirements of the Environmental Assessment (Scotland) Act 2005	Covered in this Environmental Report?
<p>responsible authority shall send to each consultation authority such sufficient details of the qualifying plan or programme as will enable the consultation authority to form a view on those matters. As specified in Section 15(1)(b)(i) the Scoping Report sets out the intended consultation period for the environmental report.</p>	<p>December 2018.</p>
<p>As soon as reasonably practicable, and in any event within 14 days of the preparation of the Environmental Report, the responsible authority shall—</p> <p>(a) send a copy of the report and the qualifying plan or programme to which it relates (“the relevant documents”) to the consultation authorities; and</p> <p>(b) invite each consultation authority to express its opinion on the relevant documents within such period as the responsible authority may specify.</p> <p>(2) The responsible authority shall also—</p> <p>(a) within 14 days of the preparation of the Environmental Report, secure the publication of a notice—</p> <p>(i) stating the title of the plan or programme to which it relates;</p> <p>(ii) stating the address (which may include a website) at which a copy of the relevant documents may be inspected or from which a copy may be obtained;</p> <p>(iii) inviting expressions of opinion on the relevant documents; and</p> <p>(iv) stating the address to which, and the period within which, opinions must be sent;</p> <p>(b) keep a copy of the relevant documents available at the authority's principal office for inspection by the public at all reasonable times and free of charge; and</p> <p>(c) display a copy of the relevant documents on the authority's website.</p> <p>(3) The periods referred to in subsections (1)(b) and (2)(a)(iv) must be of such length as will ensure that those to whom the invitation is extended are given an early and effective opportunity to express their opinion on the relevant documents.</p> <p>(Section 16(1), (2) and (3)).</p>	
<p>Taking the Environmental Report and the results of the consultations into account in decision-making (relevant extracts of Section 18)</p>	
<p>As soon as reasonably practicable after the adoption of a qualifying plan or programme, the responsible authority shall—</p> <p>(a) make available a copy of—</p>	<p>Requirement will be met at a later stage in the SEA process.</p>

Requirements of the Environmental Assessment (Scotland) Act 2005	Covered in this Environmental Report?
<p>(i) the plan or programme;</p> <p>(ii) the Environmental Report relating to it; and</p> <p>(iii) a statement containing the particulars specified in subsection (3),</p> <p>at the authority's principal office for inspection by the public at all reasonable times and free of charge.</p> <p>(Section 18(1)(a))</p>	
<p>As soon as reasonably practicable after the adoption of a qualifying plan or programme, the responsible authority shall inform the consultation authorities of the adoption of the plan or programme and shall send them a copy of—</p> <p>(a) the plan or programme as adopted; and</p> <p>(b) the statement containing the particulars specified in subsection (3).</p> <p>(3) The particulars referred to in subsections (1)(a)(iii) and (b)(iii) and (2)(b) are—</p> <p>(a) how environmental considerations have been integrated into the plan or programme;</p> <p>(b) how the Environmental Report has been taken into account;</p> <p>(c) how the opinions expressed in response to the invitations mentioned in section 16 have been taken into account;</p> <p>(d) how the results of any relevant consultation under regulation 14 of the Environmental Assessment of Plans and Programmes Regulations 2004 (S.I. 2004/1633) have been taken into account;</p> <p>(e) the reasons for choosing the plan or programme as adopted, in the light of the other reasonable alternatives considered; and</p> <p>(f) the measures that are to be taken to monitor the significant environmental effects of the implementation of the plan or programme.</p> <p>(4) Nothing in subsection (1)(b)(iii) shall require the responsible authority to provide a copy of any document free of charge; but where a charge is made, it shall be of a reasonable amount.</p> <p>(Section 18(1), (2), (3) and (4))</p>	<p>Requirement will be met at a later stage in the SEA process.</p>
<p>Monitoring</p>	
<p>(1) The responsible authority shall monitor the significant environmental effects of the implementation of every</p>	<p>Requirement will be met at a later stage in the SEA</p>

Requirements of the Environmental Assessment (Scotland) Act 2005	Covered in this Environmental Report?
<p>qualifying plan or programme for which it has carried out an environmental assessment.</p> <p>(2) The responsible authority shall do so in a manner (which may comprise or include arrangements established otherwise than for the express purpose of compliance with subsection (1)) which enables the authority to—</p> <p>(a) identify any unforeseen adverse effects at an early stage; and</p> <p>(b) undertake appropriate remedial action.</p> <p>(Section 19(1) and (2))</p>	<p>process.</p>



Respondent Information Form

Please Note this form **must** be completed and returned with your response.

Are you responding as an individual or an organisation?

- Individual
- Organisation

Full name or organisation's name

Phone number

Address

Postcode

Email

If you are responding on behalf of an organisation, please select a type/sector that best describes your organisation.

- Business / industry
- Academic / research
- Professional / trade body
- Public body
- Third sector / NGO
- Community group
- Other (please provide further details below)

The Scottish Government would like your permission to publish your consultation response. Please indicate your publishing preference:

- Publish response with name
- Publish response only (without name)
- Do not publish response

Information for organisations:

The option 'Publish response only (without name)' is available for individual respondents only. If this option is selected, the organisation name will still be published.

If you choose the option 'Do not publish response', your organisation name may still be listed as having responded to the consultation in, for example, the analysis report.

We will share your response internally with other Scottish Government policy teams who may be addressing the issues you discuss. They may wish to contact you again in the future, but we require your permission to do so. Are you content for Scottish Government to contact you again in relation to this consultation exercise?

- Yes
- No



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