Environmental Impact Assessment Report

Chapter 12 Air Quality and Climate

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

µg/m^3	Micrograms per cubic metre
µm	Micrometre
AADT	Annual average daily traffic
AQAP	Air Quality Action Plan
AQMA	Air Quality Management Area
AQO	Air Quality Objective
AQS	Air Quality Strategy
AURN	Automatic Urban and Rural Network
BEIS	Department for Business, Energy & Industrial Strategy
CAFÉ	Clean Air for Europe
CEMP	Construction Environmental Management Plan
CMP	Carbon Management Plan
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
Defra	Department for Environment, Food and Rural Affairs
DESNZ	Department for Energy Security and Net Zero
DMP	Dust Management Plan
DMRB	Design Manual for Roads and Bridges
EIA	Environmental Impact Assessment
EU	European Union
FLDP2	Falkirk Council Local Development Plan 2
FLDP3	Falkirk Council Local Development Plan 3
GHG	Greenhouse gas
HDV	Heavy duty vehicle
IAQM	Institute of Air Quality Management
IEMA	Institute of Environmental Management and Assessment
IPCC	Intergovernmental Panel on Climate Change
Km	Kilometre
kt	Kilotonnes (one thousand tonnes)
LAQM	Local Air Quality Management
LDP2	Local Development Plan 2
LDP3	Local Development Plan 3
LED	Light emitting diode

LULUCF	Land use, land use change and forestry
m	Metre
m^2	Square metre
m^3	Cubic metre
mm	Millimetre
$MtCO_2e$	Million tonnes carbon dioxide equivalent
NO_2	Nitrogen dioxide
NOx	Oxides of nitrogen
NPF4	National Planning Framework 4
NRMM	Non-road mobile machinery
ºC	Degree celsius
PAS	Publicly Available Specification
PM	Particulate matter
PM_{10}	Particulate matter with a diameter of 10 micrometres or less
$PM_{2.5}$	Particulate matter with a diameter of 2.5 micrometres or less
RCP	Representative Concentration Pathway
SO_2	Sulphur dioxide
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
tCO_2e	Tonnes carbon dioxide equivalent
UK	United Kingdom
UKCP18	United Kingdom Climate Projections 2018
UNFCCC	United Nations Framework Convention on Climate Change

12. Air Quality and Climate

12.1 Introduction

This chapter presents the results of the air quality and climate change assessments and focusses on the potential for the release of pollutants to air during construction and operation of the Scheme, resulting in impacts on the surrounding local air quality and / or those that would contribute to climate change. Further details on the scope determined for this chapter can be found in Appendix C3.1: EIA Screening and Scoping Report.

The potential emission sources assessed within this chapter include:

- dust emissions generated by the earthworks and construction related activities during the construction phase. This includes consideration of the larger 'dust' particles of particulate matter that have the potential to cause annoyance and/or damage to sensitive vegetation through deposition onto a surface, and also the smaller-sized particles associated with human health effects (i.e. particulate matter with a diameter less than 10 micrometres (µm) (PM_{10}) or 2.5 µm ($PM_{2.5}$), respectively);
- emissions of pollutants (nitrogen oxides (NO_X), PM_{10} and $PM_{2.5}$) to air from on-road vehicles travelling on the local road network and from off-road machinery during the construction phase;
- greenhouse gas (GHG) emissions (expressed as carbon dioxide equivalent: CO_2e) from the construction phase;
- GHG emissions resulting from operation of the Scheme; and
- Vulnerability of the Scheme to climate change.

12.2 Policy and Legislative Framework

12.2.1 International Level

12.2.1.1 Air Quality

EU Directive 2008/50/EC (European Union, 2008), also known as the Clean Air for Europe (CAFÉ) directive, came into force in June 2008. The directive consolidated many of the previous air quality directives, setting Limit Values or Target Values for the concentrations of specific air pollutants. The EU Limit Values of relevance to this assessment are presented in Table 12-1. Although the UK left the EU, these limit values remain part of UK law.

In December 2015, the Paris Agreement, a global climate agreement, was adopted (UNFCCC, 2015). The Paris Agreement was ratified and entered into force in November 2016. The central aim of the Paris Agreement is to strengthen the global response to climate change by limiting global temperature to well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels. To achieve limiting the increase to 1.5°C, global emissions need to be reduced 45% by 2030 and reach net zero by 2050.

12.2.2 National Legislation

12.2.2.1 Air Quality

Part IV of the Environment Act (UK Government, 1995) requires the UK government to produce a national air quality strategy (AQS) providing the policy context for Local Air Quality Management (LAQM) and assessment in the UK. The Clean Air Strategy (Defra, 2019a) and National Air Pollution

Control Programme (Defra *et al*, 2019b) published in January 2019 and March 2019, respectively, outline actions to tackle emissions from a range of pollutant sources.

The AQS contains standards, objectives and measures for improving ambient air quality, which are given statutory backing in Scotland through the Air Quality (Scotland) Regulations 2000 (Scottish Government, 2000) and the Air Quality (Scotland) (Amendment) Regulations 2002 (Scottish Government, 2002), 2016 (Scottish Government, 2016) and Air Quality Standards (Scotland) Regulations 2010. Scotland has more stringent PM_{10} and $PM_{2.5}$ Air Quality Objectives (AQOs) than the rest of the UK. The AQOs and Limit Values applicable to this assessment are shown in Table 12-1.

Table 12-1. Scottish Air Quality Objectives and Limit Values for NO_X, NO_2, PM_{10} and $PM_{2.5}$

Air Quality Objectives and Limit Values						
Scottish Air Quality Objective				Limit Value		
Pollutant	Concentration ($\mu g/m^3$)	Averaging Period	Compliance Date	Concentration ($\mu g/m^3$)	Averaging Period	Compliance Date
NO_2	200	1-hour mean (not to be exceeded more than 18 times per year)	31 December 2005	200	1-hour mean (not to be exceeded more than 18 times per year)	1 January 2010
	40	Annual mean	31 December 2005	40	Annual mean	1 January 2010
NO_x *	30	Annual mean	31 December 2000	30	Annual mean	19 July 2001
PM_{10}	50	24-hour mean (not to be exceeded more than 7 times per year)	31 December 2010	50	24-hour mean (not to be exceeded more than 35 times per year)	1 January 2005
	18	Annual mean	31 December 2010	40	Annual mean	1 January 2005
$PM_{2.5}$	10	Annual mean	31 December 2020	25	Annual mean	1 January 2010
* Designated for the protection of vegetation and ecosystems, and referred to as the 'critical level' for nitrogen oxides (NO_x)						

12.2.2.2 Climate Change

The Climate Change (Scotland) Act 2009 (Scottish Government, 2009a), established a framework for Scotland to achieve its long-term goals of reducing GHG emissions by at least 80% by 2050. An interim target of a 42% reduction by 2020 was also set. The original 2050 goal was amended through the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 (Scottish Government, 2019a), which set a 'net-zero emissions target' for all GHGs by 2045 (i.e. a 100% reduction in emissions compared to the 1990/1995 baseline). This Act also sets interim targets of a 56% reduction in emissions by 2020, a 75% reduction by 2030 and a 90% reduction by 2040.

The Climate Change (Scotland) Act 2009 (Scottish Government, 2009a) also addresses vulnerability to climate change and requires the preparation of strategic programmes for climate change adaptation, as

soon as reasonably practicable after each round of UK Climate Change Risk Assessment. The Act also sets out the duties of public bodies (such as Falkirk Council) in relation to climate change namely:

- To contribute to the delivery of the carbon emission reduction targets set out in the Act;
- To help deliver Scotland's Climate Change Adaptation programme; and
- To act in a way that it considers is most sustainable.

12.2.3 Planning Policy

The development plan relevant to the Falkirk Council area is comprised of National Planning Framework 4 (NPF4) (Scottish Government, 2023a) and the Falkirk Council Local Development Plan 2 (FLDP2) (Falkirk Council, 2020). NPF4 is the more recent publication, adopted by Scottish Ministers in February 2023. FLDP2 was adopted by Falkirk Council in 2020. Both plans are read together, however where there is any difference in policy content the more recent publication takes precedence, in this case NPF4. Falkirk Council is currently preparing a new Local Development Plan (FLDP3) which is anticipated to be adopted in 2027.

12.2.3.1 National Planning Framework 4

NPF4 Policy 23 'Health and Safety' states that … *"Development proposals that are likely to have significant adverse effects on air quality will not be supported. Development proposals will consider opportunities to improve air quality and reduce exposure to poor air quality. An air quality assessment may be required where the nature of the proposal or the air quality in the location suggest significant effects are likely."*

NPF4 includes policies to minimise GHG from developments and to ensure that developments and places are more resilient to climate change related impacts or can adapt to existing and future risks from climate change. These are set out as follows:

- NPF4 Policy 1 'Tackling the Climate Change Crises' requires that "*when considering all development proposals significant weight will be given to the global climate and nature crises*".
- NPF4 Policy 2 'Climate Mitigation and Adaption' requires development proposals to be sited and designed to minimise lifecycle GHG emissions as far as possible and to adapt to existing and future risks from climate change. Development proposals to retrofit measures to existing developments that reduce emissions or support adaption to climate change will be supported by this policy.

NPF4 Policy 10 'Coastal Development' includes a range of criteria that development proposals in developed and undeveloped coastal areas, and for coastal defence measures, are required to meet in order for the proposal to be supported. The Policy Intent for Policy 10 is "*to protect coastal communities and assets and support resilience to the impacts of climate change.*"

As described in NPF4 Annex B, the Scheme is designated as a national development. National developments are of national importance and will help to deliver the national spatial strategy for Scotland. The Scheme is part of National Development 15 (Industrial Green Transition Zones), supporting the decarbonisation of nationally important industrial sites, including the Grangemouth investment zone. NPF4 Annex B states that *"depending on the nature of the projects* [under National Development 15] *taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall net positive effect on lifecycle greenhouse gas emissions reductions targets."*

Local Development Plan

FLDP2 (Falkirk Council, 2020) includes policy PE26 'Air Quality', which requires that development should not exacerbate existing air quality issues or introduce new sources of pollution which impact on

local air quality without appropriate mitigation. Impacts on air quality are to be taken into account in assessing development proposals.

Some of the spatial strategies and policies within the FLDP2 are aimed at achieving one of the FLDP2 objectives under the Sustainable Place vision, which is to support a low carbon, circular economy and build resilience to climate change. Under the same vision, resilience to climate change is referred to in relation to the FLDP2 objective of improving the green network and protecting the area's natural environment and resources.

12.2.3.2 Other relevant plans and strategies

With regard to climate change, Falkirk Council has declared a climate emergency (Falkirk Council, 2019) and is aiming to reduce its GHG emissions to net zero by 2030 and make Grangemouth its first carbon neutral town. The declaration emphasises the importance placed on climate change issues and GHG emissions by Falkirk Council. Falkirk Council produced a Climate Emergency Update in 2022 setting out its position and progress, which also included a draft of the Climate Emergency Action Plan 2022-2030 in Appendix 1 (Falkirk Council, 2022). In October 2023, Falkirk Council issued its Climate Change Strategy and Action Plan 2023-2030 (Falkirk Council, 2023a) which formalises the council's approach to climate action across the local authority area and builds on the Climate Emergency Action Plan 2022-2030. Three key themes run throughout the strategy and action plan which seek to work towards the following:

- Reducing greenhouse gas emissions;
- Adapting to climate change, and
- Securing a just transition and Green Economic Recovery.

Falkirk Council's climate change and adaptation strategy contributes to the net zero transition and supports the Falkirk Council area becoming more resilient to the impacts of climate change by setting out a series of outcomes. Within the Action Plan in Appendix 1 of the Climate Change Strategy and Action Plan 2023-2030, a number of climate mitigation climate adaption actions are proposed to achieve these outcomes. In Section 4 (Adaption and area-wide decarbonisation), Task 4.5 (Adaptation: Improve sector-specific resilience to climate change) includes an action to *"Implement Grangemouth Flood Protection scheme."*

12.2.4 Scottish Climate Change Adaptation Programme

The Climate Change (Scotland) Act 2009 (Section 53) (Scottish Government, 2009a) placed a duty on ministers to lay a programme for climate change adaptation before the Scottish Parliament as soon as reasonably practicable after the UK Climate Change Risk Assessment, which includes a summary report for Scotland. The latest version of the programme was produced in 2019 (Scottish Government, 2019b). The Act also requires an annual report on progress and for the advisory body, the Committee for Climate Change Adaptation Sub Committee, to prepare a report within two years, setting out its independent assessment of the progress made on objectives, proposals and policies set out in the programme. The most recent progress report, the third progress report, was published in May 2023 (Scottish Government, 2023b).

12.3 Methodology

12.3.1 Construction Phase

Construction impacts of relevance to air quality include construction dust (including from demolition) and particulate matter and emissions from on-site construction machinery and construction-related vehicles travelling on the local road network.

With regard to climate change, the impacts of relevance relate to the emissions of GHGs associated with the construction of the Scheme (e.g. carbon embodied in the materials used to construct the Scheme and emissions from road transport for material deliveries, construction processes, waste removal, and construction worker travel etc). The following subsections set out how these impacts have been considered during the assessment.

12.3.1.1 Air Quality – Construction Dust

The assessment of the air quality impacts associated with the construction phase of the Scheme follows the Institute of Air Quality Management (IAQM) '*Guidance on the assessment of dust from demolition and construction activities*' (IAQM, 2016). The IAQM assessment methodology provides approaches to consider three separate dust effects:

- Annoyance due to dust soiling;
- Harm to ecological receptors; and
- Risk of health effects due to increased exposure to PM_{10} and $PM_{2.5}$.

The guidance sets out a method to determine the risks of causing dust impacts at nearby sensitive receptors from four construction activities (i.e. demolition, earthworks, construction and trackout[1]) to determine the level of required tertiary mitigation (i.e. mitigation actions or methods that are required to be undertaken which are considered standard practice and used to manage commonly occurring environmental effects such as dust emissions). The study areas for the assessment of dust during the construction phase are described as follows:

- Human receptors (e.g. residential properties) were identified up to 350 m from the construction site boundary within each Flood Cell and/or within 50 m of the access route(s) used by construction vehicles on the public highway, and up to 500 m from the construction site exit(s); and
- Ecological receptors (e.g. designated sites such as Sites of Special Scientific Interest (SSSI) designations) were considered up to 50 m from the construction site boundary in each Flood Cell, and/or within 50 m of the access route(s) used by construction vehicles on the public highway, and up to 500 m from the construction site exit(s).

Human and ecological receptors were identified and classified based on their sensitivity to dust soiling / deposition and / or PM_{10} exposure. The dust emission magnitudes of each construction activity type were then categorised as Small, Medium and Large (these were determined from the planned type and scale of the construction-related works). The sensitivity of the area was then determined by the number of receptors, their distance to the construction boundary and the background PM_{10} concentration. Based on the matrix of relationships between the sensitivity of the area and the assigned dust emission magnitude, the IAQM construction dust guidance (IAQM, 2016) determines the risk level for the key potential dust emission sources associated with construction (i.e. demolition, earthworks, construction and trackout). The guidance then sets out recommendations for the control and management of dust emissions via tertiary mitigation to achieve a residual effect of 'not significant' based on the level of risk identified. The matrices for determining the risk level are set out in Table 12-2.

Table 12-2. Determination of Dust Risks for each Dust Emission Source

Receptor sensitivity	Dust emission magnitude		
	Large	Medium	Small
Demolition			
High	High risk	Medium risk	Medium risk

[1] Trackout is the transport of dust and dirt from the construction site onto the public road network, where it may be deposited and then re-suspended by vehicles using the network. This arises when Heavy Duty Vehicles (HDVs) leave the construction site with dusty materials, which may then spill onto the road, and/or when HDVs transfer dust and dirt onto the road having travelled over muddy ground on site.

Receptor sensitivity	Dust emission magnitude		
	Large	Medium	Small
Medium	High risk	Medium risk	Low risk
Low	Medium risk	Low risk	Negligible risk
Earthworks			
High	High risk	Medium risk	Low risk
Medium	Medium risk	Medium risk	Low risk
Low	Low risk	Low risk	Negligible risk
Construction			
High	High risk	Medium risk	Low risk
Medium	Medium risk	Medium risk	Low risk
Low	Low risk	Low risk	Negligible risk
Trackout			
High	High risk	Medium risk	Low risk
Medium	Medium risk	Low risk	Negligible risk
Low	Low risk	Low risk	Negligible risk

For example, a high-risk site with several nearby receptors would be required to adopt a more comprehensive suite of tertiary mitigation measures and monitoring techniques to achieve a 'not significant' effect than a low-risk site which is remote from receptors. The significance of dust effects is a binary definition of either 'significant' or 'not significant' overall and does not include a scale of significance at each considered receptor. As the assessment is used to determine the level of tertiary mitigation required for the Scheme to avoid significant adverse effects, the determination of significance is not undertaken prior to the application of the tertiary mitigation and only defined post-mitigation. A full description of the construction dust assessment methodology is presented in Appendix C12.1 – Dust Risk Assessment and Supplementary Baseline Data and Greenhouse Gas Emissions.

It should be noted that at the time of the undertaking the assessment, IAQM construction dust guidance Version 1.1 (IAQM, 2016) was applied. The IAQM construction dust guidance has since been updated to Version 2.1 (IAQM, 2023) and includes several revisions such as a reduction in the distance for when an assessment is normally required (i.e. where there is a human receptor within 250 m of the site boundary as opposed to 350 m in IAQM Guidance Version 1.1 and where there is a human or ecological receptor up to 250 m from the site exit(s) as opposed to 500 m in IAQM Guidance Version 1.1). Furthermore, revisions have been made to defining the potential dust emission magnitude for the considered activities (i.e., Demolition, Earthworks, Construction and Trackout). For example, in IAQM construction dust guidance Version 1.1, a site may be assigned a Large dust emission magnitude for earthworks if the total site area is greater than 10,000 m^2. In IAQM construction dust guidance Version 2.1, a site may now be assigned a Large dust emission magnitude for earthworks if the total site area is greater than 110,000 m^2.

Adopting IAQM construction dust guidance Version 1.1 (IAQM, 2016) is considered a more conservative approach to the assessment than IAQM construction dust guidance Version 2.1. The approach taken therefore remains valid as it considers human and ecological receptors within a larger study area and assigns dust emission magnitudes based on lower threshold values.

12.3.1.2 Air Quality – Emissions from Construction Related Road Traffic

The Design Manual for Roads and Bridges (DMRB) LA 105 air quality guidance (Transport Scotland, 2019) states that air quality impacts from road transport emissions are negligible where the change in traffic flow is less than 1,000 as an annual average daily traffic flow (AADT) (i.e. the total volume of vehicle traffic of a highway or road for a year divided by 365 days) and the change in the flow of heavy duty vehicles (HDVs) is less than 200 as an AADT.

The construction works are expected to be undertaken in a phased approach and to last approximately 10 years. Although the works are anticipated to be undertaken in a phased approach, some Flood Cell construction works are expected to overlap with other Flood Cell construction works. The vehicle movements associated with the construction works required in each Flood Cell have been estimated and combined with the relevant concurrent Flood Cells to estimate the likely maximum number of vehicle movements at various points throughout the construction phase. The results of the screening of construction traffic flows against the above criteria is provided in Section 12.5.1.2.

12.3.1.3 Climate Change – Effects on Climate (Greenhouse Gas Emissions)

The study area to assess the direct and indirect impacts on climate from GHG emissions associated with construction of the Scheme extends to the distances from the Scheme required to capture the GHG emissions associated with the manufacture and production of the construction materials and their associated transport to the site from the supplier within the UK. It includes the GHG emissions from the construction activities carried out within the construction site boundary. The study area also incorporates the transport off-site and processing of waste for re-use, recycling or treatment / disposal and is defined by the largest extent of these activities / elements.

The GHG emissions were calculated for the construction of the Scheme using the Carbon Planning Tool (Version 6) published by the Environment Agency (Environment Agency, 2022) for use in capital delivery of flood risk and coastal management projects. This included the GHG emissions embodied in products and materials, and GHG emissions associated with the transport of materials and people to and from the site, energy and fuel use during construction and from waste materials and transport. The carbon calculator component of the tool was used to undertake the detailed calculations of GHG emissions using a bottom-up approach based on input of the Scheme details such as:

- Types of assets forming the Scheme such as embankments, tidal/non-tidal walls, revetments, channels, headwalls, drainage, tidal / flood gates, weirs, landscaping, culverts, tracks;
- Length, volume or area of the identified assets;
- Material types and quantities required for construction of the assets;
- Identification of the first intervention for each asset either as new build, replacement or refurbishment;
- Life expectancy of the newly built, replaced or refurbished assets;
- Waste percentage / quantity, waste type, whether it can be reused, recycled or removed and distance to waste disposal site or recycling plant;
- Transport type for materials and supplier distance to site;
- Transport types for construction worker travel, details on distances travelled for all construction workers and plant deliveries, number of plant deliveries; and
- Size of Scheme in terms of scale and duration.

The tool provides a mechanism to quantify GHG emissions over the whole life of constructed assets, in order to allow for the establishment of options for Scheme development that facilitate the reduction of GHG emissions. The calculation of the GHG emissions using the Carbon Calculator took account of proposed relevant embedded mitigation to reduce GHG emissions (see Section 12.6.1).

A range of primary / embedded mitigation measures were explored and adopted through the design process for the Scheme and earlier options appraisal stages. Some of these measures and design decisions led to a reduction in the associated GHG emissions to construct the Scheme and also lower GHG emissions during the Scheme's operation and maintenance. Further details of the primary / embedded mitigation in the Scheme design are provided in Section 4.2.4 Design evolution for the Scheme and embedded mitigation (see Chapter 4). On this basis, the inputs to the Carbon Calculator,

and subsequent estimates of GHG emissions for the construction and operational phases take account of this primary / embedded mitigation. The primary / embedded mitigation measures relevant to climate change, which reduce GHG emissions and are included within the GHG emissions calculations reported in Section 12.5.1.3, comprise the following:

- Raising of ground levels to integrate the flood defence embankments into the surrounding land instead of using flood gates, reducing the amount of carbon intensive materials for the construction of flood gates.
- The preference to use earth embankments, rather than flood walls using concrete, was embedded in the design where practical, reducing the amount of concrete (a carbon intensive material) required for the Scheme.
- Flood defence heights were reduced where acceptable, reducing the amount of construction materials and activities required.

The Institute of Environmental Management and Assessment (IEMA) guidance (IEMA, 2022) identifies the receptor for GHG emissions, which is the global atmosphere, as having a high sensitivity. The rationale for this is as follows:

- All GHG emissions contribute to climate change;
- The extreme importance of limiting global warming to below 2°C this century, as broadly asserted by the international Paris Agreement (UNFCCC, 2015) and the climate science community. Additionally, a recent report by the IPCC highlighted the importance of limiting global warming to below 1.5°C (IPCC, 2018); and
- Additional GHG emissions, should they be of sufficient magnitude, could compromise the UK's ability to meet its legally binding carbon reduction target of 2050 (2045 for Scotland) and associated interim targets or carbon budgets which set out the trajectory towards net zero.

In relation to determining significance, the IEMA guidance (IEMA, 2022) states:

"When evaluating significance, all new GHG emissions contribute to a negative environmental impact; however, some projects will replace existing development or baseline activity that has a higher GHG profile. The significance of a project's emissions should therefore be based on its net impact over its life time, which may be positive, negative or negligible

- *Where GHG emissions cannot be avoided, the goal of the EIA process should be to reduce the project's residual emissions at all stages*
- *Where GHG emissions remain significant, but cannot be further reduced, approaches to compensate the project's remaining emissions should be considered"*

The guidance acknowledges that there will be continuing GHG emissions over time but these should be reduced and compatible with national climate change commitments. The guidance also states:

"The crux of significance therefore is not whether a project emits GHG emissions, nor even the magnitude of GHG emissions alone, but whether it contributes to reducing GHG emissions relative to a comparable baseline consistent with a trajectory towards net zero by 2050 [or other date as defined in targets for devolved administrations…]"

In considering the emissions of GHGs, professional judgement, following a proportionate approach, has been used to provide a qualitative description of the nature of the impacts and determine the significance of the effect on climate. This has drawn on significance principles and examples of magnitude criteria set out in the IEMA guidance. The determination of magnitude included contextualising the predicted GHG emissions against estimated annual carbon budgets derived from the legislated emission reduction targets for Scotland (i.e. the interim emission reduction targets set out

in the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019) (Scottish Government, 2019a) for 2030 and 2040, respectively.

The assessment also included more localised contextualisation of the GHG emissions against other relevant data, such as the GHG emissions for the Falkirk Council area (see Section 12.4.1). Although, Falkirk Council has a commitment to achieve net zero GHG emissions by 2030, this is focused on organisational emissions for its 'Scope 1' and 'Scope 2' emissions (i.e. the GHG emissions from fuel used by its vehicles and plant and energy such as gas and electricity used in buildings and facilities) and, therefore, this is not directly applicable to the Scheme itself. The determination of magnitude also considered whether the Scheme has mitigated GHG emissions and how the Scheme meets, or does not meet, relevant existing and emerging policy requirements and good practice design standards. This included consideration of the relevant actions and policies within the Falkirk Council Climate Emergency Action Plan 2022-2030 (Falkirk Council, 2021) and Climate Change Strategy and Action Plan 2023-2030 (Falkirk Council, 2023a), where relevant to the Scheme.

The significance criteria are set out in Table 12-3 below. This includes a summary of the magnitude criteria used to determine the magnitude of environmental impact of GHG emissions on the global atmosphere receptor. The receptor has been assigned a high sensitivity, as noted above, and the significance criteria have been developed on this basis (i.e. there is no requirement to develop a significance matrix to determine the significance of effect at multiple receptors, each with differing levels of sensitivity or value).

Table 12-3. Significance Criteria for GHG Emissions

Significance	Magnitude	Magnitude Criteria
Significant	Major Adverse	The Scheme's GHG impacts are not mitigated or are only compliant with do-minimum standards set through regulation, and do not provide further reductions required by existing local and national policy for developments of this type. A project with major adverse effects is locking in emissions and does not make a meaningful contribution to the UK's (or Scotland's) trajectory towards net zero.
	Moderate Adverse	The Scheme's GHG impacts are partially mitigated and may partially meet the applicable existing and emerging policy requirements but would not fully contribute to decarbonisation in line with local and national policy goals for developments of this type. A project with moderate adverse effects falls short of fully contributing to the UK's trajectory towards net zero.
Not significant	Minor Adverse	The Scheme's GHG impacts would be fully consistent with applicable existing and emerging policy requirements and good practice design standards for developments of this type. A project with minor adverse effects is fully in line with measures necessary to achieve the UK's trajectory towards net zero.
	Negligible	The Scheme's GHG impacts would be reduced through measures that go well beyond existing and emerging policy and design standards for projects of this type, such that radical decarbonisation or net zero is achieved well before 2050. A development with negligible effects provides GHG performance that is well 'ahead of the curve' for the trajectory towards net zero and has minimal residual emissions.

12.3.2 Operational Phase

12.3.2.1 Climate Change – Effects on Climate (Greenhouse Gas Emissions)

Given the passive nature of the Scheme, there would be no direct GHG emissions as a result of its operation. However, activities associated with its operation would lead to emissions of GHGs (e.g. vehicle emissions for inspections, maintenance works, refurbishment and repairs or embodied carbon in new materials for replacement and electricity use).

GHG emissions were calculated for the operation of the Scheme using the Carbon Calculator published by the Environment Agency (Environment Agency, 2022) as for the construction phase. This calculated the GHG emissions over the whole operational life of the constructed assets and considered operational carbon (i.e. use of the Scheme, maintenance, repairs and energy use), replacement carbon and refurbishment carbon during the operational lifecycle. The same approach to the determination of significance for GHG emissions as described for the construction phase was applied for the operational phase.

12.3.2.2 Climate Change – Vulnerability of the Scheme to Climate Change

During the operational phase, it is important to consider the vulnerability of the Scheme to a changing climate (e.g. increased rainfall and flooding, increased frequency of storm events, rising sea level, higher solar radiation etc), and how this could potentially impact on the physical structure and assets of the Scheme and its effectiveness to provide the required level of flood protection. The Scheme is designed to provide a 1 in 200-year flood event standard of protection and to facilitate future extensions or improvements such as increasing the height of flood walls / embankments to mitigate the future impacts of climate change. The design life of the Scheme is anticipated to be over 100 years and resilience to climatic factors is inherent in the design. The physical assets which comprise the Scheme, including the flood walls and embankments, coastal revetment, flood relief channels and modified / replaced bridges have an inherently low vulnerability to climatic factors. On this basis, a proportionate risk-based assessment was undertaken as discussed below.

The IEMA Environmental Impact Assessment Guide to: Climate Change Resilience & Adaptation (IEMA, 2020) provides guidance for the consideration of the impacts of climate change within project design, and consideration of in-combination impacts of the project with projected climate changes. As noted in the IEMA guidance, the consideration of climate change in an Environmental Impact Assessment (EIA) should include a characterisation of the future climate and an assessment of the vulnerability of the Scheme to climate change impacts.

The assessment of the vulnerability of the Scheme to climate change considers future climate projections and the Scheme receptors (i.e. the particular assets and components which comprise the Scheme), which may be vulnerable to climate change. The development of the Scheme is designed to account for the impacts of climatic events, including floods and storm surge events, so it is likely that the majority of Scheme receptors would have a low vulnerability to climate change as this would result in similar types of impacts.

The proposed future climate is described in Section 12.4.2 and considers the lifespan of the Scheme. Lifecycle stages are then assessed in the short, medium and long-term (i.e. 2030, 2050 and 2080). The climate trends modelled within the UK Climate Projections 2018 (UKCP18) (Met Office, 2018) (refer to Section 12.4.2) 'high emissions' Receptor Concentration Pathway 8.5 (RCP8.5) scenario (50^{th} percentile) have been considered in this assessment as a conservative approach, due to the uncertainties that exist around climate projections.

The assessment has been undertaken in line with DMRB LA 114 Climate guidance (Transport Scotland, 2021), which sets out an approach to assessing the vulnerability of projects to climate change. This follows a risk assessment process which focusses on identifying the impacts and effects of climate

change, including extreme weather events, on the identified receptors. The following steps are included in the assessment:

- The identification of hazards and potential receptors affected;
- Assessment of likelihood and consequences; and
- Evaluation of significance, considering the likelihood and consequences of their occurrence, and taking into account the built-in resilience and embedded design measures and mitigation.

The Scheme receptors vulnerable to climate change have been identified based on the assets and their operation, maintenance and refurbishment, and end-users, including the public and commercial operators. Impacts are described in terms of hazards and opportunities using the climate projection data, together with the vulnerability of the Scheme to both normal and extreme weather-related scenarios.

The criteria have been developed using professional judgement and the likelihood criteria were based on those set out in Table 3.39a of the DMRB LA 114 guidance (Transport Scotland, 2021) as was the measure of consequence of an impact. For example, a Negligible consequence of impact would be an impact which results in additional maintenance to a specific isolated section of the Scheme. At the other end of the scale, a Very Large adverse impact would be an impact which leads to structural failure of the Scheme in multiple locations which requires complete replacement or could lead to widespread flooding of adjoining areas which the Scheme is designed to protect. The likelihood categories are set out in Table 12-4 and the measure of consequence of impact categories are set out in Table 12-5.

Table 12-4. Likelihood Categories

Likelihood category	Description (probability and frequency of occurrence)
Very high	The event occurs multiple times during the lifetime of the scheme (100 years) e.g. approximately annually, typically 100 events.
High	The event occurs several times during the lifetime of the scheme (100 years) e.g. approximately once every five years, typically 20 events.
Medium	The event occurs limited times during the lifetime of the scheme (100 years) e.g. approximately once every 20 years, typically five events.
Low	The event occurs during the lifetime of the scheme (100 years) e.g. once in 100 years.
Very low	The event can occur once during the lifetime of the scheme (100 years).

Table 12-5. Measure of Consequence

Likelihood category	Description (probability and frequency of occurrence)
Very large adverse	Structural failure of the Scheme in multiple locations which requires complete replacement or could lead to widespread flooding of adjoining areas.
Large adverse	Structural failure of the Scheme in one location which requires replacement or a high level of repair and could lead to localised flooding of an adjoining area.
Moderate adverse	Damage to the Scheme infrastructure in multiple locations which requires minor to moderate repairs and could lead to localised flooding if not repaired.
Minor adverse	Damage to an isolated section requiring minor repairs.
Negligible	Additional maintenance to a specific isolated section.

The significance of the effects of climate change on the receptors is determined by combining the likelihood and consequence ratings, as shown in Table 12-6.

Table 12-6. Significance Rating Matrix for Vulnerability of the Scheme to Climate Change

Likelihood	Consequence				
	Negligible	Minor adverse	Moderate adverse	Large adverse	Very large adverse
Very high	Not significant	Significant	Significant	Significant	Significant
High	Not significant	Significant	Significant	Significant	Significant
Medium	Not significant	Not significant	Significant	Significant	Significant
Low	Not significant	Not significant	Not significant	Significant	Significant
Very low	Not significant	Not significant	Not significant	Not significant	Not significant

12.3.3 Assumptions and Limitations

This assessment has been carried out based on available information at the time of the assessment. GHG emissions have not been calculated for some emission sources at this stage due to lack of suitable data or information (i.e. those associated with land use change, such as trees and vegetation lost during the construction of the Scheme, all of the possible operational energy use and operational water use). However, these emissions are likely to be substantially less than those associated with other construction and operational phase emissions. Therefore, their omission from the assessment is unlikely to have a material impact on the reported GHG emissions during operation or alter the contextualisation of emissions relative to the carbon reduction targets for Scotland. The type and range of sources for which emissions were estimated is considered to be sufficient for this assessment, as these include the main emissions associated with the Scheme.

Due to the uncertainties that exist around the subject of climate, there are limitations associated with predicting the impacts of climate change into the future, which could result in this assessment either overestimating or underestimating the impacts of climate on the Scheme. These limitations include:

- Uncertainty around climate change projections;
- Limited methodological guidance on how a climate change assessment should be carried out; and
- Limited literature describing climate change impacts on infrastructure and assets.

Although uncertainties and limitations exist around predicting climate change into the future, based on the extent of the Scheme in relation to the area and the receiving environment, these uncertainties are not anticipated to substantially affect the results of the assessment.

12.4 Baseline

This section sets out information on the existing baseline conditions with regard to air quality and climate. For air quality, this includes consideration of the work undertaken by Falkirk Council as part of the LAQM process and any relevant air quality monitoring undertaken to support this. For climate, this includes consideration of existing GHG emissions on a national and local authority scale to provide context to the estimated GHG emissions from the construction and operation of the Scheme. It also considers future climate projections.

12.4.1 Existing Baseline

12.4.1.1 Local Air Quality Management

The Scheme falls within the administrative boundary of Falkirk Council. The baseline air quality conditions discussed in this Section are for the Grangemouth and Falkirk area, within approximately 2 – 3 km of the Flood Cell boundaries.

Falkirk Council regularly reviews and assesses air quality within its area. Where a local authority identifies an area where an AQO is likely to be exceeded, it must declare an Air Quality Management Area (AQMA) and put together an Air Quality Action Plan (AQAP) to improve the air quality in this area. There are two declared AQMAs within the area administered by Falkirk Council, these are:

- Grangemouth AQMA, declared for exceedances of the sulphur dioxide (SO_2) 15-minute mean AQO, within which Cells 2, 3, 4, 5 and 6 are located; and
- Falkirk Town Centre AQMA, declared for exceedances of the annual mean NO_2 AQO, located approximately 1.5 km south-east of Cell 1. Previously, the AQMA was also declared for PM_{10} (annual and 24-hour mean), however, this was recently revoked as PM_{10} concentrations within the AQMA have been in compliance with the AQOs for a number of years.

As noted above, the Scheme is partially located within the Grangemouth AQMA and within 1.5 km of the Falkirk Town Centre AQMA. However, the Grangemouth AQMA is declared as a result of SO_2 exceedances, associated with nearby industrial sources, and the Scheme will not lead to any discernible SO_2 emissions. Therefore, the Grangemouth AQMA would not be impacted upon by the Scheme. Furthermore, a proposal has recently been published to revoke the Grangemouth AQMA as measured SO_2 concentrations in Grangemouth have declined over recent years and become regularly compliant with the AQO for SO_2 (Falkirk Council, 2023c).

12.4.1.2 Air Quality Monitoring

Introduction

There are two principal methods used for measuring air quality, either using passive sampling techniques such as diffusion tubes, or using sophisticated continuous monitoring equipment. Falkirk Council monitors NO_2, SO_2 PM_{10} and $PM_{2.5}$ concentrations using automatic monitoring stations, as well as NO_2 concentrations using a network of diffusion tubes positioned at various locations throughout its administrative area. These locations are shown in Figure B12.1 in Appendix B12.1. Details of the particulate matter monitoring are provided below as concentrations of PM_{10} and $PM_{2.5}$ and are directly relevant to the potential impact of dust emissions during the construction phase. Details of NO_2 monitoring are shown in Appendix C12.1, as this information is less relevant to this assessment.

Particulate Matter

Falkirk Council currently undertakes ambient monitoring of PM_{10} and $PM_{2.5}$ across its administrative area using a network of eight automatic monitors (Falkirk Council, 2023b). Three of the automatic monitors which measure PM_{10} and $PM_{2.5}$ are located within the Flood Cell boundaries of the Scheme, as shown in Figure B12.1 in Appendix B12.1 (A8, A10 and A11). Results of PM_{10} and $PM_{2.5}$ monitoring undertaken at these sites, and other sites located in the area shown, between 2018 and 2022 are presented in Table 12-7.

Table 12-7. Annual Mean PM_{10} And $PM_{2.5}$ Monitoring Results 2018 – 2022

Monitor ID	Location	Pollutant / Site Type	Annual Mean Concentration (µg/m³)				
			2018	2019	2020	2021	2022
A7	Falkirk West Bridge Street	PM_{10} / Automatic Monitor	13.5	11.5	8.1	10.1	10.6
A8	Grangemouth AURN[1]		12	13	9	9.3	10
A10	Grangemouth Municipal Chambers		12.4	13.9	8.5	9.5	10
A11	Grangemouth Zetland Park		No data	No data	No data	9.5	10.8
A15	Main Street, Bainsford		11.6	14.4	10.6	12.2	12.3
A7	Falkirk West Bridge Street	$PM_{2.5}$ / Automatic Monitor	6.8	6.2	4.7	5.2	5.5
A8	Grangemouth AURN[1]		7	8	6	5.4	8
A10	Grangemouth Municipal Chambers		No data	No data	4.5	5.0	5.8
A11	Grangemouth Zetland Park		No data	No data	No data	5.5	5.8
A15	Main Street, Bainsford		No data	No data	6.2	6.4	6.5

Note 1: Automatic Urban and Rural Network (AURN).

No exceedances of the annual mean AQOs for PM_{10} (18 µg/m³) and $PM_{2.5}$ (10 µg/m³) were recorded between 2018 and 2022. In 2019, between one and five exceedances of the 24-hour mean PM_{10} standard of 50 µg/m³ were recorded at the automatic monitors set out in Table 12-7 (locations A7, A8, A10 and A15) with no recorded exceedances in 2020, 2021 and 2022. The AQO permits 7 exceedances of 50 µg/m³ per calendar year. These data suggest that AQOs for PM_{10} and $PM_{2.5}$ are unlikely to be exceeded in the study area.

12.4.1.3 Background Concentrations

PM_{10} and $PM_{2.5}$ data for all of the 1 km x 1 km background map grid squares within 2 km of the Scheme for 2018 were downloaded from the Scottish background maps (Scottish Government, 2022a) and Defra website (Defra, 2020), respectively, and are summarised in Table 12-8. As indicated in Table 12-8, average background PM_{10} and $PM_{2.5}$ concentrations for 2018 are within the relevant AQOs. Background concentrations representative of future years (which are likely to be lower than estimates in earlier years due to assumed reductions in emissions) have not been used within this assessment. Instead, a conservative approach has been used whereby the 2018 concentrations have been adopted to represent the background conditions at the time of the construction activities. These are similar to the measured concentrations set out in Table 12-7.

Table 12-8. Scottish Government Background Pollutant PM_{10} and $PM_{2.5}$ Concentrations

Pollutant	2018 (Baseline)	
	Maximum Concentration at any 1km x 1km grid square (µg/m³)	Average Concentration of 1km x 1km grid squares (µg/m³)
PM_{10}	12.6	10.8
$PM_{2.5}$	7.6	6.3

12.4.1.4 Ecological Designated Sites

Construction activities relating to Flood Cells within the vicinity of ecological receptors such as SSSIs could potentially have detrimental effects on ecosystem performance as a result of the deposition of dust.

Dust deposition can have direct physical effects on plants, such as reduced photosynthesis, respiration and transpiration through coating and smothering (Environment Agency, 2003). Other direct effects can include altering the pH of the soils or surface water through deposition of dusts with high acidity or alkalinity which can lead to the loss of certain plants which prefer a specific soil or water chemistry. Indirect effects of the dust soiling and smothering can include increased susceptibility of the plant to other stresses, including air pollution or pathogens.

The sensitive ecological receptors identified, shown in Figure B12.1 in Appendix B12.1, include international conservation sites (Firth of Forth Ramsar site and Firth of Forth Special Protection Area (SPA)) and nationally designated conservation sites (Firth of Forth SSSI and Avon Gorge SSSI). As a conservative approach to defining the required mitigation, these ecological receptors were assumed to contain ecological features that could be sensitive to dust deposition, which could result in direct and indirect effects on vegetation affecting species composition and ecosystem health. On this basis, they were defined as high sensitivity receptors (i.e. assigning an equivalent value of sensitivity as the most sensitive human receptors such as residential properties, hospitals and care homes).

12.4.1.5 Greenhouse Gas Emissions

The UK's net territorial total GHG emissions for 2021 was estimated at 426.5 million tonnes of carbon dioxide equivalent ($MtCO_2e$) (Department for Business, Energy & Industrial Strategy (BEIS), 2023). UK GHG emissions are dominated by CO_2, which accounted for approximately 80% of GHG emissions in 2021. Transport was the largest emitting sector accounting for approximately 26% of all GHG emissions in the UK. The other main contributing sectors for GHG emissions include energy supply (20%), business (18%), residential (16%) and agriculture (11%). The remaining 9% was attributable to the remaining sectors; waste management, industrial processes, the public sector and the land use, land use change and forestry (LULUCF) sector. The LULUCF sector includes both sinks and sources of emissions.

The global warming potential of GHG emissions is measured in terms of the equivalent amount of CO_2 (referred as CO_2e) that would give rise to the same amount of global warming. Although CO_2 has a relatively low global warming potential compared to other GHGs, it is the most abundant contributor as noted above. Scotland's net territorial total GHG emissions for 2021 was estimated at 43.6 $MtCO_2e$ (i.e. approximately 10% of UK emissions) (Department for Energy Security and Net Zero (DESNZ), 2023)).

Baseline GHG emissions have been assessed using the local authority and regional CO_2 emissions estimates dataset (DESNZ, 2023), which provides a spatial breakdown of estimated UK GHG emissions on an 'end-user" basis. Within this dataset, therefore, UK CO_2 emissions are distributed according to the point of energy consumption (e.g. electricity consumed in residential properties) or point of emission (if not energy related). These data help identify the key contributors to total GHG emissions in an area. Table 12-9 shows the estimated GHG emissions by source within the Falkirk Council area. As indicated in Table 12-9, industry emissions represent 63% of the 2021 total emissions in the Falkirk Council area, with transportation accounting for 14%, and other sectors representing smaller contributions.

Table 12-9. Falkirk Council Local Authority Territorial GHG Emission Estimates 2021

Sector Name	2021 GHG emissions (kt CO_2e)	
	Falkirk Council Area	
Industry Total	1453.8	63.3%
Commercial total	30.3	1.3%
Public sector total	34.7	1.5%
Domestic total	242.8	10.6%
Transport total	327.4	14.3%
LULUCF Net Emissions	78.6	3.4%
Agriculture Total	61.4	2.7%
Waste management total	68.5	3.0%
Total	**2,297.5**	-

12.4.1.6 Existing Climate

According to the Köppen Climate Classification, the climate in the Falkirk area is classified as subtype "Cfb" (Marine West Coast Climate), which is characterised as an equable climate with few extremes in temperature and relatively constant precipitation throughout all the months in the year.

A set of climate change projections were produced for the UK in 2018 known as the United Kingdom Climate Projections (UKCP18) (Met Office, 2018). UKCP18 uses a 30-year baseline period of 1981-2010, from which potential climatic changes in future years are projected. Data to represent the existing climate were obtained from the Met Office website (Met Office, 2023) for the baseline period 1981-2010, which is consistent with the future projections for many of the climate parameters and facilitates comparison between the baseline and future climate.

The existing climate experienced within the study area, as represented by the weather measurements recorded at the Falkirk climate station (Met Office, 2023), are summarised as follows:

- The annual average temperature is 9.2°C and ranges between an annual average minimum of 5.4°C and an annual average maximum of 12.9°C; and
- The average annual precipitation received for the area is 949 mm, with approximately 147 days in the year receiving precipitation (i.e. rainfall greater than 1mm).

12.4.2 Future Baseline

12.4.2.1 Greenhouse Gas Emissions

Scotland's total GHG emissions in 1990 were approximately 82 $MtCO_2e$ (Scottish Government, 2022b). When compared to the 2021 emission of 43.6 $MtCO_2e$ (DESNZ, 2023), this shows a reduction of approximately 47% between 1990 and 2021. This reduction consisted of a relatively steady decrease from 2000 onwards, largely through policy-driven decreases in the power sector from the phasing out of coal and increased renewable energy production. Over the remaining period to 2045, GHG emissions in Scotland, are expected to continue to decrease towards the net zero position with the aim of achieving each of the interim reduction targets in 2030 (70% reduction) and 2040 (90% reduction). There is some uncertainty in the trajectory of GHG emissions over this period as meeting the interim reduction targets

requires substantial efforts from the Scottish Government to roll out further climate policies, implement effective coordination and supporting governance structures, as well as being reliant on wider economical and societal changes.

12.4.2.2 Climate Projections

This section provides a comparison between the existing climate (described in the previous section) and the projected future conditions in and around the Scheme area. Due to uncertainties in predicting exactly how much GHG emissions will be generated in the future, five future greenhouse gas emission scenarios (RCP2.6, RCP4.5, RCP6.0, RCP8.5 and SRES A1B) have been developed, as presented in the UKCP18 climate projections (Met Office, 2018). These scenarios are based on different assumptions relating to socio-economic development and technological change, developed by the IPCC (IPCC, 2013). As a conservative approach, the high emissions scenario (i.e. RCP8.5) is considered in this assessment, based on a 50% probability of occurrence.

Table 12-10 presents the projected climatic changes for the high emissions scenario (50% probability) and for each 30-year period, obtained from the UKCP18 projections for the 2030s, 2060s and 2080s (Met Office, 2018). These are based on the 25 km grid square, which includes Grangemouth (grid square centred on E 287500 N 687500).

Table 12-10. Future Annual Climate Projections Under RCP8.5 Emissions Scenario Compared to 1981-2010 Climate Baseline

Description	2030s (2020 – 2049)	2060s (2050 – 2079)	2080s (2070 – 2099)
	RCP8.5 (High emissions scenario) 50% probability		
Mean minimum winter temperature	+0.9°C	+2.0°C	+2.9°C
Mean maximum summer temperature	+1.1°C	+2.8°C	+4.6°C
Annual mean temperature	+0.9°C	+2.1°C	+3.2°C
Annual precipitation (%)	+2%	+3%	+4%
Mean winter precipitation (%)	+9%	+16%	+26%
Mean summer precipitation (%)	-5%	-18%	-26%

Projections into the 2030s, 2050s and 2080s, for the high emission scenario RCP8.5, indicate an increase in temperatures and precipitation. Changes in temperatures indicate increases between 0.9 and 3.5°C, in terms of mean temperature, while annual precipitation will be increased by up to 5%. The mean winter precipitation projection is an increase of 26% by the 2080s, whilst the mean summer precipitation projection is a decrease of 26% (i.e. representative of wetter winters and drier summers).

In summary, the projected general trends of climate changes in the 21st century across the UK are a move towards warmer, wetter winters and hotter, drier summers, with average temperatures increasing across all seasons. Although the annual precipitation levels are not projected to change considerably, intense heavy rainfall events are predicted to increase in both winter and summer periods. Coastal flood risk is projected to increase and the frequency and magnitude of extreme water levels around the UK coastline is expected, predominantly due to mean sea level rise. For the UKCP18 RCP8.5 scenario, the projected sea level rise by the year 2100 is between 0.33m – 0.94m at Edinburgh, depending on the probability level considered (Met Office, 2019).

12.5 Impact Assessment

12.5.1 Construction Phase

This section presents the assessment of potential impacts on air quality and climate due to construction of the Scheme.

12.5.1.1 Air Quality – Construction Dust

It has been identified that there are potentially sensitive receptors located in near proximity to the Flood Cell areas. The sensitivity of the area around each Flood Cell takes into consideration the number and the distance of human receptors from each Flood Cell and baseline conditions, and is summarised as being High to Medium sensitivity with respect to changes in dust deposition rates and Medium to Low sensitivity with respect to emissions of PM_{10}. For the assessed ecological receptor (i.e. the Firth of Forth SSSI, Ramsar and SPA), the sensitivity of the area for ecological impacts is considered High. A full description of how the sensitivities were determined is provided in Appendix C12.1 Dust Risk Assessment and Supplementary Baseline Data and Greenhouse Gas Emissions Calculations.

The scale and nature of activities associated with construction within each Flood Cell have been used to determine the dust emission magnitude for the different types of potential dust generating activities (demolition, earthworks, construction and trackout). These are shown in Table 12-11. In summary, demolition is considered to have a small dust emission magnitude, earthworks range from a small to medium dust emission magnitude depending on Flood Cell, construction ranged from a small to medium dust emission magnitude and trackout is considered to have a medium dust emission magnitude. A full description of how the dust emission magnitudes were determined is provided in Appendix C12.1 Dust Risk Assessment and Supplementary Baseline Data and Greenhouse Gas Emissions Calculations.

Table 12-11 – Dust Emission Magnitudes

Activity	Dust emission magnitude					
	Flood Cell 1	Flood Cell 2	Flood Cell 3	Flood Cell 4	Flood Cell 5	Flood Cell 6
Demolition	Small	Small	Small	Small	Small	Small
Earthworks	Medium	Small	Medium	Medium	Medium	Medium
Construction	Small	Small	Medium	Small	Small	Small
Trackout	Medium	Medium	Medium	Medium	Medium	Medium

The sensitivities of the surrounding area to demolition, earthworks, construction and trackout are shown in Table 12-12. A full description of how the sensitivity of the area was defined is provided in Appendix C12.1 Dust Risk Assessment and Supplementary Baseline Data and Greenhouse Gas Emissions Calculations.

Table 12-12 – Sensitivity of the Surrounding Area for each Flood Cell

Section	Potential impact	Sensitivity of the surrounding area			
		Demolition	Earthworks	Construction	Trackout
Flood Cell 1 – Upper Carron	Dust Soiling	High	High	High	High
	Human Health	Low	Low	Low	Low
	Ecological	N/A[1]			
Flood Cell 2 – Lower Carron	Dust Soiling	Medium	Medium	Medium	High
	Human Health	Low	Low	Low	Low
	Ecological	N/A[1]			
	Dust Soiling	Medium	Medium	Medium	Medium

Section	Potential impact	Sensitivity of the surrounding area			
		Demolition	Earthworks	Construction	Trackout
Flood Cell 3 – Port of Grangemouth	Human Health	Low	Low	Low	Low
	Ecological	High	High	High	High
Flood Cell 4 – Grange Burn	Dust Soiling	High	High	High	High
	Human Health	Medium	Medium	Medium	Low
	Ecological	High	High	High	N/A[1]
Flood Cell 5 – River Avon	Dust Soiling	Medium	Medium	Medium	Medium
	Human Health	Low	Low	Low	Low
	Ecological	High	High	High	High
Flood Cell 6 – Estuary Frontage	Dust Soiling	Medium	Medium	Medium	Low
	Human Health	Low	Low	Low	Low
	Ecological	High	High	High	High

Following the IAQM guidance (IAQM, 2016) by combining the sensitivity of the area with the dust emission magnitudes, the assessment methodology determines a dust risk for each activity (i.e. demolition, earthworks, construction and trackout activities) as presented in Table 12-13. A full description of how the dust risks were determined is provided in Appendix C12.1 Dust Risk Assessment and Supplementary Baseline Data and Greenhouse Gas Emissions Calculations.

Table 12-13 – Dust Risk at Human and Ecological Receptors

Section	Potential impact	Dust Risk			
		Demolition	Earthworks	Construction	Trackout
Flood Cell 1 – Upper Carron	Dust Soiling	Medium risk	Medium risk	Low risk	Medium risk
	Human Health	Negligible risk	Low risk	Negligible risk	Low risk
	Ecological	N/A			
Flood Cell 2 – Lower Carron	Dust Soiling	Low risk	Low risk	Low risk	Medium risk
	Human Health	Negligible risk	Negligible risk	Negligible risk	Low risk
	Ecological	N/A			
Flood Cell 3 – Port of Grangemouth	Dust Soiling	Low risk	Medium risk	Medium risk	Low risk
	Human Health	Negligible risk	Low risk	Low risk	Low risk
	Ecological	Medium risk	Medium risk	Medium risk	Medium risk
Flood Cell 4 – Grange Burn	Dust Soiling	Medium risk	Medium risk	Low risk	Medium risk
	Human Health	Low risk	Medium risk	Low risk	Low risk
	Ecological	Medium risk	Medium risk	Low risk	N/A
Flood Cell 5 – River Avon	Dust Soiling	Low risk	Medium risk	Low risk	Low risk
	Human Health	Negligible risk	Low risk	Negligible risk	Low risk
	Ecological	Medium risk	Medium risk	Low risk	Medium risk
Flood Cell 6 – Estuary Frontage	Dust Soiling	Low risk	Medium risk	Low risk	Low risk
	Human Health	Negligible risk	Low risk	Negligible risk	Low risk
	Ecological	Medium risk	Medium risk	Low risk	Medium risk
Overall Maximum Risk		Medium risk	Medium risk	Medium risk	Medium risk

Table 12-13 shows that the overall maximum dust risk for all Flood Cells is a *Medium Risk* prior to mitigation. The dust risks summarised above for each activity were used to identify the recommended level of secondary mitigation (refer to Section 12.6). A conservative approach has been adopted to

assign the highest overall maximum risk for each dust emission source for the purposes of identifying the required level of mitigation for each Flood Cell. This is described in more detail in Section 12.6.1.

12.5.1.2 Air Quality – Emissions from Construction Related Road Traffic

Table 12-14 presents the maximum combined vehicle movements for the Flood Cells under construction and their respective screening result in accordance with the DMRB LA 105 criteria. Based on the maximum number of combined vehicle movements, the changes in road traffic flows are below the relevant criteria and are not required to be assessed further. Therefore, it is unlikely that emissions from construction traffic would have a sizeable impact on air pollutant concentrations at human receptors adjacent to the local road network. There would also be a negligible impact at human receptors within the Falkirk Town Centre AQMA, declared for NO_2. In summary air quality impacts from road traffic emissions are described as negligible, and Not Significant.

It should be noted that this is a worst-case approach as it assumes that vehicle movements associated with the works in each Flood Cell would all combine onto the same road link on the local road network. This is very unlikely due to the geographical spread of the Flood Cells and that road traffic would quickly distribute onto different road links based on the origin / destination.

Table 12-14. Construction Traffic Screening Results

Year of Construction	Flood Cell	HDV movements (2-way) (AADT)	Likely exceedance of DMRB LA 105 criteria? (200 HDV AADT)?	Total vehicle movements (2-way) (AADT)	Likely exceedance of DMRB LA 105 criteria? (1,000 AADT)?
Year 1	3, 4 and 5	34	No	140	No
Year 2	3, 4 and 5	74	No	278	No
Year 3	4 and 5	38	No	184	No
Year 4	2 and 4	44	No	136	No
Year 5	1 and 4	52	No	202	No
Year 6	1, 3 and 5	78	No	230	No
Year 7	3, 5 and 6	70	No	188	No
Year 8	3 and 6	46	No	110	No
Year 9	4 and 6	38	No	100	No

Emissions from construction plant and machinery (i.e. Non-Road Mobile Machinery (NRMM)) operating within the Flood Cells and Working Areas have the potential to give rise to air quality impacts during construction. However, given the relatively low number of plant items on site at any one time, which would be distributed over the Flood Cells and Working Areas, and with standard good practice techniques and mitigation measures in place (such as switching engines off when stationary, regular maintenance and servicing of vehicles, use of mains electricity or battery powered equipment where possible, as specified in Section 12.6.1), it is considered unlikely that local air quality will be significantly affected during construction due to emissions from NRMM.

12.5.1.3 Climate Change – Effects on Climate (Greenhouse Gas Emissions)

During its construction, the Scheme has the potential to affect Earth's climate by causing (either directly or indirectly) the emission of GHGs such as CO_2 into the atmosphere. The Earth absorbs energy from the

sun and re-emits this energy as thermal infrared radiation. GHGs in the atmosphere absorb this radiation, preventing it from escaping into space. The higher the concentration of GHGs in the atmosphere, the more heat energy is retained, and the higher global temperatures become. Predominantly due to anthropogenic activities, the concentration of GHGs in the atmosphere has increased, leading to an amplification of the greenhouse effect and associated global warming. This warming leads to numerous indirect impacts (including hotter, drier summers; warmer, wetter winters; and more frequent and intense extreme weather events) as the climate responds to the increased atmospheric temperature.

The calculated GHG emissions for the construction phase of the Scheme are presented in Table 12-15. Further details of the inputs and outputs of the GHG emissions calculations for the construction phase are provided in Appendix C12.1 Dust Risk Assessment and Supplementary Baseline Data and Greenhouse Gas Emissions Calculations.

Table 12-15. Construction Phase GHG Emissions

Emission type		GHG emissions (tCO_2e)
Materials	Steel	25,136
	Concrete	12,234
	Stone	3,230
	Plastics	2,942
	Cement	2,677
	Aggregate	1,453
	Aluminium	1,023
	Pumps	510
	Bricks	365
	Asphalt	229
	Soil/Clay	47
	Metal	0.2
	Total materials	**49,847**
Materials and plant transport		669
People transport		2,115
Site establishment		766
Plant use		15,256
Waste		957
Total construction emissions		69,611

As shown in Table 12-15, the estimated total GHG emissions associated with construction of the Scheme is 69,611 tCO_2e. The majority of these emissions are associated with embodied carbon in the steel and concrete materials required to construct the Scheme (37,370 tCO_2e), and also the fuel required to power the plant when constructing the Scheme (15,256 tCO_2e). Note that these calculations assume that diesel is the main fuel source for on-site construction plant. These emissions would be anticipated to occur in the year of material use in the case of embodied emissions. Assuming these emissions would occur over the anticipated nine-year construction period (2025 – 2033) (as provided in Appendix C4.1

(minus the initial (-1) year for pre-construction works) equates to an average annual emission of 7,734 tCO_2e per year. These emissions may vary slightly on an annual basis as the intensity of construction varies across the programme or if the construction progresses faster or slower than the proposed construction programme.

As noted above, the construction emissions are anticipated to be emitted over a nine-year period from 2025 to 2033. Based on the target GHG emissions for each year reported in Annex C of Scottish Government's Update to the Climate Change Plan 2018 – 2032 report (Scottish Government, 2020), the total emission target over the period 2025 to 2034 would be approximately 212 $MtCO_2e$. This is the sum of the target total emission envelopes for each year, which are based on a reducing trajectory towards the net zero target by 2045 and the interim targets of a 56%, 75% and 90% reduction by 2020, 2030 and 2040, respectively. Therefore, the estimated construction emissions of 69,611 tCO_2e are a very small percentage (i.e. 0.03%) of the total emission envelope for Scotland.

The estimated GHG emissions were also compared to the total existing emissions estimated for the Falkirk Council area in 2021 (see Table 12-9) in order to understand the relative magnitude of emissions on a localised / regional scale. The average yearly GHG emissions over the nine-year construction phase of 7,734 tCO_2e equate to approximately 0.34% of the total 2021 estimated GHG emissions for the Falkirk Council area.

As noted above, the construction of the Scheme is anticipated to result in a very small percentage change in GHG emissions in relation to existing GHG emissions and is not anticipated to impact on the UK Government's or Scottish Government's ability to meet the respective carbon reduction budgets and targets. Furthermore, the objective of the Scheme is to provide a minimum standard of protection against flooding to residential and commercial / industrial areas of Grangemouth and the surrounding area. Chapter 1: Introduction states that the Scheme would provide protection to around 2,760 residential properties, 6,025 people, 23 km of roads and 1,200 non-residential properties including a refinery, petrochemical plant, a major port and associated nationally important infrastructure (i.e. pipelines importing crude oil and gas from the North Sea and exporting refined products to industrial installations in northeast England. In the absence of the Scheme, these properties would experience more frequent or more severe flooding and resulting damage. There would also be more frequent disruption to infrastructure, including road networks. Therefore, the Scheme would reduce the works, and associated GHG emissions, required to dry out, repair or replace flood damaged properties and infrastructure. Although the amount of avoided GHG emissions has not been quantified, it is possible that these would be equivalent to some or all (although this is highly uncertain) of the construction phase GHG emissions over the full operational phase based on a 100-year reference period.

The construction of the Scheme leads to an increase in GHG emissions over a nine-year period, and is, therefore, indirectly contrary to the climate mitigation requirements of relevant legislation (The Climate Change (Scotland) Act 2009, national planning policy (NPF4 (Scottish Government, 2023a)) and local planning policy (FLDP2 (Falkirk Council, 2020)) in relation to reducing GHG emissions on a trajectory towards net zero by 2045. However, the Scheme is consistent with and contributes towards the climate adaption objectives and policies of the legislation and planning policies. The Scheme is also aligned with the overall objectives of the Falkirk Council Climate Change Strategy and Action Plan 2023-2030 (Falkirk Council, 2023a) with regard to climate adaption and preparing for the effects of a changing climate.

Some primary/embedded mitigation to reduce GHG emissions is included within the current outline design (see Section 12.3.1.3) and, therefore, taken into account within the calculation of GHG emissions. However, this represents a partial mitigation position and further carbon reduction opportunities would need to be explored and implemented during design and construction in order for the Scheme to be in line with good practice design principles to reduce GHG emissions, and fully contributing to the trajectory towards net zero. On this basis, and although the Scheme aligns with climate adaption legislation and policy goals and would have a relatively minor contribution to existing GHG emissions and carbon targets, in the absence of secondary mitigation, a precautionary magnitude of impact of Moderate Adverse has been assigned. This would, therefore, represent a potentially Significant effect.

12.5.2 Operational Phase

This section presents the assessment of potential impacts on climate as a result of the operation of the Scheme.

12.5.2.1 Climate Change – Effects on Climate (Greenhouse Gas Emissions)

The Scheme will lead to GHG emissions into the atmosphere during its operation (i.e. ongoing GHG emissions each year throughout the 100-year design life). The calculated GHG emissions for the operational phase are presented in Table 12-16. These represent the total GHG emissions for the 100-year operational phase period (i.e. 2034 – 2133) representing the operational design life of the Scheme.

Table 12-16. Operational Phase GHG Emissions

Emission type	GHG emissions (tCO_2e)
Use	45
Maintenance	3,093
Repair	140
Replacement	1,925
Refurbishment	3,562
Energy	2,214
Total operational emissions	**10,979**

As shown in Table 12-16, the estimated total GHG emissions associated with operation of the Scheme is 10,979 tCO_2e. The majority of emissions are generated by the planned maintenance and anticipated repair, refurbishment and replacement of the various components and assets which form the Scheme. This includes emissions associated with fuel use for employees / contractor travel and plant use, consumables used for the various maintenance activities and the embodied carbon in the materials required for these activities, including where components of the Scheme are refurbished or replaced at set frequencies throughout the 100-year period. Electricity to operate the pumping stations, pumps and lock gates also contribute to the total GHG emissions. The combined emissions equate to an average annual emission of approximately 110 tCO_2e per year. Therefore, during each of the years between 2034 (the start of operational phase) and the net zero target year of 2045, the approximate annual operational GHG emissions will represent a negligible percentage of Scotland's annual emissions target (approximately 0.0007% in 2034) but will become a larger percentage of the annual target as the net zero target date of 2045 is approached. However, the relatively small average annual emission of 110 tCO_2e reflects the predominantly passive nature of the Scheme (i.e. it requires low levels of energy, activities and materials to operate).

As noted for the construction phase, the Scheme would potentially lead to the avoidance of GHG emissions through the prevention of flood damage and the GHG emissions associated with drying, cleaning, repairing and replacing damaged properties and infrastructure. The Scheme is consistent with the relevant policies on climate adaption in NPF4 (Scottish Government, 2023a) and the vision and objectives of Falkirk Council's FLDP2 (Falkirk Council, 2020) in relation to helping to reduce or avoid flood risk. The Scheme is aligned with the overall aims of the Climate Change Strategy and Action Plan 2023-2030 (Falkirk Council, 2023a) with regard to climate change adaption and preparing for the effects of climate change. In preventing potential future flooding of up to 3,000 residential and non-residential properties plus the Port of Grangemouth and the refinery and petrochemical plant and associated nationally important infrastructure, and the GHG emissions which would result from this, the Scheme is also consistent with the climate change mitigation aspects of the Climate Change Strategy and Action Plan 2023-2030 (Falkirk Council, 2023a).

Furthermore, these emissions are considered likely to be on a trajectory to net zero as GHG emissions associated with many of the operational activities would be expected to decrease in the future independently of Scheme-specific mitigation measures, for example:

- GHG emissions from electricity generation are expected to decrease over time as the national grid is gradually decarbonised. This is not fully taken into account in the estimated energy use GHG emissions.
- Emissions from road traffic and construction / maintenance plant are expected to decrease over time with increased uptake of electric vehicles and development of electric and other zero-emission technology construction plant to meet international and national requirements (e.g. banning of the sale of petrol and diesel vehicles).
- Embodied carbon in construction materials is expected to decrease over time through international and national initiatives to reduce the carbon content of materials to meet net zero targets, particularly for concrete and steel.

The likely trajectory to net zero has not been fully included in the estimates of GHG emissions during the operational phase, as a conservative approach. On the above basis, the GHG emission calculations for the operational phase are considered to be an over-estimate, representing relatively small annual emissions and would decrease in future years. Therefore, the magnitude of change in GHG emissions is assessed as Minor Adverse, representing a Not Significant effect.

12.5.2.2 Climate Change – Vulnerability of the Scheme to Climate Change

Future changes in climate conditions, including increased maximum temperatures, increased rainfall during winter months, and increased frequency of extreme weather events, could affect the resilience and vulnerability of the Scheme.

As presented in the baseline section (Section 12.4.2), for the lifespan of the Scheme, in the short term (2030), medium term (2050) and long term (2080), the likely changes in climate under a conservative high emissions scenario include:

- Increased mean temperatures of 1.0°C in the short term, 1.7°C in the medium term, and 3.4°C in the long term; and
- Increased annual rainfall by 3% in the short term, 4% in the medium term and 5% in the long term, along with considerably higher precipitation in winter months, more intense rainfall events and rising sea levels with the associated increase in coastal flood risk.

The purpose of the Scheme is to protect areas in and around Grangemouth from flooding and storm surge risks and it has been designed to provide a high level of flood protection (up to the 1 in 200-year level). In order to allow the Scheme to be adaptable and resilient to the future effects of climate change, the foundations for the flood defences have been designed to allow the height of the structures to be increased by up to 0.7 m at a future date. Whilst this may be sufficient in some areas to mitigate the impacts of climate change, it is likely that additional measures would also need to be undertaken e.g. implementation of upstream flood storage and / or large-scale nature based solutions. On this basis, the vulnerability of the Scheme to climate change over its operational lifetime is anticipated to be low and would be mitigated through the design and application of the appropriate engineering design standards. This could include consideration of the height and slope of the embankments, height and thickness of flood or sea walls and sheet piling depth, careful selection of materials to provide a long-life expectancy, height and depth of rock armour revetments, inclusion of erosion protection, selecting the required type / thickness of flood / tidal gates and capacity of channels / headwalls.

A qualitative, risk-based assessment of the potential vulnerability of the Scheme to future climate events is set out in Table 12-17. This considers the potential impact of these events on the Scheme receptors (i.e. the physical assets and operation of the Scheme), the likelihood of occurrence of the impact, the severity of the impact, should this occur, and the significance of the effect. Given the purpose of the

Scheme and the overall low vulnerability to changes in climate, the assessment has considered only those factors which could have the highest potential impact.

Potential hazards relate to all vulnerable receptors, including the Scheme elements (i.e. flood defence structures, drainage systems, flood gates, channels etc); the inability to access the working area during the operation and maintenance phases as a result of extreme weather conditions; and health and safety risks to operational staff and other end-users, including members of the public. Other impacts include potential damage or deterioration to, or a reduced life span of, the Scheme. Other impacts are associated with flood risk which could include damage to drainage systems and increased surface water runoff causing damage to nearby land / properties and potentially a risk to life.

Whilst some extreme events, such as storms, can be easily associated with direct consequences on the Scheme and its assets like flooding and landslides, there is uncertainty around the consequences associated with such events. For instance, consequences associated with disruption to maintenance activities could affect normal operation of the Scheme.

Table 12-17. Vulnerability of the Scheme to Climate Change over the Scheme Lifespan

Climate event	Potential impact to assets	Likelihood	Consequence	Significance
Increased temperatures / temperature extremes	Materials could be affected at higher temperatures which increases stress on structures, compromising the integrity causing failure of the flood protection.	Very Low	Moderate to Large adverse	Not Significant
	Higher temperatures could result in materials becoming brittle and rigid, or reducing the lifespan of the materials. This could result in increased levels of maintenance, refurbishment or replacement of assets.	Low	Negligible to Minor adverse	Not Significant
Reduced summer rainfall, increased drier periods / drought and associated solar radiation exposure	Increased rate of degradation of materials potentially leading to need for early replacement.	Low	Minor adverse	Not Significant
	Drying out of construction materials and cracking potentially leading to need for more frequent refurbishment or early replacement	Low	Minor adverse	Not Significant
	Increased dust and windborne materials affecting operation and maintenance, including silting and sedimentation	Medium	Minor adverse	Not Significant
Increased precipitation, especially in winter, and higher frequency	Water scour or soil erosion causing structural damage or weakening of structural soils leading to repairs or failure	Low	Moderate adverse	Not Significant

Climate event	Potential impact to assets	Likelihood	Consequence	Significance
of storms with extreme rainfall events	Increased corrosion of metal structures affecting scheme integrity, as well as increasing costs associated with maintenance and refurbishments.	Low	Minor to moderate adverse	Not significant
	Storm surges and / or flooding resulting in adjacent landscapes and soils washing into the infrastructure, requiring specific maintenance action.	Medium	Minor adverse	Not significant

12.5.3 Cumulative Effects

12.5.3.1 Same Project Cumulative Effects

Due to the extent of the proposed flood defences, it is anticipated that the construction works will be divided into four phases / contracts and indicative phases of work have been assumed. There is anticipated to be an overlap of construction works within some Flood Cells during the construction phase. Therefore, there is the potential for cumulative effects with regard to dust emissions. However, for those Flood Cells with anticipated overlapping works, the distances between the construction site boundaries and working areas within the Flood Cells are such that there would not be an increase in the sensitivity of the area to dust (as identified as part of the construction dust assessment, see Table 12-12). On this basis, there would not be any change to the dust risks at human or ecological receptors (see Table 12-13) and associated proposed mitigation (see Section 12.6.1).

The assessment of climate is inherently cumulative from an additive / incremental perspective as it considers the emissions of GHGs from the Scheme and vulnerability of the Scheme as a whole.

12.5.3.2 Other Project Cumulative Effects

A list of the 'reasonably foreseeable' other developments and land-use allocations considered as part of the assessment is provided in Appendix B15, Table B15-1. This list includes a number of planning applications whose construction periods may overlap with the Scheme's construction period.

As a conservative approach to the assessment, it is assumed these other projects would be constructed at the same time as the Scheme. The list of foreseeable future projects was reviewed to understand the location and type of developments to determine if there would be additive effects with regard to construction dust emissions or from emissions from construction related traffic associated with the Scheme.

A total of eight proposals partially overlap the Scheme footprint (see Figure B15.1 in Appendix B). However, only partial sections of the respective red line boundaries overlap with none being in close proximity to the Scheme's proposed works. Furthermore, the majority of these other projects are relatively small in scale (e.g. alterations or extensions to existing properties, a nursing home and a restaurant) and the additive effect of construction dust emissions or additional road traffic would be negligible.

Major developments (i.e. greater than 1 ha in size and where the scale of construction works would require specific measures to control dust and traffic) in the vicinity of the Scheme have been reviewed to determine their proximity to the Scheme and type of development to understand if there could be potential cumulative effects during the construction phase. Four developments have been identified:

- P/20/0460/FUL, Weedingshall Polmont Road (change of use of and alterations to house (class 9) to hotel (class 7) with ancillary managers flat. This development site is approximately 100 m from Cell 4, Working Area 4-1: Upstream of M9.
- P/21/0656/PPP, land to the west of 21 Polmont Park, Polmont Road. Development of land for residential use (i.e. over 30 residential properties). This development site is approximately 150 m from Cell 4, Working Area 4-1: Upstream of M9.
- P/20/0493/PPP, land to the east of Gilston Farm. Mixed use development including residential, employment, commercial and retail use, open space and landscaping with associated infrastructure. This development site is approximately 830 m from Cell 4, Working Area 4-4: Wholeflats Road, at its closest point.
- P/21/0373/FUL, Avondale Quarry. Construction of hazardous waste cell. This development site is approximately 660 m from Cell 5, Working Area 5-1: Smiddy Brae & Avondale Road.

Although the proposed construction works at Weedingshall Polmont Road (i.e. P/20/0460/FUL) are approximately 100 m from Working Area 4-1, the likely small scale dust generating activities and short construction duration means there would be a negligible cumulative effect with regard to dust emissions. The associated construction related traffic would share use of Granstable Road and Polmont Road. However, based on maximum HDV movements associated with the Scheme (see Table 12-14), any combined road traffic would lead to a Not Significant effect on air quality with regard to pollutant concentrations at human receptors close to the access routes.

For the proposed development to the west of 21 Polmont Park (i.e. P/21/0656/PPP), based on the distance to nearby human and ecological receptors, it is unlikely that the cumulative construction dust risks would be any higher than assessed for the Scheme in isolation, and the cumulative effect would be Not Significant, should there be an overlap of construction activities. The associated construction related traffic would share use of Granstable Road and Polmont Road. However, based on the maximum HDV movements associated with the Scheme (see Table 12-14), any combined road traffic would lead to a Not Significant effect on air quality.

The proposed mixed-use development to the east of Gilston Farm (i.e. P/20/0493/PPP) is approximately 830 m southeast of Working Area 4-4 at its closest point and therefore, there would be a negligible cumulative effect with regard to dust emissions. However, construction related traffic would share use of Polmont Road. Based on maximum HDV movements associated with the Scheme (see Table 12-14), any combined road traffic would lead to a Not Significant effect on air quality.

The proposed location of the hazardous waste cell (i.e. P/21/0373/FUL) is approximately 660 m southeast of Working Area 5-1 and therefore, there would be a negligible cumulative effect with regard to dust emissions. As the proposed development is in close proximity to the M9 motorway, the additive effect from combined road traffic is negligible and would lead to a Not Significant effect on air quality with regard to pollutant concentrations at human receptors.

Although other developments may occur within the Flood Cell areas during the construction phase, which are not currently included in Table B15-1 of Appendix B15, these developments would be required, through the planning process, to manage dust emissions during construction using appropriate mitigation measures.

The assessment of cumulative GHG emissions cannot be carried out in a process analogous to other environmental topics because there is no causal link between the location of GHG emissions and the impacts arising from the cumulative aggregation of GHGs in the atmosphere. This limitation has also been recognised in the update to guidance on the assessment of GHG emissions produced by IEMA (IEMA, 2022). Because of this limitation - and because it is necessary to consider GHGs in the context of a scientifically based trajectory compliant with the planetary limits for GHG emissions - the best available comparison benchmarks are the carbon envelopes / emission reduction targets adopted by

Scotland within which it must stay in order to remain on track to achieve net zero by 2045. The associated emissions envelopes, which align with the reduction targets, are inherently cumulative as they consider emissions from all sources and include future emissions from new developments. The significance criteria adopted for the impact assessment (see Table 12-3) accounts for the need to align with a scientifically based trajectory to net zero compliance with planetary limits and, therefore, considers the potential cumulative effect of GHG emissions on the global atmosphere and climate. No separate cumulative assessment has therefore been undertaken for GHG emissions.

The foreseeable future projects would not influence the climate events and potential impacts set out in Table 12-17 as part of the assessment of vulnerability of the Scheme to climate change. No separate cumulative assessment is therefore required for this aspect.

12.6 Mitigation

12.6.1 Construction Phase

12.6.1.1 Air Quality – Construction Dust

Tertiary Mitigation

The assessment process identified the risk of dust effects and thereby the level of tertiary mitigation that would be required to control the effects of dust emissions during construction. A suite of good practice (tertiary) mitigation measures, as recommended by the IAQM guidance (IAQM, 2016; 2023) and based on the highest risk level identified in the assessment for each dust emission source is presented in Appendix C12.1. The proposed mitigation and basis for the level of mitigation measures are summarised below.

- AQ01: Dust Management Plan (DMP) to include dust management and control measures, and to be approved by Falkirk Council prior to construction commencing. DMP to include measures as recommended by the IAQM guidance (IAQM, 2016; 2023) for the following dust emission categories / sources:
  - Demolition – mitigation measures based on *Medium* risk
  - Earthworks – mitigation measures based on *Medium* risk
  - Construction – mitigation measures based on *Medium* risk
  - Trackout – mitigation measures based on *Medium* risk
  - General dust management and communications – mitigation measures based on *Medium* risk (i.e. based on the highest risk from any of the specific dust emission sources above).

Where applicable, the DMP would include those control measures which were identified as 'Desirable' or 'Highly Recommended' for each dust emission source based on the assessed risk level. The proposed tertiary mitigation measure (i.e. the development and application of the DMP) and suggested specific control measures for inclusion within the DMP are set out in Table 12-18. Those control measures which were identified as 'Desirable' and 'Highly Recommended' are noted in the table. It may be the case that as the design develops, construction methods are updated and more knowledge of the construction activities and their locations is gained, some of the 'Desirable' and other suggested control measures may not be relevant or appropriate for the Scheme. It is envisaged that the DMP, and the associated control measures, would be secured through an appropriate planning condition and require approval by Falkirk Council before construction can commence. Any major differences or omissions from the DMP compared to those set out in Table 12-18 would be discussed with Falkirk Council before the DMP is submitted for approval.

In summary, the Scheme represents a relatively large construction site, when considered it its entirety, but it is not unusual in scale in comparison with other infrastructure or flood protection schemes in the

UK. There are tertiary mitigation methods already available that have been successfully applied on other, similar schemes to manage emissions of dust, such that significant off-site effects have not occurred. It is considered that there are no potentially dust generating activities proposed that could not be managed using normal good practice as set out in the DMP so as to prevent significant effects at any off-site receptor, including those located within 20 m of the boundary of any of the Scheme cells. No Primary or Secondary mitigation measures are required.

Table 12-18. Construction Dust Mitigation Measures

Mitigation Item	Mitigation Measure	Suggested Control Measures for Inclusion in the DMP	
		Sub-Category	Control Measures Based on the Outcome of the Construction Dust Assessment
AQ01	Dust Management Plan	Communications	• Develop and implement a stakeholder communications plan that includes community engagement before work commences on the site. • Display the name and contact details of person(s) accountable for air quality and dust issues at the site boundary along with head or regional office contact information.
		Dust Management	• Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner and record the measures taken. • Make the complaints log available to Falkirk Council when asked. • Record any exceptional incidents that cause dust and / or air emissions, either on-site or off-site, and the action taken to resolve the situation in the logbook. • Undertake daily on-site and off-site inspection, where receptors (including roads) are nearby to monitor dust and record inspection results and make the log available to Falkirk Council when asked. This should include regular dust soiling checks of surfaces for example checking of street furniture, cars and windowsills around the site boundary with cleaning to be provided if necessary (Desirable) • Carry out regular site inspections to monitor compliance with the DMP, record inspection results and make an inspection log available to Falkirk Council when asked. • Increase the frequency of site inspections by the person accountable for air quality and dust issues on site when activities with a high potential to produce dust are being carried out and during prolonged dry or windy conditions. • Agree dust deposition, dust flux or real-time PM_{10} continuous monitoring locations with Falkirk Council. Where possible, commence baseline monitoring at least three months before work commences on site or, if at a large site, before work on a phase commences.

Mitigation Item	Mitigation Measure	Suggested Control Measures for Inclusion in the DMP	
		Sub-Category	Control Measures Based on the Outcome of the Construction Dust Assessment
			• Plan site layout so that machinery and dust causing activities are located away from receptors, as far as is possible. • Erect solid screens or barriers around dusty activities, or the site boundary, which are at least as high as any stockpiles on site, where there is risk of causing adverse dust impacts at nearby receptors. • Fully enclose site or specific operations where there is a high potential for dust production and the site is active for an extensive period, where there is risk of causing adverse dust impacts at nearby receptors. • Avoid site runoff of water or mud. • Keep site fencing, barriers and scaffolding clean using wet methods. • Remove materials that have a potential to produce dust from the site as soon as possible, unless being re-used on site. If they are being re-used on-site, cover as described below. • Cover, seed or fence stockpiles to prevent wind whipping. • Ensure all vehicles switch off engines when stationary – no idling vehicles. • Avoid the use of diesel or petrol-powered generators and use mains electricity, battery powered or solar equipment where practicable. • Regular maintenance of plant, vehicles and equipment in accordance with manufacturers specifications or equivalent bespoke maintenance regime. • Impose and signpost a maximum speed limit of 15 mph on surfaced and 10 mph on unsurfaced haul roads and work areas (if long haul routes are required these speeds may be increased with suitable additional control measures provided, subject to the approval of the nominated undertaker and with the agreement with Falkirk Council, where appropriate) (Desirable). • Install hard surfaced haul routes, which are regularly damped down with fixed or mobile sprinkler systems, or mobile water bowsers and regularly cleaned. • Implement a Travel Plan that supports and encourages sustainable travel (public transport, cycling, walking and car sharing) (Desirable). • Where applicable, only use cutting, grinding or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as

Mitigation Item	Mitigation Measure	Suggested Control Measures for Inclusion in the DMP	
		Sub-Category	Control Measures Based on the Outcome of the Construction Dust Assessment
			water sprays or local extraction, e.g. "suitable local exhaust ventilation systems". • Ensure an adequate water supply on the site for effective dust / particulate matter suppression / mitigation, using non-potable water where possible and appropriate. • Where applicable, use enclosed chutes and conveyors and covered skips. • Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate. • Ensure equipment is readily available on site to clean any dry spillages and clean up spillages as soon as reasonably practicable after the event using wet cleaning methods. • Avoid dry sweeping of large areas. • Inspect on-site haul routes for integrity and instigate any necessary repairs to the surface as soon as reasonably practicable. • Record all inspections of haul routes and any subsequent action in a site logbook. • No bonfires or burning of waste materials.
		Demolition	• Soft strip inside buildings before demolition (retaining walls and windows in the rest of the building where possible, to provide a screen against dust). (Desirable). • Ensure effective water suppression is used during demolition operations. Handheld sprays are more effective than hoses attached to equipment as the water can be directed to where it is needed. In addition, high volume water suppression systems, manually controlled, can produce fine water droplets that effectively bring the dust particles to the ground. • Avoid explosive blasting, using appropriate manual or mechanical alternatives. • Bag and remove any biological debris or damp down such material before demolition.
		Earthworks	• Re-vegetate earthworks and exposed areas / soil stockpiles to stabilise surfaces as soon as practicable. (Desirable) • Use hessian fabric, mulches or tackifiers where it is not possible to re-vegetate or cover with topsoil, as soon as practicable. (Desirable). • If practicable, only remove the cover in small areas during work and not all at once. (Desirable).

Mitigation Item	Mitigation Measure	Suggested Control Measures for Inclusion in the DMP	
		Sub-Category	Control Measures Based on the Outcome of the Construction Dust Assessment
		Construction	• Avoid scabbling (roughening of concrete surfaces) if possible (Desirable). • Ensure sand and other aggregates are stored in bunded areas and are not allowed to dry out unless this is required for a particular process, in which case ensure that appropriate additional control measures are in place. • Ensure bulk cement and other fine powder materials are delivered in enclosed tankers and stored in silos with suitable emission control systems to prevent escape of material and overfilling during delivery (Desirable). • For smaller supplies of fine powder materials, ensure bags are sealed after use and stored appropriately to prevent dust (Desirable).
		Trackout	• Use water-assisted dust sweeper(s) on the access and local roads to remove, as necessary, any material tracked out of the site. This may require the sweeper being continuously in use. • Ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport. • Implement a wheel washing system (with rumble grids to dislodge accumulated dust and mud) prior to leaving the site where reasonably practicable. • Ensure there is an adequate area of hard surfaced road between the wheel wash facility and the site exit, wherever site size and layout permits. • Access gates to be located at least 10 m from receptors where possible.

12.6.1.2 Climate Change – Effects on Climate (Greenhouse Gas Emissions)

In line with the Scottish Government's Climate Change Delivery Plan (Scottish Government, 2009b), all developments should seek to reduce GHG emissions as far as practicable and aim to maximise their potential for reducing GHG emissions. Mitigation over and above that included as embedded / primary mitigation is required to ensure that the Scheme is fully consistent with policy requirements to decarbonise and in line with good practice design standards for developments of this type.

Secondary Mitigation

Mitigation to reduce the GHG emissions for the construction phase includes the specification and use of lower carbon materials. The use of lower carbon construction materials is estimated to reduce the GHG emissions during the construction phase by approximately 12,877 tCO_2e (a 18% decrease), with total construction emissions (including secondary mitigation) calculated as 56,733 tCO_2e. The main reductions are summarised below.

- **Mitigation Item CC01** – use of lower carbon concrete. Concrete to be used for construction of the Scheme is proposed to be low-carbon concrete where possible e.g., changing the cement concrete in the flood walls from RC 32/40 MPa 15% cement replacement to RC 32/40 50% cement

replacement. For this example, the use of the higher cement replacement content in the carbon calculations resulted in an overall 13% lower GHG emissions per tonne of material compared to concrete with lower cement replacement.

- **Mitigation Item CC02** – use of lower carbon steel. It is proposed that the sheet piles which form the core of most of the flood defences would be specified in the carbon calculations as lower carbon steel where practicable. For this example, the sheet piles have been specified as 'Engineering Steel – Recycled' instead of 'Engineering Steel' (which is assumed from a non-recycled source) which results in 43% lower GHG emissions per tonne of material.
- **Mitigation Item CC03** – use of lower carbon aluminium. It is proposed that the flood barriers, gates and flow control could be constructed from recycled aluminium instead of virgin aluminium. For this example, the use of recycled aluminium in the carbon calculations resulted in 86% lower GHG emissions per tonne of material.

The following mitigation measures have also been identified to reduce GHG emissions as far as practicable although it is not possible to quantify the likely magnitude of these measures on reducing the calculated GHG emissions at this stage.

Mitigation Item CC04 - a Carbon Management Plan (CMP) is being developed by Falkirk Council to reduce the whole life carbon emissions for the Scheme. The Scheme-specific CMP assists in delivery of the wider carbon reduction objectives of Falkirk Council. The CMP for the Scheme aims to adhere to the principles of PAS 2080 (although not seeking official accreditation), the British industry standard for managing infrastructure carbon (British Standards Institute, 2023) and, in summary, will include the following steps:

- Calculate the anticipated carbon footprint of the Scheme based on the current outline design information and use this information to assess the potential to reduce carbon across the design, construction and operational phases;
- Identify the key carbon 'hotspots' of the Scheme (i.e. those elements of the Scheme which are likely to result in the greatest carbon impacts and therefore offer the greatest potential for reduction);
- Set out carbon reduction targets against the carbon baseline;
- Set out roles and responsibilities to successfully implement the Scheme-specific CMP and achieve carbon reduction targets;
- Specify the steps needed to reduce carbon through the design, construction and operational stages; and
- Identify the carbon actions and opportunities which will be considered moving forward and prior to construction completion.

Although the Scheme-specific CMP is independent of the EIA, it will form a key part of the mitigation for the Scheme and provide a clear and systematic approach for the reduction of GHG emissions through the construction and operational phases. The Scheme-specific CMP will continue to be developed and updated as the Scheme design progresses.

The CMP could investigate the following types of mitigation measures to reduce GHG emissions as far as practicable:

- Good practice measures to be adopted during the construction phase including, for example:
  - Investigate and implement sustainable reuse of soil and aggregate materials won from excavation.
  - The reuse, where possible of materials and waste generated from construction works.
  - Procuring locally sourced materials where reasonably practicable to reduce transportation emissions.

  - Careful consideration of material quantity requirements to avoid over-ordering and generation of waste materials, while also reducing transportation-related emissions.
- Requiring the appointed contractor to develop and implement a plan to reduce fuel and energy consumption and associated GHG emissions throughout construction, including, but not limited to, for example:
  - Monitoring of fuel and mains electricity use on site (site accommodation to have motion activated lighting and use lower power lighting techniques such as light-emitting diodes (LEDs)).
  - Training of plant operatives in fuel efficient driving techniques or use of appropriate technology on construction vehicles (e.g. stop – start).
  - Consideration of renewable / and or low carbon energy sources to power construction compounds and low or zero emission construction plant and vehicles.
- Investigating opportunities to potentially reduce GHG emissions further at the detailed design stage. Potential opportunities include the following:
  - Investigate design optimisation to reduce the works or use lower amounts of carbon-intensive materials (e.g. investigating where the Scheme structures can be reduced in size / thickness but still perform the desired function).
  - Use of lower carbon materials or products beyond those which have been included within the outline design and assessment (e.g. using concrete mixes with much lower carbon content, or alternative or lower-carbon materials for other aspects of the Scheme which are not constructed with concrete, steel or aluminium).
  - Where applicable, target construction methods which use pre-cast modular components which are constructed more efficiently at offsite locations rather than onsite construction.

If required, the measures to be included within the contractor requirements during the tendering process to identify capabilities and likely cost implications of such measures. A cost-benefit analysis would need to be undertaken should any technically feasible measures be identified.

12.6.2 Operational Phase

12.6.2.1 Climate Change – Effects on Climate (Greenhouse Gas Emissions)

Secondary Mitigation

Although a significant effect was not identified in the assessment for the operational phase, given the sensitivity of the global atmosphere to GHG emissions and the importance of reducing GHG emissions to meet GHG reduction targets on a trajectory towards net zero, the proposed CMP (**Mitigation Item CC04**) would include consideration of measures to reduce GHG emissions as far as practicable during operation, including for example:

- Consideration of energy efficiency measures in the design for the operational phase or during operation to reduce electricity consumption or reduce GHG emissions (e.g. use of low-energy lighting, use of green energy tariffs).
- Investigate the feasibility and practicability of installing renewable energy sources, such as solar panels linked to e.g. lighting and signage, to further reduce GHG emissions from operational electricity use.
- Develop a plan to operate the Scheme and undertake the required inspections and maintenance as efficiently as practicable to reduce GHG emissions

12.6.2.2 Climate Change – Vulnerability of the Scheme to Climate Change

Primary Mitigation

The resilience of the Scheme to climate change to some extent is embedded in the design as its purpose is to provide protection to flooding events up to a 1 in 200-year standard of protection. It has been designed to allow the defences to be raised in future to account for the effects of climate change by over-engineering foundations and constructing heavily constrained sections (i.e. at the estuary frontage) to an increased height where required.

Secondary Mitigation

Although a significant effect was not identified in the assessment, the following secondary mitigation measures have been identified to increase the Scheme resilience:

- **Mitigation Item CC05**: Consideration of the use of construction materials with superior properties (such as increased tolerance to fluctuating temperatures, extreme temperatures and increased solar radiation) to be included within detailed design.
- **Mitigation Item CC06**: Implementation of an appropriate asset management strategy by the Scheme operator to proactively identify and, where necessary, rectify potential climate related impacts (e.g. additional visual inspections of the Scheme's assets after extreme weather events).

12.7 Residual Effects

12.7.1 Construction Phase

With the implementation of appropriate dust management measures, there are not predicted to be any significant residual air quality impacts from construction activities. IAQM guidance (IAQM, 2016; 2023) notes that, even with a rigorous package of good practice mitigation measures in place, such as that proposed in Section 12.6.1, it is not possible to guarantee that the dust mitigation measures will be effective all the time. If, for example, dust emissions occur under adverse weather conditions, or there is an interruption to the water supply used for dust suppression, the local community may experience occasional, short-term dust annoyance. The likely scale of such impacts would not however normally be considered sufficient to change the conclusion that, with mitigation, the significance of effect is **Not significant**.

With the incorporation of the mitigation provided in Section 12.6.1, it is likely that the GHG emissions from the construction of the Scheme will be reduced compared to the estimated GHG emissions reported in Section 12.5 and will represent a Scheme which is fully consistent with existing and emerging policy requirements to reduce GHG emissions towards net zero. Therefore, the magnitude of GHG emissions would be Minor Adverse and the residual significance of effect is **Not significant**.

12.7.2 Operational Phase

With the incorporation of the mitigation provided in Section 0, it is likely that the GHG emissions from the operation of the Scheme will be reduced compared to the estimated GHG emissions reported in Section 12.5. However, the magnitude of GHG emissions remains as Minor Adverse and the residual significance of effect as **Not significant**.

No significant residual impacts were identified in relation to the vulnerability of the Scheme to climate change. This relies on the fact that the Scheme would be of relatively low vulnerability given it's intended purpose, built-in expandability to address future climate change and that other potential impacts during operation can be addressed at the detailed design stage. The residual significance of effect with regard to vulnerability to climate change is **Not significant.**

12.7.3 Interaction with other Environmental Disciplines

12.7.3.1 Proposed Mitigation Measures from other Disciplines

There is a very low likelihood that any of the mitigation or enhancement measures identified to reduce the impacts associated with other environmental factors would lead to significant air quality effects, which would not be controlled by the dust mitigation measures set out in the DMP.

In terms of potential climate change impacts, there are no mitigation or enhancement measures which would significantly alter the significance of effect with regard to GHG emissions or the vulnerability of the Scheme. Some of the mitigation measures are beneficial in terms of both of these elements, for example, the mitigation associated with landscape and visual impacts (see Chapter 9 – Landscape and Visual Impact Assessment) includes planting of vegetation to offset amenity loss, replacement planting and replacement of trees lost due to Scheme construction, which would result in some carbon sequestration.

12.7.3.2 Other Indirect (Secondary) Effects

There are no apparent indirect effects on human receptors or the global climate from any significant effects identified for other environmental topics.

12.7.4 Cumulative Effects

As discussed in Section 12.5.3, no significant 'Same Project' or 'Other Project' cumulative effects on air quality receptors are anticipated or require specific mitigation and therefore no significant cumulative effects are anticipated.

As discussed in Section 12.5.3, there are not expected to be any significant cumulative effects regarding climate change.

12.8 Monitoring

12.8.1 Construction Phase

As set out in Table 12-18, monitoring of dust and / or particulates is proposed in accordance with the mitigation measures set out in the IAQM guidance (IAQM, 2016; 2023).

As part of the Scheme-specific CMP and mitigation commitments, the contractor appointed to construct the Scheme will record the relevant data to monitor and track GHG emissions during the construction phase (e.g. fuel use, material quantities, energy use, relevant transport statistics). The various metrics would be compared to relevant industry standard targets or specific targets and key performance indicators developed for the Scheme as part of the CMP.

12.8.2 Operational Phase

Depending on the requirements of the Scheme-specific CMP, Falkirk Council may be required to record relevant data to monitor and track GHG emissions during the operational phase.

12.9 References

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