Environmental Impact Assessment Report

Chapter 11: Soils, Geology and Land Contamination

Grangemouth Flood Protection Scheme 2024
Falkirk Council

GRANGEMOUTH
Flood Protection Scheme
Protecting the heart of our communities

Grangemouth Flood Protection Scheme

Environmental Impact Assessment Report

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Acronyms

BGS	British Geological Survey
CEMP	Construction Environmental Management Plan
CIRIA	Construction Industry Research and Information Association
CSM	Conceptual Site Model
DMRB	Design Manual for Roads and Bridges
EA	Environment Agency
EIA	Environmental Impact Assessment
GI	Ground Investigations
GCR	Geological Conservation Review
GPP	Guidance for Pollution Prevention
GWDTE	Groundwater Dependent Terrestrial Ecosystems
HSE	Health and Safety Executive
LGS	Local Geodiversity Site
JHI	James Hutton Institute
LCA	Land Capability for Agriculture
NPF4	National Planning Framework 4
NS	NatureScot
OS	Ordnance Survey
PAN	Planning Advice Notes
PPE	Personal Protective Equipment
RIGS	Regionally Important Geological Site
SEA	Strategic Environmental Assessment
SEPA	Scottish Environment Protection Agency
SM	Scheduled Monument
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
SWMP	Site Waste Management Plan

11. Soils, Geology and Land Contamination

11.1 Introduction

This chapter presents the results of the soils, geology and land contamination assessment undertaken for the Scheme. Additional supporting information is provided in the Geo-Environmental Desk Study Reports for each Flood Cell (Appendix C11.1 to Appendix C11.6) where appropriate.

The chapter includes an assessment of potential effects of the Scheme in relation to superficial and bedrock geology, designated geological sites and features of geodiversity interest, mineral extraction, soils and land contamination. The assessment is supported by a series of figures and the following appendices:

- Appendix B11: Soils, Geology and Land Contamination Supporting Figures (Figures B11.1 to B11.5)
- Appendix C11: Soils, Geology and Land Contamination Supporting Information (Geo-Environmental Desk Study Reports for each Flood Cell (Appendix C11.1 to Appendix C11.6) and the supporting Landmark Envirocheck Reports (Appendix C11.7a to C11.7f)

This chapter also cross-references others, where supporting considerations are described or assessed, including; Chapter 7: Biodiversity, Chapter 9: Landscape and Visual Impact Assessment and Chapter 10: Water Environment, with regards to ecological receptors, environmental designations, landforms, hydrology, hydrogeology, fluvial and coastal geomorphology and flooding.

11.2 Policy and Legislative Framework

11.2.1 General

Key legislative and planning policy themes of relevance to soils, geology and land contamination include protecting and maintaining geodiversity, the protection of soil resources, suitability of use and remediation of land contamination. At the national and local levels, these themes feature within various key legislation, policy and best practice initiatives or guidance, as described in sub-sections 11.2.2 to 11.2.4.

The requirements of this legislation, policy and best practice have been taken into account throughout the assessment. Cross-topic legislative and policy themes of relevance are also described in Chapter 7: Biodiversity, Chapter 9: Landscape and Visual Impact Assessment and Chapter 10: Water Environment; regarding ecology, environmental designations, landform and the water environment.

11.2.2 Legislation

Geological and geomorphological features of national or international importance have statutory protection in Scotland through designation as Sites of Special Scientific Interest (SSSI), or qualifying features within them under legislation including the Nature Conservation (Scotland) Act 2004 and the Wildlife and Natural Environment (Scotland) Act 2011. NatureScot (NS) is responsible for the conservation and management of SSSIs in Scotland, and also advise on protecting and maintaining Geological Conservation Review (GCR) sites. Most GCR sites have statutory protection through designation as geological or geomorphological features within SSSIs, and although some are unnotified, NS and planning authorities can treat these as 'candidate SSSIs', thus affording them the same level of protection. Some unnotified GCR sites are also identified as Local Nature Conservation Sites (which include Local Geodiversity Sites (LGS) – traditionally known as Regionally Important Geological Sites

(RIGS)), affording them statutory protection at those levels. However, all other unnotified GCR sites have no statutory protection.

There is no 'one-size-fits-all' soil protection legislation for Scotland, but there is a range of legislation that (often indirectly) protects certain aspects of soil resources or soil quality and seeks to influence how soils are managed. This includes: the Water Environment (Controlled Activities) (Scotland) Regulations 2011, Water Environment (Miscellaneous) (Scotland) Regulations 2017, the Water Environment and Water Services (Scotland) Act 2003, the Land Reform (Scotland) Act 2016, the Climate Change (Scotland) Act 2009, the Flood Risk Management (Scotland) Act 2009, the Sludge (Use in Agriculture) Regulations 1989 (and later amendments), the Waste Management Licensing (Scotland) Regulations 2011, as well as the Contaminated Land (Scotland) Regulations 2005 and associated Statutory Guidance SE/2006/44. All of these, to some degree, consider implications for soil and land that affect, and are affected by, human activity, water, air, climate and biodiversity.

The regulation and management of land contamination in Scotland is enacted via Part IIA of the Environmental Protection Act 1990, developed by the Contaminated Land (Scotland) Regulations 2005 and associated Statutory Guidance SE/2006/44. These set out a framework for the identification, assessment and remediation of contaminated land, regulated by planning authorities in consultation with the Scottish Environment Protection Agency (SEPA) where necessary. They are also supplemented with a variety of legislation aimed at protecting waterbodies from contamination, including the Water Environment (Controlled Activities) (Scotland) Regulations 2011, together with the Control of Substances Hazardous to Health (COSHH) Regulations (2002) (and later amendments) and the Construction, Design and Management (CDM) Regulations (2015) regarding the protection of workers and other persons from hazardous substances and general health, safety and welfare. Although the Scheme is being developed under Flood Risk Management (Scotland) Act 2009 it may still be subject to local planning policies. Therefore, the approach to the land contamination assessment was agreed with Falkirk Council Contaminated Land Officers in May 2019 to ensure compliance with Falkirk Council's Supplementary Planning Guidance Note: Development of Land Affected by Contamination: Guidance for applicants and Developers (Falkirk Council, 2011).

11.2.3 Planning Policy and Guidance

The Development Plan relevant to the Falkirk Council area is comprised of National Planning Framework 4 (NPF4) (Scottish Government, 2023) and the Falkirk Local Development Plan 2 (FLDP2) (Falkirk Council, 2020a). NPF4 is the more recent publication, adopted by the Scottish Ministers in February 2023. Both plans are read together, however, where there is any difference in policy content the more recent publication takes precedence, in this case NPF4.

Policies in NPF4 which are of key relevance to this chapter are summarised below.

- **Policy 5 Soils:** This policy requires that development proposals will only be supported if they are designed and constructed: (i) in accordance with the mitigation hierarchy by first avoiding and then minimising the amount of disturbance to soils on undeveloped land; and (ii) in a manner that protects soils from damage including from compaction and erosion, and that minimises soil sealing. This policy also contains criteria relating to development proposals on prime agricultural land or other important land, and development proposals on peatland, carbon-rich soils and priority peatland habitat.
- **Policy 9 Brownfield, Vacant and Derelict Land and Empty Buildings:** This policy provides support for development proposals that will result in the sustainable reuse of brownfield land including vacant and derelict land and buildings. Proposals on greenfield sites will not be supported unless the site has been allocated for development or the proposals are explicitly supported by policies in the LDP. The policy requires that where land is known or suspected to be unstable or contaminated, development proposals are required to demonstrate that the land is, or can be

made, safe and suitable for the proposed new use. The policy provides support for the reuse of existing buildings taking into account their suitability for conversion to other uses. Demolition will be regarded as the least preferred option.

- **Policy 33 Minerals:** This policy includes the requirement that: *"Development proposals that would sterilise mineral deposits of economic value will only be supported where…. there is an overriding need for the development and prior extraction of the mineral cannot reasonably be undertaken; or…. extraction of the mineral is impracticable or unlikely to be environmentally acceptable."*

FLDP2 policies which are of key relevance to this chapter are described below, alongside supplementary guidance where applicable.

- **PE19 Biodiversity and Geodiversity:** This policy provides that: "*The Council will protect and enhance habitats and species of importance, and will promote biodiversity and geodiversity through the planning process."* The policy contains a range of requirements relating to this overarching policy provision. PE19 is supported by the following supplementary guidance documents.
  - **SG07 Biodiversity and Development (Falkirk Council, 2021):** The supplementary guidance is intended to assist developers.
  - **SG08 Local Nature Conservation and Geodiversity Sites (Falkirk Council, 2020b):** The supplementary guidance identifies and provides information regarding Falkirk Council's local nature conservation and geodiversity sites.
- **PE25 Soils and Agricultural Land:** This policy aims to protect prime agricultural land and carbon rich or rare soils and to ensure the sustainable use of soils during construction and operation of any proposed development.
- **PE27 Vacant, Derelict and Contaminated Land:** This policy states: *"Proposals that reduce the incidence of vacant, derelict, unstable and contaminated land will be supported, subject to compliance with other LDP policies, particularly those related to development in the countryside. Where proposals involve the development of unstable or contaminated land, they will only be permitted where appropriate remediation or mitigation measures have been undertaken, and proposals are consistent with PAN 33."*
- **IR15 Mineral Resources:** This policy includes the provision that: *"The sterilisation through development of mineral resources which are likely to be capable of environmentally acceptable extraction will not be permitted."*

The following Planning Advice Notes (PAN) and guidance documents are relevant to this chapter: PAN 33 'Development of Contaminated Land' (Scottish Government, 2017), PAN 51 'Planning, Environmental Protection and Regulation' (Scottish Government, 2006) and PAN 60 'Planning for Natural Heritage' (Scottish Government, 2000)) and other best practice policy initiatives (including the Scottish Soil Framework (Scottish Government, 2009), Scotland's Geodiversity Charter 2018-2023 (Scottish Geodiversity Forum, 2018)), as well as supplementary planning guidance note 'Development of Land Affected by Contamination: Guidance for Applicants and Developers' (Falkirk Council, 2011).

11.2.4 Other Guidance

Further relevant national or local policies or best practice guidance in relation to soils, geology and land contamination considerations includes, but is not necessarily limited to, the following:

- 'Climate Change: Third Report on Proposals and Policies 2018-2032' (Scottish Government, 2018).
- 'Valuing your Soils: Practical Guide for Scottish Farmers' (Scotland's Rural College, 2016).
- 'Land use - getting the best from our land: strategy 2021 to 2026" (Scottish Government, 2021).

- Guidance for Pollution Prevention (GPPs) (NetRegs, 2023)
- CIRIA Report C552 'Contaminated Land Risk Assessment: A Guide to Good Practice' (CIRIA, 2001).
- 'Land Contamination: Risk Management' (Environment Agency, 2023).
- CIRIA Report C665 'Assessing Risks Posed by Hazardous Ground Gases to Buildings' (CIRIA, 2007).
- 'EH40/ 2005 Workplace Exposure Limits, Fourth Edition' (Health and Safety Executive, 2020).
- Position Statement (WAT-PS-10-01) 'Assigning Groundwater Assessment Criteria for Pollutant Inputs, Version 3.0' (SEPA, 2014).
- Supporting Guidance (WAT-SG-53) 'Environmental Quality Standards and Standards for Discharges to Surface Waters, Version 7.1' (SEPA, 2020).

The Land Contamination Risk Management (LCRM) publication follows the same overarching principles for the assessment of land contamination as the now withdrawn Model Procedures for Land Contamination (CLR11) (Environment Agency, 2004) and has been endorsed by the Environment Agency (EA), Natural Resources Wales and Northern Ireland Environment Agency for use within England, Wales and Northern Ireland respectively. Whilst SEPA have not yet formally endorsed the LCRM publication, this is considered to represent the most current statutory guidance for the United Kingdom and hence has been adopted for this assessment.

It is also notable that SEPA has consulted on a revision of Position Statement WAT-PS-10-01 which was originally scheduled for publication in 2023. However, the status of the revision is still unconfirmed and there has been no further communication from SEPA. The adoption of this position statement will be discussed with Falkirk Council's Contaminated Land Officers as appropriate during any future assessments relating to land contamination.

11.3 Methodology

11.3.1 Scope and Guidance

The assessment in relation to geology and soils has been undertaken with broad guidance from the Design Manual for Roads and Bridges (DMRB) 'Sustainability and Environment Appraisal LA109 Geology and Soils, Revision 0' (Highways England et al., 2019) and the NS 'Handbook on Environmental Impact Assessment' (SNH, 2018[1]) where appropriate. The assessment in relation to land contamination has been undertaken with guidance from CIRIA Report C552 'Contaminated Land Risk Assessment: A Guide to Good Practice' (CIRIA, 2001) and 'Land Contamination: Risk Management' (Environment Agency, 2023).

The Grangemouth Flood Protection Scheme EIA: Screening/ Scoping Report (Jacobs, 2018a) stated that the land use assessment for the Scheme would be provided within a Land Use, Geology and Contamination chapter. However, given the subsequent revision of DMRB guidance documents in late 2019 and early 2020, it is considered appropriate that the land use assessment be placed within Chapter 6: Population and Human Health in cognisance of DMRB 'Sustainability and Environment Appraisal LA112 Population and Human Health Revision 1' (Highways England et al., 2020).

11.3.2 Study Area

The study area for the assessment of soils, geology and land contamination covers the extent of the Site Boundary and Permanent Works Footprint within each Working Area and Flood Cell of the Scheme and extends to include a 100m buffer around these. The Scheme alignment, boundaries of each Flood Cell,

[1] As of 24 August 2020, Scottish Natural Heritage (SNH) is now NatureScot. Where a document was published prior to the NatureScot name change, it has been referenced as SNH.

Working Areas, the Site Boundary and the Permanent Works Footprint are shown in Figures A4-1 to A4-28 in Appendix A.

11.3.3 Baseline Data Collection

Baseline conditions described cover the following aspects:

- Superficial and bedrock geology;
- Designated geological receptors and features of geodiversity interest;
- Mineral extraction;
- Soils; and
- Land contamination.

Baseline conditions were determined through desk-based data assessments, and consultation with Falkirk Council, SEPA and other stakeholders where relevant (refer to sub-section 11.3.6).

11.3.4 Desk Study Reports

Desk-based data assessments are contained in Appendix C11.1 to Appendix C11.6 for each Flood Cell. These include a review of the following information:

- Envirocheck Reports containing historical Ordnance Survey (OS) mapping and other information related to waste, hazardous substances and industrial land uses (presented in Appendix C11.7a to C11.7f);
- National Library of Scotland (NLS) Map Images (NLS, 2023);
- British Geological Survey (BGS) data including BGS Superficial and Bedrock Geological Maps (1:50,000 Scale) (BGS, 2015a), BGS Superficial and Solid Aquifer Productivity Maps of Scotland (1:100,000 Scale) (BGS, 2015b), historical BGS borehole logs and the BGS Online GeoIndex (BGS, 2023);
- The Coal Authority Interactive Map Viewer (including the BGS non-coal mining and mining plans database) (The Coal Authority, 2023);
- NS SiteLink Database (NS, 2023) and Carbon and Peatland Map (SNH, 2016);
- James Hutton Institute (JHI) and other published soil data including Soil Maps of Scotland (1:25,000 Scale) (JHI, 2011a), the Land Capability for Agriculture (LCA) Map of Scotland (1:50,000 Scale) (JHI, 2011b), and Scotland's Soils Online Map Viewer (Scotlands Soils, 2023);
- SEPA interactive Water Classification Hub mapping (SEPA, 2023a);
- SEPA interactive Water Environment Hub mapping (SEPA, 2023b);
- SEPA Flood Risk mapping (SEPA, 2023c); and
- Previous assessments and information, including the Strategic Environmental Assessment (SEA) and Post Adoption Statement on the Flood Risk Management Strategy for the Forth Estuary Local Plan District (SEPA, 2015a; 2015b), the Grangemouth Flood Protection Scheme EIA: Screening/ Scoping Report (Jacobs, 2018a) and a previous Geotechnical Desk Study Report (Jacobs, 2018b).

11.3.5 Field Surveys

No specific field surveys in relation to geology or soils were completed to inform this assessment. However, site walkover inspections for each Flood Cell were undertaken in April 2018 as part of a previous geotechnical desk study report (Jacobs, 2018b), in order to establish the general existing conditions within them and to preliminarily identify possible geotechnical and geo-environmental

issues that may require attention in planning for delivery of the Scheme or investigation works for it. Available information from the walkover inspections have therefore been considered where appropriate.

11.3.6 Consultation

Consultation with Falkirk Council, SEPA and other statutory bodies was undertaken through submission of the EIA: Screening/ Scoping Report (Jacobs, 2018a) for the Scheme and full details of the comments received in relation to this are presented in Appendix C3.2 (Scoping Responses).

No specific comments with regards to geology or soils were received. However, in June 2019, the Falkirk Council Contaminated Land Team noted that the screening/ scoping report recommended that detailed ground investigations (GI) (including Phase 1 Desk Studies, Phase 2 Site Investigations and Risk Assessments) would be completed as part of the planning process, to determine potential contamination risks and subsequent remedial requirements for the Scheme. It was additionally noted that the Contaminated Land Team would review this information when submitted, to determine if contaminated land issues had been adequately addressed in accordance with current legislation and guidance.

Supporting consultation was also undertaken with the Falkirk Council Contaminated Land Team in May 2019, prior to the receipt of scoping report comments, to discuss the approach to the assessment of land contamination for the Scheme as part of the EIA Report. As only partial data from ongoing GI was anticipated to be available for this, it was agreed that an overall desk-based approach for each Flood Cell would be adopted. It was also agreed that the full factual GI information would be assessed in an equivalent series of stand-alone Phase 2 Contamination Assessment Reports when it becomes available, post-submission of the EIA Report.

Additional consultation with Falkirk Council Contaminated Land Team was undertaken during an EIA pre-application consultation workshop held in January 2020, during which feedback received from Falkirk Council was discussed and considered, and subsequently incorporated into the chapter and supporting desk studies, as appropriate.

11.3.7 Impact Assessment

The potential impacts in relation to soils, geology and land contamination have been assessed as per the individual methodologies described in sub-sections 11.3.8 and 11.3.9. The criteria outlined are based on those that have been applied to similar developments in Scotland and are designed to comply with the requirements of relevant regulations outlined in Chapter 2: Legislative and Regulatory Framework and Section 11.2. The significance of effect criteria have also been developed to be consistent with the terminology described in Chapter 3: Environmental Impact Assessment Methodology where possible.

Operational stage impacts were screened out within the EIA: Screening/ Scoping Report (Jacobs, 2018a) for the Scheme. However, the assessment undertaken recognises that the majority of construction stage impacts and effects (such as disturbance and removal of excavated soil or other materials) will be long-term and permanent; so, these will remain during operation. In relation to land contamination, the assessment also acknowledges that interaction with potential source areas will primarily be initiated as a result of construction activities, but that this will vary in the longer-term during operation, due to the physical presence of the Scheme and its elements. Potential impacts and effects in relation to this are therefore considered for each stage in turn where necessary.

11.3.8 Geology and Soils

For superficial and solid geology, designated geological receptors, features of geodiversity interest, mineral extraction and soils, the value and magnitude of impact criteria in Table 11-1 and Table 11-2 were applied. The significance of the effect was then determined using Table 11-3.

In relation to soils, the criteria for defining value were initially informed based on LCA categories. However, appreciation has also been given to potential soil conservation value and rarity based on professional judgement, as well as the NS Carbon and Peatland Map (SNH, 2016[2]) and information related to carbon-rich and rare soils in the Falkirk area (Falkirk Council, 2017; 2020a).

Table 11-1: Value Criteria – Geology and Soils

Value	Description
Very High	Areas containing very rare geological features considered to be of international importance with no potential for replacement such as UNESCO World Heritage Sites, UNESCO Global Geoparks, SSSI or GCR sites where citations indicate features of international importance. Presence of extensive areas of economically important minerals valuable as an international resource. Presence of soils of LCA Class 1 and Class 2 and/ or soils which support an EU designated site.
High	Areas containing geological or geomorphological features considered to be rare and of a national importance with little potential for replacement such as geological SSSI and GCR sites or geological sites which meet national designation criterion yet are not designated as such. Presence of extensive areas of economically important minerals valuable as a national resource. Presence of soils of LCA Class 3.1 and/ or soils supporting a UK designated site such as a SSSI. Presence of NS priority peatland Class 1 (nationally important carbon-rich and peaty soils, deep peat and priority peatland habitat likely to be of high conservation value) and Class 2 (nationally important carbon-rich and peaty soils, deep peat and priority peatland habitat likely to be of potentially high conservation value and restoration potential).
Medium	Areas containing geological features of designated regional importance considered worthy of protection for their educational, research, historic or aesthetic importance, such as LGS/ RIGS or geological sites which meet regional designation criterion yet are not designated as such. Presence of areas of economically important minerals of regional value. Presence of soils of LCA Class 3.2 and/ or soils which directly support a non-statutory designated site such as Local Nature Reserves or Sites of Nature Conservation Importance. Presence of NS priority peatland Class 3 (Dominant vegetation cover is not priority peatland habitat but is associated with wet and acidic type. Occasional peatland habitats can be found. Most soils are carbon-rich and peaty soils, with some areas of deep peat).
Low	Sites and geological features not currently identified as SSSI, GCR or LGS/ RIGS but may be of local importance and require protection in the future. Presence of mineral areas or resource of local importance only. Presence of soils of LCA Classes 4.1 to 7 and/ or soils supporting non designated notable or priority habitats. Presence of NS priority peatland Class 5 (soil information takes precedence over vegetation data and there is no peatland habitat recorded, but all soils are carbon-rich and peaty soil and deep peat).
Negligible	Geological features not currently protected and unlikely to require protection in the future.

[2] As of 24 August 2020, Scottish Natural Heritage (SNH) is now NatureScot. Where a document was published prior to the NatureScot name change, it has been referenced as SNH.

Value	Description
	No exploitable minerals or geological resources. Presence of previously developed land with little potential to return to agriculture. Presence of NS priority peatland Class 4 (areas unlikely to be associated with peatland habitats or wet and acidic type, and unlikely to include carbon-rich or peat soils), Class 0 (mineral soils where peatland habitats are not typically found), Class -1 (unknown soil types) and Class -2 (non-soil (i.e. loch, built up area, rock and scree)).

Table 11-2: Magnitude of Impact Criteria – Geology and Soils

Magnitude	Description
Very large (adverse)	Total permanent loss of a geological feature/designation or mineral resource. Physical removal or permanent sealing of soil resource, peatland or agricultural land which is irreversible or where the value of the area would be severely affected.
Large (adverse)	Partial (greater than 50%) permanent loss of geological feature/ designation or mineral resource with detrimental change to quality or integrity or severe damage to key characteristics, features or elements such that the value of the site would be affected. Permanent loss or long-term (greater than 6 years) reduction of one or more soil function(s) and restriction to current or approved future use (e.g. through degradation, compaction, erosion of soil resource) which is likely to be irreversible. Over 2ha loss/sealing of LCA classes 1, 2 and 3.1 agricultural soils or over 10ha loss/sealing of LCA classes 3.2 to 7 agricultural soils.
Medium (adverse)	Measurable permanent change in geological feature/ designation or mineral resource attributes adversely affecting the integrity of the feature/designation or partial loss of/alteration to key characteristics, features or elements where the value of the site would be affected, but not to a major degree. Permanent loss or temporary/short-term (less than 6 years) reduction of one or more soil function(s) and restriction to current or approved future use (for example through degradation, compaction, erosion of soil resource) where the value of the area would be affected, but not to a major degree. Between 1 and 2ha loss/reduction of LCA classes 1, 2 and 3.1 agricultural soils or between 1 and 10ha loss/reduction of LCA classes 3.2 to 7 agricultural soils.
Small (adverse)	Minor measurable permanent change in geological feature/ designation or mineral resource attributes, quality or integrity; or alteration to one (maybe more) key characteristics, features or elements on a local scale. Permanent loss or temporary/ short-term (less than 6 years) reduction of one or more soil function(s) and restriction to current or approved future use (for example through degradation, compaction, erosion of soil resource) where soils will be disturbed but the value of the area would not be affected.
Very small (adverse)	Slightly detectable/ noticeable change from geological feature/ designation or mineral resource baseline conditions on a local scale where overall integrity of resource is not affected. No discernible and very short term (less than 1 year) loss/ reduction of soil function(s) that restrict current or approved future use.

Magnitude	Description
Negligible	Undetectable or very slightly detectable/ noticeable temporary or permanent loss/ disturbance of geological feature/ designation or mineral resource characteristics or elements. Undetectable or very slightly detectable/ noticeable loss/ reduction of soil function(s) that restrict current or approved future use. Under 1ha permanent loss/ sealing for all LCA classes of agricultural soils.

Table 11-3: Matrix for Determining Significance of Effect – Geology and Soils

Magnitude of Impact	Value Criteria				
	Very High	High	Medium	Low	Negligible
Very large (adverse)	Major adverse	Major-Moderate adverse	Moderate adverse	Moderate-Minor adverse	Minor adverse
Large (adverse)	Major-Moderate adverse	Moderate adverse	Moderate-Minor adverse	Minor adverse	Negligible
Medium (adverse)	Moderate adverse	Moderate-Minor adverse	Minor adverse	Minor adverse	Negligible
Small (adverse)	Moderate-Minor adverse	Minor adverse	Minor adverse	Minor adverse	Negligible
Very small (adverse)	Minor adverse	Minor adverse	Minor adverse	Minor adverse	Negligible
Negligible	Negligible	Negligible	Negligible	Negligible	Negligible

Beneficial impacts in terms of geological features can also occur, as rock exposures can help to develop an understanding of local geology and/ or provide new or enhanced sites of interest (e.g. rock cuttings being designated as a SSSI or GCR). If such potential impacts in relation to this are relevant, they have been considered by applying professional judgement within the context of the Scheme and the value of the receptor based on the categories in Table 11-1.

Effects on geology and soils receptors of Moderate significance and above are considered to be potentially significant, and the level at which mitigation would generally be required or proposed.

11.3.9 Land Contamination

The assessment in relation to land contamination has focused on the potential for impacts on receptors as a consequence of the Scheme encountering contamination, within the context of a preliminary conceptual site model (CSM) for each Flood Cell. A receptor can be a person (construction or maintenance workers, or local residents), the water environment (groundwater, surface water features or private water supplies), ecological receptors (designated sites or potential groundwater dependent terrestrial ecosystems (GWDTE)) and/ or built environment/ property receptors (buried concrete, services, structures, livestock and agricultural land).

Each preliminary CSM represents an outline of potential 'pollutant linkages' that may be present between a source of contamination, pathways by which a contaminant may move and ultimately, affected receptors. Should any element of that linkage relationship (contaminant, pathway or receptor) be missing or removed, then the contamination is unlikely to represent a potential risk or impact. For the purposes of the assessment, each preliminary CSM therefore disregards pollutant linkages that are incomplete and cannot pose a risk to identified receptors. Where a complete pollutant linkage may exist however, a preliminary qualitative risk assessment has been undertaken.

The output of the assessments cannot be reported in terms of 'sensitivity'. Instead, they are reported in terms of the 'likelihood or probability' of a complete pollutant linkage being present, which is defined within CIRIA Report C552 'Contaminated Land Risk Assessment: A Guide to Good Practice' (CIRIA, 2001), and 'Land Contamination: Risk Management' (Environment Agency, 2023). In line with the above guidance, for land contamination assessments, the probability is based on the criteria summarised in Table 11-4 and the magnitude is defined in terms of the consequence of the impact on likely receptors as outlined in Table 11-5. The significance of effect is then defined as the overall risk, taking account of both probability and consequence, with reference to the matrix in Table 11-6.

Table 11-4: Probability Criteria – Land Contamination

Probability	Assessment Criteria
High Likelihood	There is a complete pollution linkage and an event that either appears very likely in the short-term and almost inevitable over the long-term, or there is evidence at the receptor of harm or pollution.
Likely	There is a complete pollution linkage and all the elements are present and available, which means that it is probable that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short-term and likely over a long-term.
Low Likelihood	There is a complete pollution linkage and the circumstances are possible under which an event could occur. However, it is by no means certain that even over a longer period such an event would take place, and is less likely in the shorter-term.
Unlikely	There is a complete pollution linkage, but circumstances are such that it is improbable that an event would occur even in the very long-term.

Table 11-5: Consequence (Magnitude of Impact) Criteria – Land Contamination

Consequence	Assessment Criteria
Severe	Short-term (acute) damage to human health (significant harm). Pollution of sensitive water resources as a result of short-term exposure. Damage to a particular ecosystem as a result of acute exposure. Catastrophic damage to buildings/ property/ services/ Scheduled Monument (SM).
Medium	Long-term (chronic) damage to human health (significant harm). Pollution of sensitive water resources as a result of chronic exposure. A significant change in a particular ecosystem, or organism forming part of such an ecosystem. Substantial damage to buildings/ property/ services/ SM.
Mild	No significant impact or harm to human health based on the potential effects on the critical human health receptor. Pollution of non-sensitive water resources. Damage to ecological systems with no significant impairment. Significant damage to sensitive buildings/ structures/ SM/ services or the environment.

Consequence	Assessment Criteria
Minor	Harm (not necessarily significant), which may result in financial loss or require expenditure to resolve. Non-permanent health effects to human health. No appreciable pollution. Easily repairable effects or damage to ecological systems. Easily reparable damage to buildings, structures, SM and services.

Table 11-6: Matrix for Determining Significance of Effect (Risk) – Land Contamination

Consequence	Probability			
	High likelihood	Likely	Low Likelihood	Unlikely
Severe	Very high	High	Moderate	Moderate/ Low
Medium	High	Moderate	Moderate/ Low	Low
Mild	Moderate	Moderate/ Low	Low	Very Low
Minor	Moderate/ Low	Low	Very Low	Very Low

In relation to land contamination, effects of Moderate/Low significance and above, are considered potentially significant, and the level at which further assessment or mitigation would generally be required or proposed.

11.3.10 Limitations to Assessment

Information from historical BGS borehole logs has been used to inform the baseline geology and soil conditions where available. However, as previously noted, given only partial data from ongoing more recent GI are available at the time of writing, it was agreed with the Falkirk Council Contaminated Land Team that an overall desk-based approach for each Flood Cell would be adopted in relation to land contamination for the EIA Report.

Chemical testing results for soil, soil leachate, groundwater and surface water or other information such as groundwater and ground gas monitoring from previous or other historical investigations are not discussed, and the identification of potential land contamination sources has therefore been solely reliant on desk-based assessments and the accuracy of historical mapping.

11.4 Baseline Conditions

11.4.1 Geology

Detailed descriptions of the indicated made ground, superficial and bedrock geology conditions in the study area are presented for each Flood Cell in the desk study reports within Appendix C11.1 to Appendix C11.6 and summarised in the following sub-sections.

11.4.1.1 Made Ground

The developed urban and industrial nature of the study area, historical BGS borehole logs and available BGS mapping (1:50,000 Scale) (BGS, 2015a), as reproduced in Appendix B, Figure B11.2, indicate that

there are significant areas of made ground present within each Flood Cell. There are also significant areas of land that have been historically reclaimed from the Firth of Forth, at the eastern extents of the Scheme, principally within Flood Cell 2, Flood Cell 3 and Flood Cell 6.

Where present, the made ground is likely to be variable in thickness, physical and chemical composition. The review of historical BGS logs indicates that thicknesses may typically range from less than 0.5 m to 5 m, although this may be deeper in areas that have been reclaimed. The physical composition of the deposits is likely to comprise variable intermixed materials ranging from clay to boulder-sized particles, with various anthropogenic and extraneous inclusions. The chemical composition of the deposits will also vary according to local variations in historical and current land uses, in addition to that of imported materials used for previous flood defence works and land reclamation.

The presence of made ground has been further acknowledged and incorporated into the description of potential land contamination sources in sub-section 11.4.5.

11.4.1.2 Superficial Geology

The study area is situated immediately south / south-west of the present day Firth of Forth channel. The Firth of Forth was created during the last glacial period and comprises a deep glacial channel eroded into the underlying bedrock. This has since been infilled with glacial and post-glacial superficial deposits during the glacial retreat and subsequent periods of marine transgression / regression.

The thickness of superficial deposits is anticipated to vary across the study area and in each Flood Cell, due to the presence of the Firth of Forth and other relatively smaller, infilled buried glacial channels. Typically, the thickness of superficial deposits and corresponding depth to bedrock increases from north to south, towards the main Firth of Forth channel where there can be a considerable accumulated thicknesses of over 100 m in the north-east of Flood Cell 3 and 140 m in the north of Flood Cell 6. In the west of Flood Cell 1, superficial deposit thicknesses are reported to be in the order of 25 m to 50 m. In the south of Flood Cell 5 and Flood Cell 6, thicknesses of less than 5 m have been recorded on the south-easterly cusp of the buried glacial channel, which deepens sharply towards the north / north-west, where a maximum superficial thickness of 140 m has been recorded.

The shallow superficial deposits are typical of an estuarine depositional environment. Published BGS mapping (1:50,000 Scale) (BGS, 2015a) for the study area, as reproduced in Appendix B, Figure B11.2, shows these to comprise large areas of raised marine deposits and raised tidal flat deposits (and potentially glaciofluvial ice contact deposits). These have been locally reworked/ replaced/ overlain with more recent intertidal deposits (silt and clay) and alluvium (clay, silt, sand and gravel), associated with the post glacial depositional environment of the Forth and its tributaries, namely the River Avon, River Carron and Grange Burn. The raised marine deposits and raised intertidal deposits within the area also flank the more recent deposits and are anticipated as being likely to be underlain by glacial till at depth throughout the majority of the study area, resting on the underlying bedrock.

The raised tidal flat deposits are anticipated to comprise silt, clay and fine-grained sand with lenses of gravel, while raised marine deposits are likely to comprise gravel, sand, silt and clay, commonly charged with organic debris (plant and shell). The glacial till deposits are likely to comprise compact sands or stiff clayey diamicton (poorly sorted material with particles ranging in size from clay to boulders) and may contain beds of very dense sand and gravel, with many cobbles and boulders. Intertidal deposits are anticipated to comprise gravel through to clay and may be rich in organic matter from the intertidal coastal zone. Glaciofluvial Ice Contact Deposits are likely to comprise stratified sand and gravel and interbedded diamicton deposited by meltwater with lenses of silt, clay and organic material.

Based on the criteria in Table 11-1, the superficial geology in the study area is considered to be of Negligible value.

11.4.1.3 Bedrock Geology

As shown in Appendix B, Figure B11.1 based on available BGS mapping (1:50,000 Scale) (BGS, 2015a), the bedrock geology throughout the study area is indicated to comprise a range of sedimentary Carboniferous strata, including the Scottish Lower Coal Measures Formation (Flood Cell 1 to Flood Cell 4), the Scottish Middle Coal Measures Formation (Flood Cells 1 and 2), the Passage Formation (Flood Cell 1 to Flood Cell 6) and the Upper Limestone Formation which includes the Castlecary Limestone Formation (Flood Cell 3 to Flood Cell 6). The stratigraphical boundaries between these strata vary between lithological conformities and faulted unconformities.

The Scottish Lower Coal Measure Formation comprises sequences of sandstones, siltstones, mudstones, ironstones, coals and seatrocks. The Scottish Middle Coal Measure Formation is described as sandstone, siltstone and mudstone in repeated cycles with seatclay or seatearth and coal. The Passage Formation comprising sandstones with fireclays and thin siltstones, mudstones, ironstones, sparse thin coals with seatrocks and thin marine mudstones or limestones. The Upper Limestone Formation consists of sandstones, siltstones, mudstones, marine limestones, a few coals and seatrock. The Castlecary Limestone Formation comprises a white or pale grey, medium to fine grained crinoidal, bioclastic, locally dolomitic limestone interpreted to be of marine origin and containing algal nodules.

An east to west trending dolerite or basalt Intrusion Is recorded towards the northern extent of Flood Cell 3 bisecting the Eastern Channel water body in Grangemouth Harbour.

Based on the criteria in Table 11-1, bedrock geology in the study area is considered to be of Negligible value.

11.4.2 Designated Geological Sites and Features of Geodiversity Interest

The Firth of Forth SSSI is located partially within and / or adjacent to the boundaries of Flood Cell 3, Flood Cell 4, Flood Cell 5 and Flood Cell 6 (refer to Chapter 7: Biodiversity, Figure B7.1); and is the only designated site within the study area that is, in part, designated for geological interests. The SSSI is important for the wide range of geology that can be found, with the geological and geomorphological diversity including a range of features that have aided in an understanding of the Earth's history (SNH, 2011). These include fossil deposits, volcanic rocks, minerals, strata exposures and raised beaches, the majority of which are understood to be located on the Fife coast to the north of the Forth estuary. The geological features included within the Firth of Forth SSSI are considered to be of High value based on the criteria in Table 11-1.

No other features or sites of potential geodiversity interest were identified in the study area based on site walkover observations (Jacobs, 2018b) and a review of the Falkirk Council Supplementary Guidance document SG08 'Local Nature Conservation and Geodiversity Sites' (Falkirk Council, 2020b).

Non-geological qualifying features associated with the Firth of Forth SSSI and other designated sites are described in Chapter 7: Biodiversity, with fluvial and coastal geomorphology described in Chapter 10: Water Environment.

11.4.3 Mineral Extraction

There are no records of current coal or other mineral extraction activity within the study area. However, information obtained from Coal Authority reports and available online resources show records of historical mine workings at depth and probable shallow coal mine workings within Flood Cell 1, Flood Cell 4 and Flood Cell 6, together with the potential for other unrecorded former workings to be present in these and other parts of the Scheme area. Historical mapping has also identified the presence of coal pits, quarries, clay pits and ironstone clay band mining in several locations across the Scheme area.

Further details on mineral extraction activities are included within the desk study reports for each Flood Cell provided in Appendix C11.1 to Appendix C11.6.

Mineral extraction aspects have been incorporated into the description of potential land contamination sources in sub-section 11.4.5 where appropriate. Given their historical presence, and the indicated superficial and bedrock geological conditions, the potential for further mineral resources to be present in the study area cannot be entirely discounted. However, based on the criteria in Table 11-1, any mineral resource would be expected to be of no more than local importance and would, therefore, be considered Low value.

11.4.4 Soils

The soils present in the study area have been identified using BGS mapping (1:50,000 Scale) (BGS, 2015a), Soil Maps of Scotland (1:25,000 scale) (JHI, 2011a), the Scotland's Soils Online Map Viewer and the 'Soil Survey of Scotland, South-east Scotland' (The Macaulay Institute for Soil Research, 1982).

As shown in Appendix B, Figure B11.3 the majority of the study area is comprised of non-soils due to its predominantly urban and built-up nature. Mineral soils comprising alluvial soils, mineral gleys and brown soils are shown to be present within the less developed/urbanised areas of the study area.

The alluvial soils are derived from recent riverine and lacustrine deposits and are found alongside the River Carron within Flood Cell 1 and Flood Cell 2. The majority of the alluvial soils are described as imperfectly or poorly drained silty alluvial soils or freely draining loamy alluvial soils with an area to the west of Work Area 1.1 (Stirling Road) described as a peaty alluvial soil. In addition, the alluvial soils adjacent to the River Carron within its tidal extent are described as saline alluvial soils which are also known as 'saltings'. Saltings are very poorly drained soils and are derived from salt marsh, marine and estuarine alluvial deposits. Flood Cell 2 is the only flood cell to contain saline alluvial soils which are located along the northern boundary of the cell. Falkirk Council considers peaty alluvial soils and saltings to be rare soil types and of potential national interest (Falkirk Council, 2017; 2020a).

Mineral gleys are derived from estuarine low raised beach deposits of silts and clays and are found within Flood Cell 1, Flood Cell 4, Flood Cell 5 and Flood Cell 6. The mineral gleys are indicated to be poorly or imperfectly drained with additional localised components of non-calcareous gleys, silty alluvial soils and made ground in proximity to areas of industrial land use.

Localised areas of free draining brown earth soils are indicated to be present in Flood Cell 1, Flood Cell 4 and Flood Cell 5. Brown earth soils are derived from raised beach deposits of sands and gravels derived from Carboniferous rocks.

No carbon-rich, deep peat or priority peatland areas have been identified in the study area based on a review of the NS Carbon and Peatland Map (SNH, 2016[3]).

In terms of the agricultural capability of the soils present within the study area the Land Capability for Agriculture (LCA) 1:50,000 scale mapping was reviewed via the Scotland's Soils Online Map Viewer. The vast majority of the study area is classified as a built-up area with no potential for agricultural capability. Two areas shown to have capability of supporting prime agricultural land have been identified in the study area. One area in the centre-west of Flood Cell 1 is identified as LCA Class 2 (land capable of producing a wide range of crops) and a small area in the south-western extent of Flood Cell 4 is identified as LCA Class 3.1 (land capable of producing consistently high yields of a narrow range of crops). Land capable of average production (LCA class 3.2) is shown within Flood Cell 1, Flood Cell 4,

[3] As of 24 August 2020, Scottish Natural Heritage (SNH) is now NatureScot. Where a document was published prior to the NatureScot name change, it has been referenced as SNH.

Flood Cell 5 and Flood Cell 6. In addition, one small area of LCA Class 6.1 (land capable for use as rough grazing) is shown in the south of Flood Cell 6.

Based on the criteria within Table 11-1 the following values have been assigned:

- Soils with a LCA class of 2 are considered to be of Very High value;
- Soils with a LCA class of 3.1, peaty alluvial soils and saltings are considered to be of High value;
- Soils with a LCA class of 3.2 are considered to be of Medium value;
- Soils with LCA classes between 4.1 and 7 are considered to be of Low value; and
- All other soils are considered to be of Negligible value.

11.4.5 Land Contamination

The study area and overall Grangemouth vicinity has an extensive industrial legacy, with historical land uses including foundries, ship yards, docks, petrochemical plants, coal mining, other mineral extraction activities and a range of others. Current industrial land uses in the area also include chemical works and refineries. Several discharge consents related to trade effluents, septic tanks and sewage have also been identified throughout the study area and within its immediate vicinity, together with a variety of contemporary trade directory entries, hazardous substance and industrial land use licence records.

This review of the historical and current land uses has identified a variety of potential sources of land contamination. A detailed breakdown of the potential sources identified for each Flood Cell is provided in the relevant Geo-Environmental Desk Study Reports which are presented as Appendix C11.1 to Appendix C11.6. A summary of the identified potential sources for all Flood Cells is provided in Table 11-7. Approximated locations and indicative boundaries for each potential source area are also shown in Appendix B, Figure B11.5.

Table 11-7: Potential Land Contamination Sources

Location/ Working Area Ref.	On-site (Site Boundary#) Historical/ Current Sources	Offsite (within 100 m*) Historical/ Current Sources
Flood Cell 1		
Stirling Road (Working Area 1-1)	• Red Brae Landfill (1921-early 1980s) (GC-134) • Colliery (1897) (GC-03) • Bus/tramway depot (1915-Present) (GC-04) • Garage (1972-Present) (GC-05) • Smithy and the Forge Landfill (1972-2016) (GC-06) • Rifle Range (1899) (GC-113) • Depot/warehouse (1943-Present) (GC-117)	• Mill (1860-Present) (GC-01) • Infilled pond/mill lade (1951) (GC-02)
Carron Bridges (Working Area 1-2)	• Carron Iron Works (including waste transfer station with WML) (1874-Present) (GC-07) • Railway/tramway land (1874-1988) (GC-08, GC-09, GC-15) • Spoil heap (1874-1897) (GC-12) • Timber depot (1874) (GC-119) • Charcoal works (1874) (GC-120) • Electrical substation (1993-Present) (GC-121)	• Saw pit (1874-1897) (GC-10) • Lime Works (1874-1897) (GC-13) • Basin (infilled) (1874) (GC-14) • Electric substation (1988-Present) (GC-16) • Canal (1874-1993) (GC-17) • Carron Iron Works (1874-1972) (GC-118)

Location/ Working Area Ref.	On-site (Site Boundary#) Historical/ Current Sources	Offsite (within 100 m*) Historical/ Current Sources
		• Refuse tip (1951-1952) (GC-135)
Carronshore (Chapel Burn) (Working Area 1-3)	• Canal (1874-1993) (GC-17) • Mill (1874-1897) (GC-24)	• Disused Coal Pit (1874) (GC-23) • Timber yard (1982-2006) GC-25) • Electrical substation (1991-Present) (GC-122, GC-123)
Carronshore (Dock Street) (Working Area 1-4)	• Railway/tramway land (1859-1943) (GC-18) • Ship graving dock (1859-1943) (GC-19) • Sewage tanks (1943-1960) (GC-21)	• Colliery (1897-1916) (GC-20) • Disused Coal pit/Spoil (1859-1945) (GC-22) • Electrical substation (1990-Present) (GC-124)
Flood Cell 2		
Lower Carron (Working Areas 2-1 and 2-2)	• Rope works (1864-1899) (GC-26) • Quay (1864 only) (GC-29) • Graving Dock (1864 only) (GC-30) • Timber Yard (1864 only) (GC-31) • Ship Building Yard (1864-1951) (GC-32) • Timber Basin (1864-1968) (GC-34) • Smithy (1864-1899) (GC-38) • Old Harbour (infilled) (1864-1968) (GC-39) • Engineering works (1892 only) (GC-41) • Smithy (1899–1938) (GC-44) • Timber Shed (1921-1951) (GC-46) • Smithy (1899-1938) (GC-47) • Smithy (1899-1921) (GC-48) • Works (1968-1993) (GC-49) • Warehouse (1973-Present) (GC-50) • Pumping Station (1987-Present) (GC-51) • Depot (1987-Present) (GC-52) • Depot (1987-Present) (GC-53) • Reclaimed land (GC-116)	• Gas works (1899-1921) (GC-27) • Smithy (1864 only) (GC-28) • Basin (infilled) (1864-1968) (GC-33) • Wet Dock (1864-Present) (GC-35) • Timber Basin (1864-1968) (GC-36) • Curling Pond (infilled) (1864 only) (GC-40) • Smithy (1899 only) (GC-42) • Canal (infilled) (1864-1968) (GC-43) • Railway land (1899-1987) (GC-45) • Timber Yard (1987-2006) (GC-54)
Flood Cell 3		
Forth Ports (Working Areas 3-1, 3-2, 3-3 and 3-4)	• Railway Land (1899-1987) (GC-45) • Infilled ground (Infilled 1899-Present) (GC-55) • Bulk Oil Depot / Oil and Naphtha Storage Area / Oil Storage Depot / Petroleum Installation (various including associated tanks and infrastructure) (1915-Present) (GC-56) • Infilled land (Infilled 1951-Present) (GC-57) • Railway Sidings (various 1899-1973) (GC-60) • Warehouses (1951-1973) (GC-61)	• Wet Dock (1864-Present) (GC-35) • Timber Yard/Works (1921-Present) (GC-59) • Tallow works (1951 only) (GC-62) • Ponded Area (1951-Present) (GC-63) • Pumping Station (1951 only) (GC-64) • Bulk Oil Depot / Oil and Naphtha Storage Area / Oil Storage Depot / Petroleum Installation (various

Location/ Working Area Ref.	On-site (Site Boundary#) Historical/ Current Sources	Offsite (within 100 m*) Historical/ Current Sources
	• Electrical Substation (1984-Present) (GC-70) • Works (2006-Present) (GC-71) • Reclaimed Dockland (2006-Present) (GC-72) • Railway and railway sidings (1921-Present (as track / roads) (GC-74) • Reclaimed land (GC-116)	including associated tanks and infrastructure) (1915-Present) (GC-65, GC-66)) • Tanks associated with oil depot (1984-Present) (GC-69)
Flood Cell 4		
Grange Burn - Northern Section (Working Areas 4-5, 4-6, 4-7, 4-8 and 4-9)	• Infilled ground (Infilled in 1899-present) (GC-55) • Warehouse (1973-Present) (GC-68) • Container base (2006-Present) (GC-73) • Railway and railway sidings (1921-Present (as track / roads)) (GC-74) • Grangemouth Refinery and associated infrastructure including storage tanks (1952-Present) (GC-114) • Reclaimed land (GC-116) • Oil Refinery reclaimed land (1974-Present) (GC-129)	• Electric power station (1921 only) (GC-58) • Works (1973-Present) (GC-67) • Warehouses / Works (1968-Present) (GC-76, GC-83, GC-84) • Pumping station (1943-1992) (GC-82) • Depot (1978-Present) (GC-85, GC-86) • Bitumen depot (1960-1992) (GC-102) • Refuse tip (1974 only) (GC-130)
Grange Burn - Southern Section (Working Areas 4-2, 4-3 and 4-4)	• Infectious diseases hospital (1915-1951) (GC-95) • Piggery / kennels (1955-1993) (GC-96) • Sewage pumping station (1979-1997) (GC-127)	• Gasometer (1899 only) (GC-87) • M9 motorway (1980-Present) (GC-88) • Depot (1980-Present) (GC-90, GC-91) • Works (1979-Present) (GC-92) • Quarry and BGS Recorded Mineral Site (1865-1951) (GC-94) • Smithy (1899 only) (GC-125) • Corn mill (1865-1899) (GC-126) • Tank (1972-1984) (GC-133)
Upstream of M9 (Working Area 4-1)	• M9 motorway (1968-Present) (GC-88) • Cemetery (1921-Present) (GC-89) • Falkirk Distillery (2013-Present) (GC-115) • Clay pit (1897 only) (GC-131)	• Clay pit (1897 only) (GC-132)
Flood Cell 5		
River Avon (Working Areas 5-1, 5-2, 5-3 and 5-4)	• Corn mill (1856-1951) (GC-93) • Settlement ponds (1955-Present) (GC-98) • Sewage works (1958-1979) (GC-99) • Pumping station (tank present at this location) (1974-Present) (GC-101) • Gas separator plant (1974-Present) (GC-110) • Chemical works (various associated infrastructure including tanks, flare stacks,	• Hospital (1915-1951) (GC-95) • Avonbank knackery (1915-1951) (GC-97) • Area of spoil (1969 only) (GC-100) • Electric substation (1974-Present) (GC-109) • Grangemouth Airfield (1958 only) (GC-128)^

Location/ Working Area Ref.	On-site (Site Boundary#) Historical/ Current Sources	Offsite (within 100 m*) Historical/ Current Sources
	cooling towers) (1973-Present) (GC-111, GC-112) • Oil refinery (1959-Present) (GC-114) • Reclaimed land (GC-116)	
Flood Cell 6		
West of River Avon (Working Areas 6-1 and 6-2)	• Railway Sidings (1984-Present) (GC-74) • Rifle range (1921-1951) (GC-106) • Oil refinery (including associated tanks and infrastructure) (1959-Present) (GC-114) • Reclaimed land (GC-116) • Oil refinery reclaimed land (1974-Present) (GC-129)	• Warehouse (1973-Present) (GC-68) • Container base (2006-Present) (GC-73) • Avonbank knackery (1915-1951) (GC-97) • Area of spoil (1968 only) (GC-100) • Refuse tip (1974 only) (GC-130)
East of River Avon (Working Areas 6-3 and 6-4)	• Sewage works (1984-1994) (GC-103) • Rifle range (1921-1951) (GC-108) • Chemical works (including associated tanks and infrastructure) (1974-Present) (GC-110) • Reclaimed land (GC-116) • Reclaimed land likely to incorporate landfill materials (1893-Present) (GC-139)	• Electric Substation (associated with sewage works) (1984-1994) (GC-104) • Sewage works with WML (2006-Present) (GC-105) • Kinneil Kerse Landfill (1893–1999/Present) (GC-107) • Oil refinery (including associated tanks and infrastructure) (1959-Present) (GC-114)
# - Site Boundary (includes Permanent Works Footprint, haul roads and site compound areas). * - 100 m buffer is based around Permanent Works Footprint only ^ - The Grangemouth Airfield is 120 m from the Permanent Works Footprint at its closest point but has been included due to the local significance of the source.		

The potential sources include a reasonably wide variety of former or current industrial land uses; all of which are in addition to the indicated presence of made ground throughout the study area and its general vicinity. For the purposes of assisting the assessment at this stage, the sources have therefore been collectively generalised to comprise the following, considering their potential exposure pathways to relevant receptors:

- Made ground materials or other potentially contaminated soils and water associated with historical or current contaminative land uses within the Working Areas, Site Boundary and Permanent Works Footprint;
- Asbestos present in made ground materials or existing structures;
- Ground gas and vapours associated with made ground materials, mineworkings or organic-rich natural superficial deposits; and
- Potentially contaminated soils and water associated with historical or current contaminative land uses in the immediate vicinity of the Site Boundary (i.e. within 100m to 250m).

Potential receptors that could require assessment in the context of these being present have been compiled based on the definitions provided in 'The Environmental Protection Act 1990: Part IIA Contaminated Land – Statutory Guidance: Edition 2' (Scottish Executive, 2006), as well as the geological and wider baseline conditions in the study area. Further detail on the identified receptors for each Flood Cell is provided in the relevant Geo-Environmental Desk Study Reports which are presented as Appendix C11.1 to Appendix C11.6.

The following potential receptors (including their relevant reference from Appendix C11.1 to Appendix C11.6) have been identified:

- Human health: construction (R1) or maintenance workers (R6), future site users (R2), off-site neighbouring residents and workers (R5).
- Water Environment: groundwater within superficial deposits and underlying bedrock (R7) and surface water features (R3) (including the River Carron, Polmont Burn, Grange Burn/ Westquarter Burn, River Avon, the Forth Estuary and others).
- Ecological receptors: designated sites (including the Firth of Forth SSSI, Special Protection Area (SPA) and Ramsar site) and potential downgradient GWDTEs (including wet grasslands, swamp and other discrete wetland habitats) (R9).
- Subsurface buried concrete and infrastructure installed as part of the development works (R4).
- Property: livestock and domestic pets (R8).

The locations and boundaries of designated sites are described in Chapter 7: Biodiversity and shown in Appendix B, Figure B7.1. Potential GWDTE are identified and described in both Chapter 7: Biodiversity and Chapter 10: Water Environment and illustrated in Figure B10.15. Surface watercourses and possible private water supply features (wells) are also described in Chapter 10: Water Environment, and are shown in Appendix B, Figure B10.1, Figure B10.4 and Figure B10.15.

11.4.6 Future Baseline

A review of the current baseline conditions for soils, geology and contamination has been undertaken. It is unlikely that the baseline conditions will change prior to the construction of the Scheme. It is possible that there may be further development undertaken in close proximity to the Site Boundary (e.g. development works on neighbouring sites), however, any such works are unlikely to significantly change the baseline at the site with respect to soils, geology and land contamination.

11.5 Impact Assessment

11.5.1 General

The works associated with the Scheme are described in Chapter 4: The Proposed Scheme. The proposals primarily comprise the construction of flood walls and embankments across the Scheme extents, with lock gates, flood gates, some land raising, and rock armour revetments also proposed to be undertaken. The majority of these features are likely to be limited in terms of width. However, more extensive site preparation works are likely to be required, together with demolition of some existing structures, areas of excavation and construction techniques that involve piling.

There are therefore a variety of ways in which the Scheme could impact upon geology and soils features or interact with areas of land contamination, including the following:

- Excavating exposures of rocks or superficial geological deposits of scientific or geodiversity interest, particularly if the features of interest are not reproduced elsewhere in the area;
- Constraint or limitation to existing or potential commercial exploitation of mineral resources;
- Excavation, removal, sealing or compaction of local soil resources, including carbon-rich soils, soils of potential conservation interest or agricultural soils;
- Creation of new contaminant migration pathways as a result of piling; and

- Impacts on soils, geology, groundwater, surface water and other receptors due to the direct and indirect disturbance of potential land contamination sources and associated contaminated soils or water.

A key aspect of the impact assessment has been to consider the works proposed for the Scheme in the context of the known or anticipated baseline conditions, identified receptors and how these may realistically interact. As part of this, it has been assumed that excavations will be required for a variety of the Scheme works elements, particularly flood walls and embankments; and that these would be up to a maximum of 1 m in depth. Piling to greater depths will also be required beneath flood walls and possibly embankments, and it has been assumed that these would vary in depth, depending on the thickness of the superficial geological deposits in the locality and any relevant geotechnical requirements.

The potential impacts and resultant effects associated with the Scheme have therefore been assessed within this context, in the absence of mitigation, and are all considered to be adverse unless otherwise stated.

11.5.2 Geology

11.5.2.1 Superficial Geology

Superficial deposits of negligible sensitivity (alluvium, raised marine deposits, raised tidal flat deposits and intertidal deposits) within the Site Boundary and overall Permanent Works Footprint of the Scheme are likely to be impacted by the construction of a variety of elements, including flood walls and embankments, associated excavations, rock armour revetments and piling activities, to varying extents.

The disturbance and/ or reduction in the extent of these deposits as a result of the construction activities is considered to be of very small magnitude because of their widespread occurrence in the region and country, and therefore minimal percentage loss. As a result, the overall significance of effect is considered to be Negligible for both construction and operation.

11.5.2.2 Bedrock Geology

Bedrock of negligible sensitivity is unlikely to be excavated as part of the Scheme construction, given the assumed maximum depth of excavation required for the flood walls and embankments, and corresponding likely depths to rockhead. Piling is proposed beneath the flood walls however, and may also be needed below embankments, so the possibility of the piles locally extending to, and intercepting bedrock cannot be entirely discounted.

The magnitude of potential impact on the bedrock geology would nevertheless be considered to be of no more than very small due to the widespread occurrence of the rock types in the region. This would therefore result in an overall effect of Negligible significance during construction and operation.

11.5.3 Designated Geological Sites and Features of Geodiversity Interest

No direct or indirect impacts on geological interest features (fossil deposits, volcanic rocks, minerals, strata exposures and raised beaches) associated with the Firth of Forth SSSI (high sensitivity) are anticipated as a result of the Scheme during construction or operation.

Potential impacts in relation to non-geological interest features associated with the Firth of Forth SSSI and other designated sites are described in Chapter 7: Biodiversity, with impacts in relation to fluvial and coastal geomorphology considered and described in Chapter 10: Water Environment.

11.5.4 Mineral Extraction

There is historical evidence of coal mining and other mineral (sand, clay and ironstone) extraction in the study area. Any potential impact on future exploitation of similar possible resources (low sensitivity) from the Scheme, however, would be considered to be no more than very small in magnitude – given most minerals of economic importance are likely to have already been exploited and therefore, the minimal percentage potential loss based on the criteria in Table 11-2. This results in an effect of Minor significance during construction and operation.

11.5.5 Soils

Soils are likely to be locally impacted within the Site Boundary through general construction activities, the construction of flood walls and embankments, associated excavations, rock armour revetments, piling and possibly, accidental spillages. The Permanent Works Footprint indicate the areas to be permanently lost or sealed.

With respect to mineral soils, the areas of permanent loss represent a small magnitude of impact as defined in Table 11-2 which equates to partial losses and disturbance, but where the overall value of areas would not be affected. Potential effects in relation to saltings (high value) and other mineral soils (negligible value) are therefore assessed to be of Minor and Negligible significance respectively during both construction and operation.

The magnitude of impact with respect to agricultural soils as defined in Table 11.2 depends upon the hectarage lost or sealed. Table 11-8 presents the hectarage lost within each Flood Cell and as a total for the Scheme based on the area of the Permanent Works Footprint for each LCA class present. The table then also provides the assessed Significance of Effects on agricultural soils for the Scheme during both construction and operation. Soils of LCA Class 6.1 which are present in the south of Flood Cell 6 are located outside of the Permanent Works Footprint so no permanent loss or sealing of soils is anticipated and therefore, a negligible magnitude of impact and a negligible significance of effect is predicted for these soils.

Table 11-8: Magnitude of Impact and Significance of Effect for Agricultural Soils

LCA Class (Value)	Permanent Land Take (Ha) *					Magnitude of Impact for Scheme	Significance of Effect for Scheme
	Flood Cell				Total for Scheme		
	1	4	5	6			
2 (Very High)	0.891	0	0	0	0.891	Negligible	Negligible
3.1 (High)	0	0.028	0	0	0.028	Negligible	Negligible
3.2 (Medium)	0	3.307	0.364	0.770	4.441	Medium	Minor
* Permanent land take calculated from hectarage of LCA Classes present within Permanent Works Footprint.							

11.5.6 Land Contamination

A number of potential contamination source areas have been identified in the study area, as shown in Appendix B, Figure B11.5 To assess the environmental impact of the Scheme due to the presence of these potential contamination sources, a series of land contamination risk assessments have been completed for each Flood Cell. These land contamination risk assessments have been undertaken in accordance with CIRIA C552 (CIRIA, 2001) and are presented in full within the desk study reports included in Appendix C11.1 to Appendix C11.6. These assessments focus on the identified source terms listed in Table 11-7 and their potential impacts to site receptors via relevant pollutant linkages. These assessments mirror the criteria and definitions for probability, consequence, and significance set out in Table 11-4, Table 11-5 and Table 11-6 and hence equate to the environmental impact assessment. A summary of the derived significance of effect for each pollutant linkage as a result of construction or

operation of the Scheme is provided below in Table 11-9. Unless stated otherwise in Table 11-9, each pathway is considered relevant for both construction and operation of the Scheme.

Table 11-9: Summary of Significance of Effect of identified Land Contamination Pollutant Linkages

Pollutant Linkage Assessment			Significance of Effect					
			Flood Cell					
Source	Pathway	Receptor	1	2	3	4	5	6
S1 – Made ground and potential onsite contaminants (associated with historical land uses)*	P1 – Dermal contact with contaminants within site soils and/or groundwater	R1 – Construction workers	**Moderate**					
		R6 – Maintenance workers						
	P7 – Inhalation, ingestion of soils/dust **post** construction	R2 – Future site users	**Moderate/Low**					
	P7 – Inhalation, ingestion of soils/dust **during** construction	R5 – Off-site neighbouring residents and workers	**Moderate**					
	P7 – Inhalation, ingestion of soils/dust **post** construction		Low					
	P7 – Inhalation, ingestion of soils/dust **during** construction	R8 – Property (livestock and domestic pets)	**Moderate/ Low**	Low	Receptors Absent	**Moderate/ Low**		
	P7 – Inhalation, ingestion of soils/dust **post** construction		Very Low		Receptors Absent	Very Low		
	P3 – Leaching of contaminants in soils to groundwater and subsequent migration to surface water or deeper aquifer units via piling	R3 – Surface water features	**Moderate**					
		R7 – Superficial and bedrock groundwater						
		R9 – Ecological receptors (designated sites and/or potential downgradient GWDTEs)	**Moderate/ Low**		**Moderate**		**Moderate/ Low**	**Moderate**

Pollutant Linkage Assessment			Significance of Effect					
			Flood Cell					
Source	Pathway	Receptor	1	2	3	4	5	6
	P4 – Direct contact with soil contaminants	R4 – Subsurface buried concrete and infrastructure	Low					
S2 – Ground gas associated with made ground deposits/ landfill. (site wide)	P2 – Ground gas/ vapours and build up/ inhalation within confined spaces and lateral migration along preferential pathways	R1 - Construction workers	**Moderate**					
		R6 – Maintenance workers						
		R2 – Future site users	**Moderate/Low**					
S3 – Asbestos present in made ground (site wide)	P6 – Inhalation of asbestos containing dust	R1 – Construction workers	**Moderate**					
		R6 – Maintenance workers						
		R2 – Future site users						
S4 – Offsite sources*	P5 – Migration of contaminants (through groundwater flow) onsite from offsite and discharge to surface water	R3 – Surface water features	**Moderate**					
*** Source List**								
S1 - Made ground and potential onsite contaminants (associated with historical land uses) –- GC-03, GC-04, GC-05, GC-06, GC-07, GC-08, GC-09, GC-12, GC-15, GC-17, GC-18, GC-19, GC-21, GC-24, GC-26, GC-29, GC-30, GC-31, GC-32, GC-34, GC-38, GC-39, GC-41, GC-44, GC-45, GC-46, GC-47, GC-48, GC-49, GC-50, GC-51, GC-52, GC-53, GC-55, GC-56, GC-57, GC-60, GC-61, GC-68, GC-70, GC-71, GC-72, GC-73, GC-74, GC-88, GC-89, GC-93, GC-95, GC-96, GC-98, GC-99, GC-101, GC-103, GC-106, GC-107, GC-108, GC-110, GC-111, GC-112, GC-113, GC-114, GC-115, GC-116, GC-117, GC-119, GC-120, GC-121, GC-127, GC-129, GC-131, GC-134 and GC-139								
S4 – Offsite sources –- GC-01, GC-02, GC-10, GC-13, GC-14, GC-16, GC-20, GC-22, GC-23, GC-25, GC-27, GC-28, GC-33, GC-35, GC-36, GC-40, GC- 42, GC-43, GC-54, GC-58, GC-59, GC-62, GC-63, GC-64, GC-65, GC-66, GC-67, GC-69, GC-76, GC-82, GC-83, GC-84, GC-85, GC-86, GC-87, GC-90, GC-91, GC-92, GC-94, GC-97, GC-100, GC-102, GC-104, GC-105, GC-107, GC-109, GC-118, GC-122, GC-123, GC-124, GC-125, GC-126, GC-128, GC-130, GC-132, GC-133 and GC-135								

The above assessments have been completed with reliance solely on desk based information. Each land contamination risk assessment has been developed to be as specific as possible, based on consideration of the information available including; site history and published industry profiles, evidence for potential or actual contamination presence, the proximity of receptors and how these may interact with the local geology, hydrogeology and anticipated construction or operation activities.

The findings suggest that direct interaction may occur with all of the on-site potential contamination sources (those within the Site Boundary and Permanent Works Footprint for each Flood Cell) to varying degrees. This is principally as a result of excavation and earthwork operations for the flood walls, embankments and other Scheme elements (including demolition of existing structures) having the potential to disturb made ground material or other potentially contaminated soils, dusts and water, and create pathways which may allow pollutant linkages to develop. There is also the potential for direct and indirect mobilisation and migration of contamination towards and within the Site Boundary and towards the water environment or ecological receptors via groundwater flows, together with the potential for cross-contamination of groundwater aquifer units as a result of piling.

In relation to human health, these interactions are considered of likely probability to occur and may affect construction workers (R1) and off-site neighbouring residents and workers (R5) during construction; and maintenance workers (R6) during operation; in all Flood Cells, with medium consequence and potential effects of **Moderate** significance. There is also the potential for ground gas or vapour migration and build-up within confined spaces or excavations, assessed to be of low probability for all Flood Cells, the severe consequence determines a **Moderate** significance for construction and maintenance workers (R1 and R6) during construction and operation respectively within the Flood Cells. Interaction with the same sources may also occur during operation with similar consequence for future site users (R2) and off-site neighbouring residents and workers (R5), but at realistically lower probabilities. Resultantly, potential human health contamination effects during operation/ post construction would be proportionately lower and of **Moderate/ Low** significance for future site users (R2) and Low significance for off-site neighbouring residents and workers (R5). That said, the potential risks associated with potential asbestos containing materials (ACM) within made ground for future site users (R2) remains as a **Moderate** significance during operation in the absence of mitigation and as the presence of ACM cannot be discounted based on the information available at this stage of assessment.

Groundwater flow paths are likely to be complex within the study area, due to the naturally layered nature of the aquifers, as described in Chapter 10: Water Environment. Groundwater may also be present under unconfined or confined conditions, at various depths, and different groundwater heads may be seen in different aquifer layers. Due to several potential contamination sources being present within the Site Boundary (on-site) and the immediate surroundings (off-site), there is the potential for contaminated groundwater to be encountered or drawn into the Permanent Works Footprint for each Flood Cell, or be mobilised from within them due to disturbance, run-off or leaching, or as a result of piling. In addition, it may be necessary to remove any standing water/drawn in groundwater within excavations and discharge of this water directly to the water environment (both surface water and groundwater). Therefore, in relation to the water environment receptors, the probability for land contamination risks to occur has been assessed as likely for surface waters (R3), superficial groundwater (R7); and also for bedrock groundwater (R7) (as they cannot be discounted based on the information available at this stage of assessment) with medium consequence (in the absence of mitigation) resulting in potential effects of **Moderate** significance during both construction and operation.

The probability for land contamination risks to ecological receptors associated with the Firth of Forth SSSI and /or GWDTEs (R9) has been based on the proximity of the proposed permanent works footprint and the feature. Where the permanent works footprint is within 100m of the Firth of Forth SSSI and/or directly interacts with or is within 250m and up groundwater gradient of a GWDTE, it is considered likely that groundwater beneath the site will be in close hydraulic continuity with the feature(s). Where the

permanent works footprint is located beyond 100m of the Firth of Forth SSSI and/or in excess of 250m or down groundwater gradient or hydraulically disconnected from a GWDTE, the probability is considered to be of low likelihood. At this stage of assessment only the presence of potential GWDTEs has been established (as discussed in Chapter 10: Water Environment and shown in Appendix B, Figure B10.15). Potential GWDTEs located within 250m and downgradient of or within a Permanent Works Footprint have been identified for Flood Cell 3, Flood Cell 4 and Flood Cell 6. Potential GWDTEs located within 250m and upgradient or hydraulically disconnected from a Permanent Works Footprint have been identified for Flood Cell 1 and Flood Cell 5. No potential GWDTE were identified within Flood Cell 2. Although there will be some attenuation and dilution of contaminants within either groundwater or surface water during migration towards the identified ecological receptors, the consequence has been considered to be medium based on the information available at this stage of assessment and in the absence of mitigation. The resultant significance of effects is therefore **Moderate** for ecological receptors considered to be in close proximity or down groundwater gradient and of **Moderate/Low** significance for ecological receptors located at distance and up groundwater gradient during both construction and operation.

For the assessment of potential risks to property such as livestock or pets (R8), consideration was given to the presence of land with the ability to home livestock or the presence of residential areas within each Flood Cell. Flood Cells considered to have the potential to home livestock were considered to have a likely probability (based on the assumption the livestock have no indoor accommodation). Flood Cells with residential areas, and therefore the possibility of pet ownership, were considered to have a low likelihood probability. For Flood Cells, such as Flood Cell 3, with neither suitable open space or residential areas it has been considered that there is no livestock/pet receptor present and therefore no complete pollutant linkage to assess. During construction, access to the Working Areas is likely to be controlled, however, there could be dust generation that could leave the Working Areas and have a potential impact of mild consequence on neighbouring (off-site) livestock/pets. The resultant significance of effects is therefore **Moderate/Low** for livestock and Low for pets during construction. The probability of dust generation during the operation of the Scheme is considered to be unlikely and therefore the significance of effect during operation is considered to be Very Low for both livestock and pet receptors.

There is a potential risk to any subsurface buried concrete installed as part of the development (R4) due to direct contact with any potential contaminant within soils or groundwater. The probably has been considered as low likelihood with a mild consequence and a resultant effect of Low significance.

In addition to the identified Land Contamination Pollutant Linkages discussed in Table 11-9 where made ground or other material is excavated and temporarily stored during construction (including materials from demolished structures), these may represent additional potential risks to human health, the water environment and ecological receptors, or property receptors such as buried concrete, or livestock and agricultural land in adjacent areas. In the absence of mitigation, the potential of this occurring has been assessed to vary between low and likely probability in each Flood Cell, and of mild to medium consequence during construction. Potential risks to the same receptors during operation are also possible if the materials were re-used, and are assessed to be of similar consequence, but lower likelihood. Potential effects are, therefore, identified to be of **Moderate/ Low** to **Moderate** significance during construction and **Low to Moderate**/ Low significance during operation.

11.6 Mitigation

11.6.1 General

Based on the findings of the assessment, no potentially significant effects have been identified in relation to superficial and bedrock geology, designated geological receptors, features of geodiversity interest, mineral extraction considerations or soils, so mitigation measures are not proposed for these.

Mitigation measures in relation land contamination have been identified to be required and these are described in the following sub-sections. These will be developed alongside relevant management systems to structure, monitor, control and communicate their implementation, which will include preparation of a Construction Environmental Management Plan (CEMP). The mitigation measures identified apply prior to construction, during construction and/ or following construction as stated. The definitions for Primary, Secondary and Tertiary mitigation have followed the guidance set out in the 2016 IEMA guidance document Environmental Impact Assessment Guide to: Delivering Quality Development (IEMA, 2016).

11.6.2 Primary Mitigation

Full details of primary mitigation for the Scheme (intrinsic elements or modifications of the design intended to reduce impacts, without the requirement for additional mitigation) are described in Chapter 4: The Proposed Scheme. At this stage, no specific primary mitigation measures related to soils, geology and land contamination considerations have been included.

11.6.3 Secondary Mitigation

Secondary mitigation measures are additional actions that are not embedded in the Scheme design, but that will be required to further avoid, reduce or offset potential impacts associated with it, or represent actions that may be imposed as part of planning consent or specified in the construction contract.

Interaction is expected between construction of the Scheme and areas of potential land contamination, which could lead to direct and indirect effects on a variety of human health, water environment, ecological and built environment/ property receptors, predicted to range from Very Low to Moderate significance. The following mitigation items should therefore be implemented to negate or reduce the predicted effects through further investigation, monitoring and remediation where necessary, and to minimise contact with potentially contaminated soils, water or other materials as far as possible.

- Prior to construction and where potential land contamination sources have been identified, further GI and ground gas/ groundwater monitoring sufficient to determine the extent and type of contaminants present will be undertaken to inform detailed risk assessments, identification of appropriate construction methods and procedures, as well as any additional mitigation or remedial measures that may be required. This will include completion of the currently ongoing GI, a detailed assessment of the findings and implementation of any additional investigation and monitoring work that may be deemed necessary in accordance with the regulatory guidance prevalent at the time of assessments (**Mitigation Item G1**).
- In the event that unexpected soil or water contamination is encountered, works would be stopped, and the working procedures (see Tertiary **Mitigation Item G9)** re-assessed to confirm the working methods remain appropriate (**Mitigation Item G2**).
- Construction staff will be trained to identify asbestos containing material and any other hazardous contaminants potentially present, and appropriate training will be provided for personnel involved in all earthworks activities, to enable implementation of a watching brief to identify presence of unexpected soil or water contamination (**Mitigation Item G3**).
- Should ground gas or vapour issues be identified during further GI or monitoring, appropriate working methods will be developed and adopted during below ground site construction works (including piling works and excavations) and should include as a minimum, monitoring undertaken prior to any entry into excavations, confined spaces or below ground structures and the use of personal protective equipment (PPE) as a last resort. If similar issues are identified during construction, further post-construction monitoring will be undertaken if necessary (**Mitigation Item G4**).

- Storage of excavated soils and made ground will be minimised on site (spatially and in duration) to what is only practicably necessary and storage areas will be appropriately lined, with adequate drainage management in place and appropriate stand-offs from watercourses (**Mitigation Item G5**).
- Standing water within excavations will be controlled where possible and pumped out if necessary. Any water encountered within excavation areas will be assessed for licensed removal or discharge. Containment facilities and discharge locations for abstracted water during construction will be defined taking water quality characteristics into account (**Mitigation Item G6**).
- Where buildings/ structures are to be demolished, the appointed demolition contractor will undertake asbestos surveys of the structures as appropriate prior to any demolition works commencing and identify appropriate management and disposal routes (**Mitigation Item G7**).

11.6.4 Tertiary Mitigation

Tertiary mitigation measures are actions that will be undertaken to meet all existing relevant legislative requirements and best practice methods in relation to potential impacts associated with land contamination. The following tertiary mitigation measures will be adopted by appointed contractors in accordance with legislative requirements and industry standards:

- Prior to construction and alongside **Mitigation Item G1**, consultation will be undertaken with Falkirk Council and SEPA (as necessary) regarding works in relation to land affected by contamination to support the obligations set out in 'Planning Advice Note 33: Development of Contaminated Land' (Scottish Government, 2017). Any remedial action undertaken in relation to land affected by contamination will be carried out under the appropriate remediation licencing (**Mitigation Item G8**).
- Prior to construction, appropriate health, safety and environment procedures for working with potentially contaminated soils and water will be established. This will include provision to manage risks to construction and maintenance staff working with/ near contaminated land and neighbouring site users/ land users. Consideration will be given to the adoption of appropriate systems of work, including dust-suppression and air monitoring measures where necessary and the use of PPE. Reference should be made to the relevant Health and Safety Executive (HSE) Approved Code of Practice and Guidance Notes including HSE Guidance Note MS31 (HSE, 2012). These procedures will be implemented as appropriate during construction. (**Mitigation Item G9**).
- To prevent cross contamination and pollution from piling works undertaken in areas of land affected by contamination, Piling Risk Assessments will be undertaken to inform appropriate piling techniques and designs, which should adhere to appropriate guidance including the 'Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention, National Groundwater and Contaminated Land Centre Report NC/99/77' (Environment Agency, 2001) (**Mitigation Item G10**).
- The appointed Contractor will develop a Site Waste Management Plan (SWMP) in consultation with SEPA, to identify, prior to the start of construction, the types and likely quantities of waste that may be generated and set out, in an auditable manner, how waste will be prevented, re-used, recycled and otherwise recovered in accordance of the principles of the 'Waste Hierarchy' as set out Article 4 of the revised Waste Framework (Directive 2008/98/EC) (European Parliament, 2018) (**Mitigation Item G11**).
- To maximise the reuse of site-won materials on-site (and minimise the need for disposal of waste in line with the principles of the 'Waste Hierarchy') whilst ensuring that no risks are posed to human health, the water environment or other receptors, a soil re-use assessment will be undertaken prior to construction. The soil re-use assessment will identify any potential risks from potentially contaminated soils re-used throughout the Scheme. The soil re-use assessment will take cognisance of SEPA guidance document Land Remediation and Waste Management Guidelines (SEPA, no date), (**Mitigation Item G12**).

- Waste management procedures will take account of inter alia Waste Management Licence (Scotland) Regulations 2011 (as amended by the Waste Management Licensing (Scotland) Amendment Regulations 2016), (**Mitigation Item G13**).
- If excavated soils are deemed unsuitable for re-use they will be assessed in line with the 'Waste Classification: Guidance on the Classification and Assessment of Waste' (Technical Guidance WM3) (Natural Resources Wales et al, 2021) prior to disposal, to determine whether they are hazardous or non-hazardous. This will establish the most appropriate and cost effective waste stream for the waste materials. Any waste materials removed from the site must be disposed of in accordance with the Waste Management Licensing (Scotland) Regulations 2011 (as amended by the Waste Management Licensing (Scotland) Amendment Regulations 2016) (Scottish Statutory Instruments, 2016) (**Mitigation Item G14**).
- Any recovered waste materials imported to site (such as imported soils) must be stored and used only in accordance with a waste management licence or exemption under the Waste Management Licensing (Scotland) Regulations 2011 (as amended by the Waste Management Licensing (Scotland) Amendment Regulations 2016) (Scottish Statutory Instruments, 2016) (**Mitigation Item G15**).
- Where concrete materials are proposed to be used, appropriate guidance such as 'Building Research Establishment (BRE) SD1:2005' (BRE Construction Division, 2017) and 'British Standard (BS) BS8500' (British Standards Institution, 2020) will be followed to ensure that ground conditions are appropriate for the use of concrete at each given location (**Mitigation Item G16**).

11.6.5 Cross-Factor Mitigation

In addition to the secondary and tertiary mitigation measures identified with respect to land contamination, there are a range of primary, secondary and tertiary mitigation items from Chapter 7: Biodiversity, Chapter 10: Water Environment and Chapter 12: Air Quality and Climate Change that will offer additional protection.

11.7 Cumulative Effects

11.7.1 Same Project Cumulative Effects

Indirect (secondary) effects may arise as a result of inter-linked impacts of the Scheme on geology and soils receptors, or receptors considered as part of the land contamination assessment. The effects of the Scheme on these are closely linked to, and in some instances interdependent on, some of those described in Chapter 6: Population and Human Health, Chapter 7: Biodiversity and Chapter 10: Water Environment.

Potential indirect effects could include the presence of and impacts on rare soils of conservation value, which could also affect important habitats or vegetation. Impacts in relation to land contamination as a result of disturbance, direct or indirect mobilisation and migration additionally could be affected by changes in groundwater or surface water levels, flows or flooding, while also having the potential to impact upon human health, as well as groundwater and surface water quality, ecological and built environment/ property receptors. Based on this assessment and a review of the residual impacts and mitigation measures proposed in the other relevant technical Chapters however, no additional significant adverse effects have been identified with regards to soils, geology and land contamination.

11.7.2 Other Project Cumulative Effects

There is potential for cumulative effects due to other projects affecting the same geology and soils receptors as the Scheme or interacting with areas of potential land contamination. Based on a review of the relevant other developments, their locations, and given they are likely to be subject to a degree of

appropriate control measures to limit potential impacts (most notably those associated with potential land contamination), any potential cumulative effects are considered unlikely to be significant.

11.8 Residual Effects

Following implementation of mitigation and associated monitoring; potential impacts and effects in relation to land contamination for the Scheme will be avoided, reduced or off-set where practicable. Residual effects are those that remain once the measures have been implemented.

Provided the mitigation measures related to additional GI, detailed risk assessments and monitoring (**Mitigation Item G1**), remedial work and design measures being implemented where necessary (**Mitigation Items G8** and **G10**), and appropriate site work practices, materials management and planning, and other works (**Mitigation Items G2** to **G7, G9 and G11 to G16**) are adhered to, potential effects in relation to land contamination can also reasonably be expected to reduce, to be of Low and Very Low significance during construction and operation.

With the Scheme in place, and taking the identified mitigation into account, no significant residual effects are anticipated, and it is generally considered, at this stage, that it would accord with all key national and local legislation, plans and policies related to soils, geology and land contamination where practicable.

11.9 Monitoring

Mitigation Items G1, G4 and **G9** include a requirement for monitoring of gas, groundwater and air (dust) to protect the site receptors during the construction period. The specific monitoring requirements for each mitigation measure and associated receptor(s) will be developed and refined during the design and construction of the Scheme in consultation with the regulators and included in the CEMP as appropriate. This will include agreement of monitoring details, frequencies and reporting requirements for all aspects with Falkirk Council, SEPA and others as required, and will be tailored to provide meaningful indications of the ongoing works, impacts and mitigation implementation where necessary.

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