Environmental Impact Assessment Report

Appendix C12: Air Quality and Climate Change

Grangemouth Flood Protection Scheme 2024
Falkirk Council

GRANGEMOUTH
Flood Protection Scheme
Protecting the heart of our communities

Contents

Appendix C12.1: Dust Risk Assessment, Supplementary Baseline Data and Greenhouse Gas Emissions Calculations

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1. Introduction

This technical appendix supports Chapter 12 of the EIA Report and provides details of the following:

- the assessment of impacts arising from dust emitted by construction activities associated with the proposed Scheme, in accordance with the guidance developed by the Institute of Air Quality Management (IAQM, 2016). This section (Section 2) sets out a description of the methodology, the assessment itself and relevant input data, recommended mitigation and monitoring measures and conclusions.
- baseline air quality data which supplements the baseline air quality data provided in Chapter 12 of the EIA Report (Section 3).
- the calculation of the greenhouse gas (GHG) emissions associated with the construction and operation of the Scheme. This section (Section 4) sets out a brief description of the methodology and relevant input data, including relevant assumptions and limitations.

It should be noted that at the time of undertaking the construction dust 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 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 the criteria used to define 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, however, 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, and therefore the assessment remains valid, as it considers human and ecological receptors within a larger study area and assigns dust emission magnitudes based on lower threshold values. The recommended mitigation measures (see Section 2.2.4) considers both versions of the IAQM construction dust guidance.

2. Construction Dust Assessment

2.1 Assessment Methodology

2.1.1 Outline of Method

The methodology for the assessment of the construction impacts is based on a five-step approach as set out in Figure 2-1.

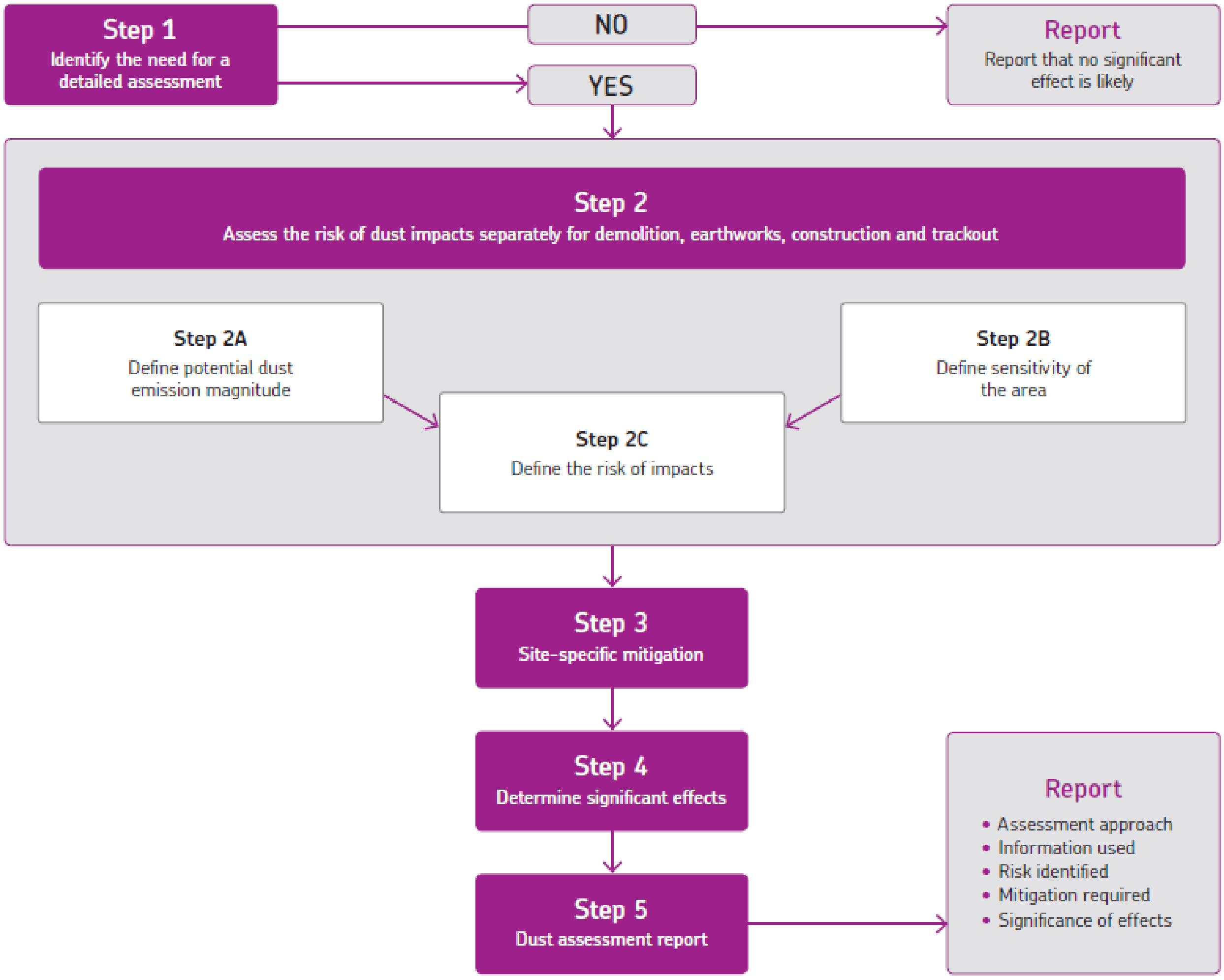

Figure 2-1 Methodology for Assessing Construction Impacts (IAQM, 2016)

2.1.2 Step 1: Identify the Need for a Detailed Assessment

An assessment would normally be required where there is:

- a human receptor within 350 m of the proposed Scheme 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/or
- an ecological receptor within 50 m of the proposed Scheme 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 site exit(s).

A human receptor refers to any location where a person or property may experience the adverse effects of airborne dust or dust-soiling, or exposure to particulate matter (PM_{10}) (i.e. particulate matter with a diameter of 10 micrometres or less), over a period relevant to the Air Quality Objectives (AQOs) (Defra, 2007). Although $PM_{2.5}$ (i.e. particulate matter with a diameter of 2.5 micrometres or less) is not specifically included as a parameter within the assessment, the risk levels associated with PM_{10} and any subsequent mitigation measures would also apply to $PM_{2.5}$, as $PM_{2.5}$ is included within the PM_{10} fraction.

An ecological receptor refers to any sensitive habitat affected by dust soiling. For locations with a statutory national or international designation, such as a Site of Specific Scientific Interest (SSSI), Special Area of Conservation (SACs) and Special Protection Areas (SPAs), or locally designated sites such as Local Nature Reserves, consideration should be given as to whether the particular site is sensitive to dust.

Where the need for a more detailed assessment is screened out (e.g. where there are no human or ecological receptors within the specified distances detailed above), it can be concluded that the level of risk is 'negligible' and any effects would be 'not significant'.

2.1.3 Step 2: Assess the Risk of Dust Impacts

A site is allocated to a risk category based on the scale and nature of the works (Step 2A) and the sensitivity of the area to dust impacts (Step 2B). These two factors are combined in Step 2C to determine the risk of dust impacts before the implementation of mitigation measures. Risks are described in terms of there being a low, medium or high risk of dust impacts for each of four separate potentially dust emitting activities (demolition, construction, earthworks and trackout[1]). Site-specific mitigation would be required, proportionate to the level of risk identified.

Step 2A: Define the Potential Dust Emission Magnitude

The potential dust emission magnitude is based on the scale of the anticipated works and is classified as small, medium or large. Table 2-1 presents the dust emission criteria outlined for each construction activity.

Table 2-1 Potential Dust Emission Magnitude Criteria

Construction activity	Large	Medium	Small
Demolition	Total building volume >50,000 m^3, potentially dusty construction material (e.g. concrete), on-site crushing and screening, demolition activities >20 m above ground level.	Total building volume 20,000 m^3 – 50,000 m^3, potentially dusty construction material, demolition activities 10-20 m above ground level.	Total building volume <20,000 m^3, construction material with low potential for dust release (e.g. metal cladding or timber), demolition activities <10 m above ground, demolition during wetter months.
Earthworks	Total site area >10,000 m^2, potentially dusty soil type (e.g. clay, which will be prone to suspension when dry due to small particle size), >10 heavy earth moving vehicles active at any one time, formation of bunds >8 m in height, total material moved >100,000 tonnes.	Total site area 2,500 m^2 – 10,000 m^2, moderately dusty soil type (e.g. silt), 5-10 heavy earth moving vehicles active at any one time, formation of bunds 4 m – 8 m in height, total material moved 20,000 tonnes – 100,000 tonnes.	Total site area <2,500 m^2, oil type with large grain size (e.g. sand), <5 heavy earth moving vehicles active at any one time, formation of bunds <4 m in height, total material moved <20,000 tonnes, earthworks during wetter month.
Construction	Total building volume >100,000 m^3, on site concrete batching, sandblasting.	Total building volume 25,000 m^3 – 100,000 m^3, potentially dusty construction material (e.g. concrete), on site concrete batching.	Total building volume <25,000 m^3, construction material with low potential for dust release (e.g. metal cladding or timber).
Trackout	>50 HDV (>3.5 t) outward movements[1] in any one day[2], potentially dusty surface material (e.g. high clay content), unpaved road length >100 m.	10-50 HDV (>3.5 t) outward movements[1] in any one day[2], moderately dusty surface material (e.g. high clay content), unpaved road length 50 m – 100 m.	<10 HDV (3.5 t) outward movements[1] in any one day[2], surface material with low potential for dust release, unpaved road length <50 m.

1 A vehicle movement is a one-way journey, i.e. from A to B and excludes the return journey.
2 HDV movements during a construction project vary over its lifetime, and the number of movements is the maximum not the average.

Step 2B Define the Sensitivity of the Area

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.

The sensitivity of the area is described as low, medium and high and takes a number of factors into account:

- the specific sensitivities of receptors in the area;
- the proximity and number of those receptors;
- the local background PM_{10} concentrations; and
- site-specific factors, such as whether there are natural shelters, such as trees, to reduce the risk of wind-blown dust.

Table 2-2 presents indicative examples of classification groups for the varying sensitivities of people to dust soiling effects, to the health effects of PM_{10} and the sensitivities of receptors to ecological effects. A judgement is made at the site-specific level where sensitivities may be higher or lower, for example a soft fruit business may be more sensitive to soiling than an alternative industry, such as coal mining, in the same location. Box 6, Box 7 and Box 8 within the IAQM guidance (IAQM, 2016) outline more detailed guidance for defining sensitivity.

Table 2-2 Indicative Examples of the Sensitivity of Different Types of Receptors

Sensitivity of receptor	Sensitivities of people and ecological receptors		
	Dust soiling effects[1]	Health effects of PM_{10} [2]	Ecological effects [3]
High	Dwellings, museums and other culturally important collections, medium and long-term car parks and car showrooms.	Residential properties, hospitals, schools and residential care homes.	Locations with an international or national designation and the designated features may be affected by dust soiling (e.g. SAC/SPA/Ramsar). Locations where there is a community of a particularly dust sensitive species such as vascular plant species included in the Red Data list for Great Britain.
Medium	Parks, places of work.	Office and shop workers not occupationally exposed to PM_{10}.	Locations where there is a particularly important plant species, where dust sensitivity is uncertain or unknown. Locations with a national designation where the features may be affected by dust deposition (e.g. SSSIs).
Low	Playing fields, farmland, footpaths, short-term car parks and roads.	Public footpaths, playing fields, parks and shopping streets.	Locations with a local designation where the features may be affected by dust deposition (e.g. LNR).

1 People's expectations would vary depending on the existing dust deposition in the area.

2 This follows the Department for Environment, Food and Rural Affairs (Defra *et al*, 2022) guidance as set out in Local Air Quality Management Technical Guidance (LAQM.TG (22)). Notwithstanding the fact that the air quality objectives and limit values do not apply to people in the workplace, such people can be affected to exposure of PM_{10}. However, they are considered to be less sensitive than the general public as a whole because those most sensitive to the effects of air pollution, such as young children are not normally workers. For this reason, workers have been included in the medium sensitivity category.

3 Only if there are habitats that might be sensitive to dust. A Habitat Regulation Assessment of the site may be required as part of the planning process if the site lies close to an internationally designated site i.e. SACs and SPAs designated under the Habitats Directive (92/43/EEC) (European Union, 1992); and Ramsar sites.

The IAQM guidance advises consideration of the risk associated with the nearest receptors to each phase of work. Where there are multiple receptors in a single location, a worst-case representative receptor is considered and the highest risk applicable is allocated.

The receptor sensitivity and distance are then used to determine the potential dust risk for each dust effect for each construction activity as shown in Table 2-3, Table 2-4 and Table 2-5.

It should be noted IAQM guidance recommends that the receptor distance is based on the distance from the source rather than the site boundary. This assessment was undertaken on the basis that all activities (i.e. demolition, earthworks, construction and trackout) take place at the construction boundary of each section. This represents a conservative assumption, as in practice most activities would not take place at the site boundary, thus increasing the distance between the source and the receptor.

For trackout, the distances should be measured from the side of the roads used by construction traffic. Without site specific mitigation, IAQM guidance suggests trackout may occur from roads up to 500 m from large sites, 200 m from medium sized sites and 50 m from small sites, as measured from the site exit. The impact declines with distance from the site, and it is only necessary to consider trackout impacts up to 50 m from the edge of the road.

Table 2-3 Sensitivity of the Area to Dust Soiling Effects on People and Property[1]

Receptor sensitivity	Number of receptors	Distance from the source (m)			
		<20	<50	<100	<350
High	>100	High	High	Medium	Low
	10-100	High	Medium	Low	Low
	1-10	Medium	Low	Low	Low
Medium	>1	Medium	Low	Low	Low
Low	>1	Low	Low	Low	Low

1 Estimate the total number of receptors within the stated distance. Only the highest level of area sensitivity from the table needs to be considered. For example, if there are seven high sensitivity receptors <20 m from the source and 95 high sensitivity receptors between 20 and 50 m away, then the total of number of receptors <50 m is 102. The sensitivity of the area in this case would be high.

Table 2-4 Sensitivity of the Area to Human Health Impacts

Receptor sensitivity	Annual mean PM_{10} concentration (Scotland)[2]	Number of receptors[1,3]	Distance from the source (m)				
			<20	<50	<100	<200	<350
High	>18 µg/m³	>100	High	High	High	Medium	Low
		10-100	High	High	Medium	Low	Low
		1-10	High	Medium	Low	Low	Low
	16-18 µg/m³	>100	High	High	Medium	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	High	Medium	Low	Low	Low
	14-16 µg/m³	>100	High	Medium	Low	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	Medium	Low	Low	Low	Low
	<14 µg/m³	>100	Medium	Low	Low	Low	Low
		10-100	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
Medium	>18 µg/m³	>10	High	Medium	Low	Low	Low
		1-10	Medium	Low	Low	Low	Low
	16-18 µg/m³	>10	Medium	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
	14-16 µg/m³	>10	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
	<14 µg/m³	>10	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
Low	-	≥1	Low	Low	Low	Low	Low

1 Estimate the total number of receptors within the stated distance (e.g. the total within 350 m and not the number between 200 and 350m), noting that only the highest level of area sensitivity from the table needs to be considered. For example, if there are 7 high sensitivity receptors <20 m of the source and 95 high sensitivity receptors between 20 and 50 m, then the total of number of receptors <50 m is 102. If the annual mean PM_{10} concentration is 29 µg/m³, the sensitivity of the area would be high.
2 Most straightforwardly taken from the national background maps but should also take account of local sources. In Scotland, the annual mean AQO is 18 µg/m³.
3 In the case of high sensitivity receptors with high occupancy (such as schools or hospitals) approximate the number of people likely to be present. In the case of residential dwellings, just include the number of properties.

Table 2-5 Sensitivity of the Area to Ecological Impacts

Receptor sensitivity[1]	Distance from the source (m)	
	<20	<50
High	High	Medium
Medium	Medium	Low
Low	Low	Low

1 Only the highest level of area sensitivity from the table needs to be considered.

Step 2C Define the Risk of Impacts

The dust emission magnitude is then combined with the sensitivity of the area to determine the overall risk of impacts with no mitigation measures applied. The matrices in Table 2-6 provide a method of assigning the level of risk for each activity. These can then be used to determine the level of mitigation that is required.

Table 2-6 Risks of Dust Impacts

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

2.1.4 Step 3 Site Specific Mitigation

During the construction phase, it would be important to control dust levels for High, Medium and Low risk construction activities. In order to avoid significant impacts from dust during activities associated with the construction of the Scheme, suitable mitigation measures should be adopted. Following the identification of the overall risk category for the demolition, earthworks, construction and trackout activities based on Table 2-6, appropriate mitigation measures can be identified for the Scheme works.

Activities identified as a High risk would require a greater level of mitigation than those identified as Low risk.

A selection of these measures has been specified for Low risk to High risk sites in the IAQM guidance as measures suitable to mitigate dust emissions from activities such as those that would be undertaken during the Scheme works.

2.1.5 Step 4 Determine Significant Effects

Following Step 2 (definition of the proposed scheme and the surroundings and identification of the risk of dust effects occurring for each activity), and Step 3 (identification of appropriate site-specific mitigation), the significance of the potential dust effects can be determined. The recommended mitigation measures should normally be sufficient to reduce construction dust impacts to a not significant effect.

The approach in Step 4 of IAQM dust assessment guidance has been adopted to determine the significance of effects regarding dust emissions. The guidance states the following:

"For almost all construction activity, the aim should be to prevent significant effects on receptors through the use of effective mitigation. Experience shows that this is normally possible. Hence the residual effect will normally be 'not significant."

IAQM guidance also states that:

"Even with a rigorous DMP [Dust Management Plan] in place, it is not possible to guarantee that the dust mitigation measures will be effective all the time, and 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 this would not normally be considered sufficient to change the conclusion that, with mitigation, the effects will be 'not significant'."

Step 4 of IAQM guidance recognises that the key to the above approach is that it assumes that the regulators ensure that the proposed mitigation measures are implemented. The management plan would include the necessary systems and procedures to facilitate on-going checking by the regulators to ensure that mitigation is being delivered, and that it is effective in reducing any residual effect to 'not significant' in line with the guidance.

2.2 Assessment

2.2.1 Step 1 Identify the need for a Detailed Assessment

The first step is Step 1, where the need for a detailed assessment is determined based on the location of human and / or ecological receptors within the distances specified in Table 2-3. The study areas for this assessment have been split into six Flood Cells across the study area, in accordance with construction boundaries. Although works in more than one Flood Cell may occur simultaneously, given the size and geographical spread/separation of many of the Flood Cells, determining the risk on a Flood Cell by Flood Cell basis is considered to represent an appropriate approach. The combined dust risks would not be considerably higher than those for the individual flood cells and a conservative approach has been adopted to assign the overall risk for the scheme for the purposes of identifying the required level of mitigation (as discussed in Step 2C of the assessment).

Flood Cell 1 – Upper Carron

Human Receptors

There are human receptors within 350 m of the construction site boundary, therefore further assessment is required. An approximate count of relevant human receptors within the various distance bands from the construction site boundary was carried out as recommended in IAQM guidance, the results of which are set out in Table 2-7. IAQM guidance also recommends an approximate trackout count is undertaken (i.e. those receptors within 50 m of the route(s) used by construction vehicles on the public highway, up to 500 m from the site exit(s)). The assessment has demonstrated that there are human receptors (i.e. residential properties or commercial premises etc.) within 50 m of the local road network up to 500 m from the site exit during the Scheme works.

Table 2-7 Dust Soiling and Human Health Receptor Count – Flood Cell 1

Receptor Count		
Demolition, Earthworks & Construction		**High sensitivity receptors**
Distance from the construction site boundary	<20 m	10-100
	<50 m	>100
	<100 m	>100
	<350 m	>100
Trackout		**High sensitivity receptors**
Distance from roads up to 500 m from the site exit	<20 m	10-100
	<50 m	10-100

Ecological Receptors

There were no ecological sites within 50 m of the Flood Cell 1 construction site boundary or within 50 m of the route used by construction vehicles on the public highway up to 500 m from the site exit(s). Therefore, the dust impacts on ecological receptors was not required to be considered further in the assessment for Flood Cell 1. The nearest ecological receptor is Carron Dams SSSI, approximately 320 m west of the Flood Cell 1 construction site boundary.

Flood Cell 2 – Lower Carron

Human Receptors

There are human receptors within 350 m of the construction site boundary, therefore further assessment is required. The results of the receptor count are set out in Table 2-8. The trackout assessment has demonstrated that there are human receptors within 50 m of the local road network up to 500 m from the site exit(s) during the Scheme works.

It should be noted that there are between 1 – 10 high sensitivity receptors (i.e. dwellings) within 50 m of the construction site boundary, which would normally result in a low sensitivity of the area (see Table 2-3) being assigned for dust soiling impacts. However, the presence of industrial / commercial premises (considered a medium sensitivity receptor) within 20 m of the construction site boundary, and in some instances within the construction site boundary, means the sensitivity to the area is considered medium (see Table 2-14) for dust soiling impacts.

Table 2-8 Dust Soiling and Human Health Receptor Count – Flood Cell 2

Receptor Count		
Demolition, Earthworks & Construction		**High sensitivity receptors**
Distance from the construction site boundary	<20 m	0
	<50 m	1-10
	<100 m	10-100
	<350 m	10-100
Trackout		**High sensitivity receptors**

Receptor Count		
Demolition, Earthworks & Construction		**High sensitivity receptors**
Distance from roads up to 500m from the site exit	<20 m	10-100
	<50 m	10-100

Ecological Receptors

There were no ecological sites within 50 m of the Flood Cell 2 construction site boundary or within 50 m of the route used by construction vehicles on the public highway up to 500 m from the site exit(s). Therefore, the dust impacts on ecological receptors was not required to be considered further in the assessment for Flood Cell 2. The nearest ecological receptor is the Firth of Forth SSSI, Ramsar and SPA approximately 900 m north of the construction site boundary.

Flood Cell 3 – Port of Grangemouth

Human Receptors

There are human receptors within 350 m of the construction site boundary, therefore further assessment is required. The results of the receptor count are set out in Table 2-9. The trackout assessment has demonstrated that there are human receptors within 50 m of the local road network up to 500 m from the site exit(s) during the Scheme works.

It should be noted that there are between 10 – 100 high sensitivity receptors (i.e. dwellings) within 100 m of the construction site boundary, which would normally result in a low sensitivity of the area (see Table 2-3) being assigned for dust soiling impacts. However, the presence of industrial / commercial premises (considered a medium sensitivity receptor) within 20 m of the construction site boundary, and in some instances within the construction site boundary, means the sensitivity to the area is considered medium (see Table 2-14) for dust soiling impacts.

Table 2-9 Dust Soiling and Human Health Receptor Count – Flood Cell 3

Receptor Count		
Demolition, Earthworks & Construction		**High sensitivity receptors**
Distance from the construction site boundary	<20 m	0
	<50 m	0
	<100 m	10-100
	<350 m	10-100
Trackout		**High sensitivity receptors**
Distance from roads up to 500 m from the site exit	<20 m	0
	<50 m	1-10

Ecological Receptors

The effect of construction dust on ecological sites has also been considered as the construction site boundary of Flood Cell 3 is located on the boundary of the Firth of Forth SSSI, Ramsar and SPA. Therefore, the Firth of Forth SSSI, Ramsar and SPA has been included in the assessment. As recommended by the IAQM guidance (IAQM, 2016), as the site is within 20 m of the construction site boundary, the Firth of Forth SSSI, Ramsar and SPA has been designated as high sensitivity to ecological impacts (based on the conservative assumption that the international / national designated site contains features which are sensitive to dust).

Flood Cell 4 – Grange Burn

Human Receptors

There are human receptors within 350 m of the construction site boundary, therefore further assessment is required. The results of the receptor count are set out in Table 2-10. The trackout assessment has demonstrated that there are human receptors within 50 m of the local road network up to 500 m from the site exit(s) during the scheme works.

Table 2-10 Dust Soiling and Human Health Receptor Count – Flood Cell 4

Receptor Count		
Demolition, Earthworks & Construction		**High sensitivity receptors**
Distance from the construction site boundary	<20 m	>100
	<50 m	>100
	<100 m	>100
	<350 m	>100
Trackout		**High sensitivity receptors**
Distance from roads up to 500 m from the site exit	<20 m	10-100
	<50 m	10-100

Ecological Receptors

The effect of construction dust on the ecological sites has also been considered. The construction site boundary is located approximately 10 m south-southwest of the Firth of Forth SSSI, Ramsar and SPA. Therefore, the Firth of Forth SSSI, Ramsar and SPA has been included in the assessment. As recommended by the IAQM guidance (IAQM, 2016), as the site is within 20 m, the Firth of Forth SSSI, Ramsar and SPA has been designated as high sensitivity to ecological impacts (based on the conservative assumption that the international / national designated site contains features which are sensitive to dust).

Flood Cell 5 – River Avon

Human Receptors

There are human receptors within 350 m of the construction site boundary, therefore further assessment is required. The results of the receptor count are set out in Table 2-11. The trackout assessment has demonstrated that there are human receptors within 50 m of the local road network up to 500 m from the site exit(s) during the Scheme works.

It should be noted that there are between 1 – 10 high sensitivity receptors (i.e. dwellings) within 50 m of the construction site boundary, which would normally result in a low sensitivity of the area (see Table 2-3) being assigned for dust soiling impacts. However, the presence of industrial / commercial premises (considered a medium sensitivity receptor) within 20 m of the construction site boundary, and in some instances within the construction site boundary, means the sensitivity to the area is considered medium (see Table 2-14) for dust soiling impacts.

Table 2-11 Dust Soiling and Human Health Receptor Count – Flood Cell 5

Receptor Count		
Demolition, Earthworks & Construction		**High sensitivity receptors**
Distance from the construction site boundary	<20 m	0
	<50 m	1-10
	<100 m	1-10
	<350 m	10-100
Trackout		**High sensitivity receptors**
Distance from roads up to 500 m from the site exit	<20 m	1-10
	<50 m	1-10

Ecological Receptors

The effect of construction dust on ecological sites has also been considered. The construction site boundary is adjacent to the Firth of Forth SSSI, Ramsar and SPA. Therefore, the Firth of Forth SSSI, Ramsar and SPA has been included in the assessment. As recommended by the IAQM guidance (IAQM, 2016), the Firth of Forth SSSI, Ramsar and SPA has been designated as high sensitivity to ecological impacts (based on the conservative assumption that the international / national designated sites contain features which are sensitive to dust).

Flood Cell 6 – Estuary Frontage

Human Receptors

There are human receptors within 350 m of the construction site boundary therefore further assessment is required. The results of the receptor count are set out in Table 2-12. The trackout assessment has demonstrated that there are no high sensitivity human receptors (i.e. dwellings) within 50 m of the local road network up to 500 m from the site exit during the Scheme works. However, the Tank Farm bus stop (considered a low sensitivity receptor) on the A904 (Grangemouth Road) has been included in the assessment.

It should be noted that there are between 1 – 10 high sensitivity receptors (i.e. dwellings) within 350 m of the construction site boundary, which would normally result in a low sensitivity of the area (see Table 2-3) being assigned for dust soiling impacts. However, the presence of industrial / commercial premises (considered a medium sensitivity receptor) within 20 m of the construction site boundary means the sensitivity to the area is considered medium (see Table 2-14) for dust soiling impacts.

Table 2-12 Dust Soiling and Human Health Receptor Count – Flood Cell 6

Receptor Count		
Demolition, Earthworks & Construction		**High sensitivity receptors**
Distance from the construction site boundary	<20 m	0
	<50 m	0
	<100 m	0
	<350 m	1-10
Trackout		**High sensitivity receptors**
Distance from roads up to 500 m from the site exit	<20 m	0
	<50 m	0

Ecological Receptors

The effect of construction dust on the ecological sites has also been considered. The proposed construction site boundary is located along the boundary of the Firth of Forth SSSI, Ramsar and SPA in parts and approximately 20 m south in other areas. Therefore, the Firth of Forth SSSI, Ramsar and SPA has been included in the assessment. As recommended by the IAQM guidance (IAQM, 2016), the Firth of Forth SSSI, Ramsar and SPA has been designated as high sensitivity to ecological impacts (based on the conservative assumption that the international / national designated site contains features which are sensitive to dust).

2.2.2 Step 2 Assess the Risk of the Dust Impacts

Step 2A Define the Potential Dust Emission Magnitude

The activities associated with the construction of the Scheme would be split into several stages, which could potentially involve different periods of demolition, earthworks, construction and trackout, and activity levels that would not necessarily peak simultaneously. As a worse-case approach, the temporal aspect of the works has not been taken into account and it has been assumed that all different types of activities associated with the construction of the scheme would occur at the same time.

The dust emission magnitudes of each activity have been specified using the definitions of dust emissions magnitudes in Section 2.1.3 and using professional judgement, in line with IAQM guidance.

Flood Cell 1 – Upper Carron

Demolition: The total demolition volume anticipated for Flood Cell 1 is likely to be less than 20,000 m^3 and the height of demolition activity above ground level is assumed to be less than 10 m. Although the construction material may be potentially dusty (e.g. concrete), the minimal demolition activities anticipated means the dust emission magnitude for demolition is classed as 'Small'.

Earthworks: Earthworks activities include site clearance and formation of an embankment at Carron Bridges (work area 1-2) and Chapel Burn (work area 1-3). Further earthworks activities include excavation to facilitate construction of the sheet pile wall and replacement bridge (on the B902) and extending an existing culvert. The anticipated total material moved within Flood Cell 1 is estimated to be between 20,000 and 100,000 tonnes. The total site area for Flood Cell 1 is over 10,000 m^2 and may comprise a potentially dusty soil type. It is assumed that there will be >10 earth moving vehicles active and the height of bunds will be between 4-8 m. This scenario for bunds has been adopted due to embankments being constructed. Based on the anticipated total material moved, the dust emission magnitude for earthworks is classed as 'Medium'.

Construction: Construction activities include the sheet pile wall, the replacement bridge and culvert extension. The total construction volume for Flood Cell 1 is anticipated to be less than 25,000 m^3 and there is not likely to be on-site batching or sand blasting activities. Due to the work areas being on or close to water, temporary dams or crossing points and bridges may need to be constructed for works to take place. Although there may be potentially dusty construction materials (i.e. concrete) utilised, the minimal construction activities anticipated means the dust emission magnitude for construction is classed as 'Small'.

Trackout: During the construction phase, the maximum number of daily outward movements of HDVs is likely to be between 10-50 in any one day. Therefore, on this basis, the assessment for trackout is based on a dust emission class of 'Medium'.

Flood Cell 2 – Lower Carron

Demolition: The total demolition volume anticipated for Flood Cell 2 is likely to be less than 20,000 m^3 and the height of demolition activity above ground level is assumed to be less than 10 m. Although the construction material may be potentially dusty (e.g. concrete), the minimal demolition activities anticipated means the dust emission magnitude for demolition is classed as 'Small'.

Earthworks: Earthworks activities include site clearance and formation of an embankment at Forth and Clyde canal lock (work area 2-1). Further earthworks activities include excavation and placement of materials to facilitate construction of the sheet pile wall (approximately 1,100 m in length). The anticipated total material moved within Flood Cell 2 is estimated to be less than 20,000 tonnes. The total site area for Flood Cell 2 is over 10,000 m^2 and may comprise a potentially dusty soil type. It is assumed that there will be >10 earth moving vehicles active and the height of bunds will be between 4-8 m. This scenario for bunds has been adopted due to embankments being constructed. Based on the anticipated total material moved, the dust emission magnitude for earthworks is classed as 'Small'.

Construction: Construction activities include the sheet pile wall (approximately 1,100 m in length) and the total construction volume for Flood Cell 2 is anticipated to be less than 25,000 m^3. There is not anticipated to be on-site batching or sand blasting activities. Due to the work areas being on or close to water, temporary dams or crossing points and bridges may need to be constructed for works to take place. Although there may be potentially dusty construction materials (i.e. concrete) utilised, the minimal construction activities anticipated means the dust emission magnitude for construction is classed as 'Small'.

Trackout: During the construction phase, the maximum number of daily outward movements of HDVs is likely to be between 10-50 in any one day. Therefore, on this basis, the assessment for trackout is based on a dust emission class of 'Medium'.

Flood Cell 3 - Port of Grangemouth

Demolition: The total demolition volume anticipated for Flood Cell 3 is likely to be less than 20,000 m^3 and the height of demolition activity above ground level is assumed to be less than 10 m. Although the construction material may be potentially dusty (e.g. concrete), the minimal demolition activities anticipated means the dust emission magnitude for demolition is classed as 'Small'.

Earthworks: Earthworks activities include site clearance and excavation to facilitate construction of the sheet pile wall and revetment, which requires ground improvements below ground level. The anticipated total material moved within Flood Cell 3 is estimated to be between 20,000 tonnes and 100,000 tonnes. The total site area is over 10,000 m^2 and may comprise a potentially dusty soil type. It is assumed that there will be >10 earth moving vehicles active and the height of bunds will be between 4-8 m. This scenario for bunds has been adopted due to embankments being constructed. Based on the anticipated total material moved, the dust emission magnitude for earthworks is classed as 'Medium'.

Construction: Construction activities include the sheet pile wall and revetment (totalling approximately 4,700 m in length). The total construction volume for Flood Cell 3 is estimated to be between 25,000 m^3 and 100,000m^3 and potentially dusty construction materials (i.e. concrete) may be utilised. There is not likely to be on-site batching or sand blasting activities. Due to the work areas being on or close to water, temporary dams or crossing points and bridges may need to be constructed for works to take place. Based on the anticipated total material moved, the dust emission magnitude for construction is classed as 'Medium'.

Trackout: During the construction phase, the maximum number of daily outward movements of HDVs is likely to be between 10-50 in any one day. Therefore, on this basis the assessment for trackout is based on a dust emission class of 'Medium'.

Flood Cell 4: Grangemouth

Demolition: The total demolition volume anticipated for Flood Cell 4 is likely to be less than 20,000 m^3 and the height of demolition activity above ground level is assumed to be less than 10 m. Although the construction material may be potentially dusty (e.g. concrete), the minimal demolition activities anticipated means the dust emission magnitude for demolition is classed as 'Small'.

Earthworks: Earthworks activities include site clearance, regrading an existing embankment at FRC – Wholeflats Road (work area 4-4) and formation of an embankment at GB-Zetland Park (work area 4-5) and at the mouth of the Grange Burn (work area 4-9). Further earthworks activities include excavation to facilitate construction of the sheet pile wall and replacement bridge (on Dalratho Road). The anticipated total material moved within Flood Cell 4 is estimated to be between 20,000 tonnes and 100,000 tonnes. The total site area for Flood Cell 4 is over 10,000 m^2 and may comprise a potentially dusty soil type. It is assumed that there will be >10 earth moving vehicles active and the height of bunds will be between 4-8 m. This scenario for bunds has been adopted due to embankments being constructed. Based on the anticipated total material moved, the dust emission magnitude for earthworks is classed as 'Medium'.

Construction: Construction activities include the sheet pile wall and a replacement bridge on Dalratho Road. The total construction volume for Flood Cell 4 is estimated to be less than 25,000 m^3 and there is not likely to be on-site batching or sand blasting activities. Due to the work areas being on or close to water, temporary dams or crossing points and bridges may need to be constructed for works to take place. Although there may be potentially dusty construction materials (i.e. concrete) utilised, the minimal construction activities anticipated means the dust emission magnitude for construction is classed as 'Small'.

Trackout: During the construction phase, the maximum number of daily outward movements of HDVs is likely to be between 10-50 in any one day. Therefore, on this basis the assessment for trackout is based on a dust emission class of 'Medium'.

Flood Cell 5: River Avon

Demolition: The total demolition volume anticipated for Flood Cell 5 is likely to be less than 20,000 m^3 and the height of demolition activity above ground level is assumed to be less than 10 m. Although the construction material may be potentially dusty (e.g. concrete), the minimal demolition activities anticipated means the dust emission magnitude for demolition is classed as 'Small'.

Earthworks: Earthworks activities include site clearance and excavation to facilitate construction of the sheet pile wall. Additional activities include formation of an embankment at Smiddy Brae and Avondale Road (work area 5-1), Flare Road (work area 5-2), Grangemouth Road (work area 5-3) and at the mouth of the River Avon (work area 5-4). The anticipated total material moved within Flood Cell 5 is estimated to be between 20,000 tonnes and 100,000 tonnes. The total site area is over 10,000 m^2 and may comprise a potentially dusty soil type. It is assumed that there will be >10 earth moving vehicles active and the height of bunds will be between 4-8 m. This scenario for bunds has been adopted due to embankments being constructed. Based on the anticipated total material moved, the dust emission magnitude for earthworks is classed as 'Medium'.

Construction: Construction activities include the sheet pile wall (approximately 4,000 m in length) and the total construction volume for Flood Cell 5 is anticipated to be less than 25,000 m^3 and there is not likely to be on-site batching or sand blasting activities. Due to the work areas being on or close to water, temporary dams or crossing points and bridges may need to be constructed for works to take place. Although there may be potentially dusty construction materials (i.e. concrete) utilised, the minimal construction activities anticipated means the dust emission magnitude for construction is classed as 'Small'.

Trackout: During the construction phase, the maximum number of daily outward movements of HDVs is likely to be between 10-50 in any one day. Therefore, on this basis the assessment for trackout is based on a dust emission class of 'Medium'.

Flood Cell 6: Estuary Frontage

Demolition: The total demolition volume anticipated for Flood Cell 6 is likely to be less than 20,000 m^3 and the height of demolition activity above ground level is assumed to be less than 10 m. Although the construction material may be potentially dusty (e.g. concrete), the minimal demolition activities anticipated means the dust emission magnitude for demolition is classed as 'Small'.

Earthworks: Earthworks activities include site clearance and excavation to facilitate construction of the sheet pile wall and revetment, which requires ground improvements below ground level. The anticipated total material moved within Flood Cell 6 is between 20,000 tonnes and 100,000 tonnes. The total site area is over 10,000 m^2 and may comprise a potentially dusty soil type. It is assumed that there will be >10 earth moving vehicles active and the height of bunds will be between 4-8 m. This scenario for bunds has been adopted due to embankments being constructed. Based on the anticipated total material moved, the dust emission magnitude for earthworks is classed as 'Medium'.

Construction: Construction activities include the sheet pile wall and revetment (totalling approximately 2,100 m in length). The total construction volume for Flood Cell 6 is anticipated to be less than 25,000 m^3 and potentially dusty construction materials (i.e. concrete) may be utilised. There is not likely to be on-site batching or sand blasting activities. Due to the work areas being on or close to water, temporary dams or crossing points and bridges may need to be constructed for works to take place. Based on the anticipated construction activities, the dust emission magnitude for construction is classed as 'Small'.

Trackout: During the construction phase, the maximum number of daily outward movements of HDVs is likely to be between 10-50 in any one day. Therefore, on this basis the assessment for trackout is based on a dust emission class of 'Medium'.

2.2.3 Summary of Dust Emission Magnitudes

Introduction

Table 2-13 presents a summary of the dust emission magnitude for each activity associated with the considered Flood Cells, based on the criteria set out above.

Table 2-13 Dust Emission Magnitudes for each Flood Cell

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

Step 2B Define the Sensitivity of the Area

The proposed construction site boundary of Flood Cell 1 is surrounded by high sensitivity receptors, which include residential properties and other high sensitivity receptors such as care homes. There are also medium sensitivity receptors such as hotels and low sensitivity receptors such as car parks and Falkirk Golf Course. In some directions, there are receptors within 10 m of the proposed construction site boundary.

The proposed construction site boundary of Flood Cell 2 is surrounded by high sensitivity receptors that include residential properties and also include medium and low sensitivity receptors such industrial and commercial premises and car parks, respectively. The nearest high sensitivity receptors are approximately30 m from the proposed construction site boundary.

The area surrounding the proposed construction site boundary of Flood Cell 3 is dominated by industrial and commercial premises, which would be considered medium or low sensitivity. The nearest industrial property is within 5 m of the construction site boundary. At Station Road, Grangemouth, there are high sensitivity receptors (i.e. dwellings) approximately 80 m from the proposed construction site boundary.

Human receptors in the vicinity of the proposed construction site boundary of Flood Cell 4 include residential properties, schools and care homes within Grangemouth. There are also some lower sensitivity receptors including sports centres, commercial properties, hotels and car parks. The nearest receptors are within 10 m from the proposed construction site boundary.

The proposed construction site boundary of Flood Cell 5 is surrounded by industrial premises and therefore receptors of medium to low sensitivity. However, there are some residential properties close to the road network which could be affected by trackout. The nearest receptors, which are residential properties, are approximately 50 m of from the proposed construction site boundary and trackout route.

The proposed construction site boundary of Flood Cell 6 is bordered by industrial buildings, which are considered medium to low sensitivity receptors. These receptors are approximately 20 m from the proposed construction site boundary.

Table 2-14 displays the sensitivities of the surrounding area to demolition, earthworks, construction and trackout based on the criteria set out in Table 2-3 and Table 2-4, numbers of receptors within certain distance bands of the respective Flood Cell construction boundary (see Table 2-7 to Table 2-12) and existing PM_{10} concentrations (i.e. less than 14 µg/m^3 (see Table 12-5, monitoring locations A8, A10 and A15 and the background map concentrations in Table 12-6 of Chapter 12 of the ES)).

Table 2-14 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]			
Flood Cell 3 – Port of Grangemouth	Dust Soiling	Medium	Medium	Medium	Medium
	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

Note 1: Ecological receptors not considered in the assessment

Table 2-14 shows that based on the number of receptors within proximity of the respective Flood Cell construction site boundary, the sensitivity of the area for dust soiling impacts is High for Flood Cells 1 and 4, Medium for Flood Cells 3 and 5, Medium to High for Flood Cell 2 and Low to Medium for Flood Cell 6. Based on the number of receptors in proximity to the respective Flood Cell and an applied background PM_{10} concentration of less than 14 µg/m^3 across the Scheme), the sensitivity of the area for human health impacts is categorised as Low for Flood Cells 1, 2, 3, 5 and 6 and Low to Medium for Flood Cell 4.

At the assessed Firth of Forth SSSI, Ramsar and SPA, the sensitivity of the area for ecological impacts is considered High for Flood Cells 3, 4, 5 and 6. As discussed previously, ecological receptors were not considered for Flood Cells 1 and 2 as the nearest ecological receptors were outside the study area.

Step 2C Define the Risk of Impacts

Using the dust emission magnitudes for various activities in Table 2-13 and the sensitivity of the area provided in Table 2-14, the definition of the risks of each activity within the respective Flood Cells is provided in Table 2-15 for dust soiling, human health and ecological impacts. Additionally, a maximum overall risk has been provided based on the highest risk for each potential impact determined at each Flood Cell. The maximum risk has been used to determine the level of mitigation required. This approach allows a more simplified and conservative approach to the identification, implementation and management of the dust mitigation measures.

Table 2-15 Dust Risk at Human and Ecological Receptors

Section	Potential impact	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[1]			
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[1]			
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[1]
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**

Note 1: Ecological receptors not considered in the assessment.

The results in Table 2-15 indicate that there is an overall maximum *Medium* risk for demolition, earthworks, construction and trackout activities.

Good practice mitigation measures would be needed to reduce the potential for dust emissions to potentially lead to significant dust effects in the vicinity of the construction areas of the Flood Cells. In relation to human health, these proposed mitigation measures would also prevent or reduce potential PM_{10} and / or $PM_{2.5}$ emissions which are associated with health effects. The suggested good practice mitigation measures which should be adopted for the construction areas of the Flood Cells are set out in Section 2.2.4.

2.2.4 Step 3 Site Specific Mitigation

The results in Table 2-15 indicate the works associated with the construction of the Scheme are a *Medium* risk (assigned for dust soiling, human health and ecological impacts).

As discussed previously, good practice mitigation measures would be needed to reduce the potential for dust emissions to potentially lead to significant dust effects in the vicinity of the proposed construction areas of the cells. The suggested good practice mitigation measures which should be adopted for the construction of the Scheme are set out below.

The mitigation measures have been derived from those specified in the IAQM construction dust guidance (IAQM, 2016; 2023) and where possible at this stage, adapted to the activities associated with the construction of the Scheme. Measures such as those specified in the guidance would normally be sufficient to reduce construction dust nuisance, risks to human health or effects on ecological sites to a 'Not Significant' effect. These measures are listed in Table 2-18 to Table 2-21 with a recommendation as to whether or not they should be applied based on the risk levels identified in the dust assessment (i.e. *Medium* risk for dust soiling, human health and ecological impacts). Some specific comments or observations have been added or amendments made to the text, where appropriate. Some of the mitigation measures listed within IAQM construction dust guidance (IAQM, 2016; 2023) for trackout (mitigation numbers 44, 46, 47 and 48) were considered to represent general on-site activities and operation of haul roads and were moved to the 'Operations' section (see Table 2-17) of the general mitigation measures required for all sites. The general mitigation measures were specified based on their highest risk category (i.e. *Medium* risk) as recommended by IAQM construction dust guidance (IAQM, 2016; 2023).

As specified above, the measures to control dust emissions taken forward from this assessment, derived from the highly recommended or desirable measures (see Table 2-18 to Table 2-21), and the monitoring of the effectiveness of the mitigation, would be included in an appropriate management plan such as a DMP. These would be delivered during construction.

When applying the mitigation measures, IAQM guidance states the following:

"The most important aspects of the Dust Management Plan are assigning responsibility for dust management to an individual member of staff of the principal contractor, training staff to understand the importance of the issue, and communicating with the local community. Good dust management practices implemented at high risk sites have resulted in no or minimal complaints, which illustrates the value of the recommended approach."

The mitigation measures set out in Table 2-18 to Table 2-21 do not specifically include assigning responsibility for dust management to a staff member or training staff on the importance of dust management and awareness of dust issues. However, these would be included within the proposed mitigation measures.

Table 2-16 Mitigation for all Sites: Communications

Mitigation Measure	Maximum Flood Cell 1-6
1. Develop and implement a stakeholder communications plan that includes community engagement before work commences on the site.	Highly recommended
2. Display the name and contact details of person(s) accountable for air quality and dust issues on the site boundary. This may be the environment manager/engineer or the site manager.	Highly recommended
3. Display the head or regional office contact information.	Highly recommended

Table 2-17 Mitigation for all Sites: Dust Management

Mitigation Measure	Maximum Flood Cell 1-6
4. Develop and implement a DMP, which may include measures to control other emissions, approved by Falkirk Council. The level of detail will depend on the risk, and should include, as a minimum, the highly recommended measures in this assessment. The desirable measures should be included as appropriate for the site.	Highly recommended
5. 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.	Highly recommended
6. Make the complaints log available to Falkirk Council when asked.	Highly recommended
7. 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 log book.	Highly recommended
8. Hold regular liaison meetings with other high-risk construction sites within 500 m of the site boundary to ensure plans are coordinated, and dust and particulate matter emissions are minimised. It is important to understand the interactions of the off-site transport/deliveries which might be using the same strategic road network routes.	Not required
9. 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 the local authority when asked. This should include regular dust soiling checks of surfaces for example checking of street furniture, cars and window sills around the site boundary with cleaning to be provided if necessary,	Desirable
10. 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.	Highly recommended
11. 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.	Highly recommended
12. 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. Further guidance is provided by IAQM on monitoring during demolition, earthworks and construction (IAQM, 2018).	Highly recommended
13. Plan site layout so that machinery and dust causing activities are located away from receptors, as far as is possible.	Highly recommended
14. Erect solid screens or barriers around dusty activities, or the site boundary, which are at least as high as any stockpiles on site.	Highly recommended
15. Fully enclose site or specific operations where there is a high potential for dust production and the site is active for an extensive period.	Highly recommended
16. Avoid site runoff of water or mud.	Highly recommended
17. Keep site fencing, barriers and scaffolding clean using wet methods.	Highly recommended
18. 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.	Highly recommended
19. Cover, seed or fence stockpiles to prevent wind whipping.	Highly recommended
21. Ensure all vehicles switch off engines when stationary – no idling vehicles.	Highly recommended
22. Avoid the use of diesel or petrol-powered generators and use mains electricity or battery powered equipment where practicable.	Highly recommended

Mitigation Measure	Maximum Flood Cell 1-6
23. 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 of Falkirk Council, where appropriate).	Desirable
24. Produce a Construction Logistics Plan to manage the sustainable delivery of goods and materials.	Not required
25. Implement a Travel Plan that supports and encourages sustainable travel (public transport, cycling, walking and car sharing).	Desirable
26. Where applicable, only use cutting, grinding or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as water sprays or local extraction, e.g. "suitable local exhaust ventilation systems".	Highly recommended
27. Ensure an adequate water supply on the site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate.	Highly recommended
28. Where applicable, use enclosed chutes and conveyors and covered skips.	Highly recommended
29. Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate.	Highly recommended
30. 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.	Highly recommended
44. Avoid dry sweeping of large areas.	Highly recommended
46. Inspect on-site haul routes for integrity and instigate any necessary repairs to the surface as soon as reasonably practicable.	Highly recommended
47. Record all inspections of haul routes and any subsequent action in a site log book.	Highly recommended
48. Install hard surfaced haul routes, which are regularly damped down with fixed or mobile sprinkler systems, or mobile water bowsers, and regularly cleaned.	Highly recommended
31. Avoid bonfires and burning of waste materials.	Highly recommended

Table 2-18 Mitigation Measures Specific to Demolition

Mitigation Measure	Maximum Flood Cell 1-6
32. 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
33. Ensure effective water suppression is used during demolition operations. Hand-held spays 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.	Highly recommended
34. Avoid explosive blasting, using appropriate manual or mechanical alternatives.	Highly recommended
35. Bag and remove any biological debris or damp down such material before demolition.	Highly recommended

Table 2-19 Mitigation Measures Specific to Earthworks

Mitigation Measure	Maximum Flood Cell 1-6
36. Re-vegetate earthworks and exposed areas/soil stockpiles to stabilise surfaces as soon as practicable.	Desirable
37. Use hessian fabric, mulches or tackifiers where it is not possible to re-vegetate or cover with topsoil, as soon as practicable.	Desirable
38. Only remove the cover in small areas during work and not all at once.	Desirable

Table 2-20 Mitigation Measures Specific to Construction

Mitigation Measure	Maximum Flood Cell 1-6
39. Avoid scabbling (roughening of concrete surfaces) if possible.	Desirable
40. 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.	Highly recommended
41. 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
42. For smaller supplies of fine powder materials, ensure bags are sealed after use and stored appropriately to prevent dust.	Desirable

Table 2-21 Mitigation Specific to Trackout

Mitigation Measure	Maximum Flood Cell 1-6
43. 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.	Highly recommended
45. Ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport.	Highly recommended
49. Implement a wheel washing system (with rumble grids to dislodge accumulated dust and mud) prior to leaving the site where reasonably practicable.	Highly recommended
50. 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.	Highly recommended
51. Access gates to be located at least 10 m from receptors where possible.	Highly recommended

2.2.5 Step 4 Determine Significant Effects

There are mitigation methods already available that have been successfully applied on other similar schemes to manage emissions of dust so that significant off-site effects have not occurred. Such measures are considered to be no more than normal good practice that would be adopted by any contractor meeting the requirements of the DMP.

It is considered that there are no potentially dust generating activities proposed that could not be managed using normal good practices (based on the mitigation specified above) so as to prevent significant effects at any off-site receptor, including those located within 20 m of the proposed construction site boundary of the Flood Cells.

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 2.2.4, 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**.

3. Supplementary Baseline Data

3.1 Nitrogen Dioxide Monitoring

In 2022, as part of the Local Air Quality Management (LAQM) process, Falkirk Council undertook ambient monitoring of nitrogen dioxide (NO_2) across its administrative area using a network of seven automatic monitors and 61 passive diffusion tubes. The 6 automatic monitors recording NO_2 and 56 of the NO_2 diffusion tube monitoring sites located in the Grangemouth Air Quality Management Area (AQMA), Falkirk Town Centre AQMA or within proximity to the Scheme are shown in Figure 12.1. Results of NO_2 monitoring undertaken at these sites between 2018 and 2022 are presented in Table 3-1 (Falkirk Council, 2023).

Table 3-1. Annual Mean NO_2 Monitoring Results 2018 – 2022

Monitor ID	Site Type	Annual Mean NO_2 Concentration (µg/m^3)				
		AQO – 40 µg/m^3				
		2018	2019	2020	2021	2022
A5	Automatic Monitor – roadside	21	20	14	16	14
A7	Automatic Monitor – roadside	39	38	27	31	27
A8	Automatic Monitor – urban background / industrial	14	15	11	13	14
A9	Automatic Monitor – urban background / industrial	17	15	12	14	12
A10	Automatic Monitor – urban background / industrial	18	17	12	13	14
A15	Automatic Monitor – roadside	22	25	20	20	19
NA3	Diffusion Tube – urban background	18	19	15	15	13
NA5	Diffusion Tube - roadside	24	27	19	19	18
NA7	Diffusion Tube – urban background	17	15	12	12	No data
NA9	Diffusion Tube - roadside	22	23	18	17	16
NA21	Diffusion Tube - roadside	28	26	21	20	18
NA24	Diffusion Tube - roadside	34	33	25	24	24
NA26	Diffusion Tube – urban background	20	18	13	14	12
NA27	Diffusion Tube - roadside	**44**	**47**	35	35	30
NA29	Diffusion Tube – urban background	18	17	13	12	12
NA38	Diffusion Tube – urban background	17	16	13	12	11
NA41	Diffusion Tube - roadside	22	23	19	17	16
NA42	Diffusion Tube – urban centre/industrial	19	19	15	14	13
NA44	Diffusion Tube – urban background	19	18	14	13	12
NA48	Diffusion Tube – urban background	18	19	15	16	13
NA50	Diffusion Tube – urban background	24	24	18	18	15
NA51	Diffusion Tube - roadside	24	24	18	17	17
NA52	Diffusion Tube - roadside	23	22	20	18	17
NA57	Diffusion Tube – urban background / industrial	21	No data	No data	No data	No data
NA58	Diffusion Tube - roadside	23	21	16	15	14
NA59	Diffusion Tube - roadside	28	29	23	22	21

Monitor ID	Site Type	Annual Mean NO_2 Concentration (µg/m³) AQO – 40 µg/m³				
		2018	2019	2020	2021	2022
NA60	Diffusion Tube - roadside	24	25	21	20	22
NA61	Diffusion Tube - roadside	24	23	19	18	16
NA62	Diffusion Tube - roadside	34	34	27	24	25
NA63	Diffusion Tube – urban background	35	34	27	27	24
NA64	Diffusion Tube - roadside	16	17	11	11	10
NA65	Diffusion Tube - roadside	24	24	19	18	15
NA67	Diffusion Tube – urban background	27	26	22	22	20
NA68	Diffusion Tube - roadside	25	No data	No data	No data	No data
NA69	Diffusion Tube - roadside	32	30	23	23	21
NA71	Diffusion Tube - roadside	31	30	25	24	22
NA72	Diffusion Tube - roadside	26	27	22	21	18
NA73	Diffusion Tube - roadside	31	31	24	23	21
NA76	Diffusion Tube - roadside	20	20	16	15	14
NA77	Diffusion Tube - roadside	22	23	18	17	16
NA78	Diffusion Tube - roadside	30	28	21	20	19
NA80	Diffusion Tube - roadside	28	30	25	20	20
NA81	Diffusion Tube - roadside	30	32	24	22	21
NA82	Diffusion Tube - roadside	19	18	15	13	13
NA83	Diffusion Tube - roadside	34	34	25	25	24
NA86	Diffusion Tube – urban background	16	16	12	11	10
NA89	Diffusion Tube - roadside	30	30	23	22	20
NA94	Diffusion Tube - roadside	31	30	24	22	21
NA98	Diffusion Tube – urban background	18	13	16	15	14
NA99	Diffusion Tube - roadside	25	25	20	18	18
NA101	Diffusion Tube - roadside	23	23	17	16	15
NA105	Diffusion Tube - rural	8	8	6	6	5
NA107	Diffusion Tube - roadside	27	30	23	19	17
NA114	Diffusion Tube - roadside	39	**41**	31	29	25
NA115	Diffusion Tube – urban background	18	19	13	13	11
NA116	Diffusion Tube – urban background / industrial	No data	20	15	15	14
NA117	Diffusion Tube – urban background / industrial	No data	20	15	14	12
NA118	Diffusion Tube - roadside	No data	23	18	17	15
NA119	Diffusion Tube – urban background	No data	22	18	17	15
NA120	Diffusion Tube – roadside / industrial	No data	No data	No data	No data	14
NA121	Diffusion Tube - roadside	No data	No data	No data	No data	19

Note: Bold denotes exceedance of the NO_2 annual mean AQO.

Table 3-1 indicates that the automatic and non-automatic monitoring data showed exceedances of the annual mean AQO for NO_2 at two locations, tube location NA27, West Bridge Street, Falkirk (44 µg/m³ and 47 µg/m³, in 2018 and 2019 respectively) and NA114, Glasgow Road, Camelon (41 µg/m³, 2019 only). NA27 is a roadside location within the Falkirk AQMA approximately 2 km to the south of the nearest Scheme Flood Cell (Flood Cell 1) and NA114 is a roadside location in Camelon approximately 0.5 km to the south of Flood Cell 1. Location NA27 is not representative of roadside NO_2 concentrations adjacent to roads which are close to the Scheme Flood Cells which could be used by construction traffic. It is possible that some construction traffic may travel on Glasgow Road in Camelon, close to location NA114, as this road is on the route from the Flood Cell 1 construction compound to a nearby motorway junction (junction 1of the M876). The measured concentrations in 2020, 2021 and 2022 at NA114 (and all other monitoring locations) were well within the AQO. However, measurements during 2020 and possibly 2021 are likely to have been influenced by the travel restrictions during the Covid-19 pandemic.

Measured concentrations at sites adjacent to or within the Scheme construction cells suggest that the annual mean NO_2 AQO (40 µg/m^3) is unlikely to be exceeded in the study area. For example, the highest concentration recorded in 2022 at any location (roadside or otherwise) close to or within the Scheme cells was 21 µg/m^3 (NA94, a roadside (A905) location within the Flood Cell 2 area).

3.2 Background Maps

Nitrogen oxides (NOx) and NO_2 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 website (Scottish Government, 2022) and are summarised in Table 3-2. As indicated, average background concentrations for 2018 are within the relevant AQOs (30 and 40 µg/m^3, respectively). 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 adopted whereby the 2018 concentrations have been adopted to represent the background conditions at the time of the construction activities.

Table 3-2 Scottish Government Background Pollutant Concentrations

Pollutant	2018 (Baseline)	
	Maximum Concentration at any 1km x 1km grid square (µg/m^3)	Average Concentration of 1km x 1km grid squares (µg/m^3)
NOx	27.8	17.6
NO_2	18.2	12.2

4. Greenhouse Gas Emissions Calculations

4.1 Introduction

Jacobs undertook greenhouse gas (GHG) quantification for the Scheme through the use of the Environment Agency's Carbon Calculator, version 6.0, in July 2023 (Environment Agency, 2022). The calculator allows for the various elements of the Scheme to be quantified in relation to the different life cycle stages.

PAS2080: Carbon Management in Buildings and Infrastructure (British Standards Institute, 2023) provides an overview of the various life cycle stages associated with a project. While PAS 2080 does not make direct reference to modules within the main document, the PAS 2080 guidance document (Institution of Civil Engineers, 2023) provides an example of lifecycle stages for a civil engineering works assessment, as demonstrated in Figure 4-1.

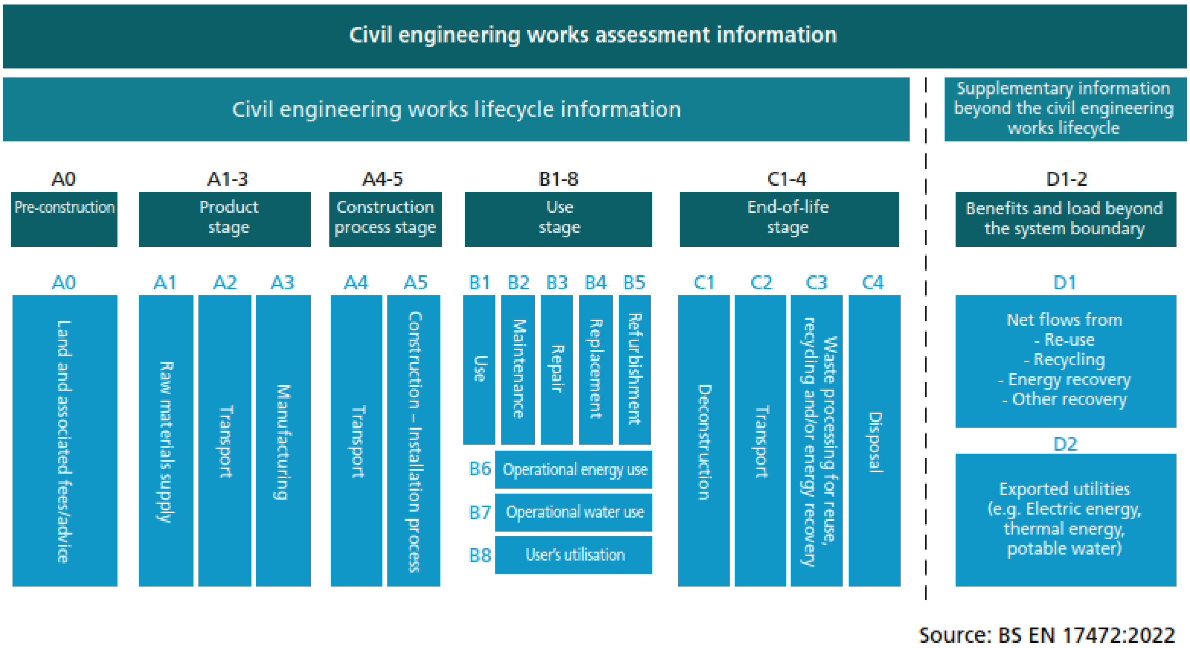

Figure 4-1 Modular approach showing the life cycle stages and individual modules for infrastructure GHG emissions quantification (as adapted from Figure 4.3 of PAS 2080 (2023) Guidance Document)

It should be noted that the modular approach was developed for Life Cycle Assessment (LCA) reporting (BS EN 17472:2022 - Sustainability of construction works. Sustainability assessment of civil engineering works. Calculation methods) whereas the PAS 2080 framework is for value chain members to collaboratively decarbonise projects by identifying emissions / removals within their control and influence. However, for the purposes of obtaining emissions associated with the scheme consistent with the Environment Agency Carbon Calculator, a modular approach has been applied.

GHG emissions for relevant life cycle modules (i.e. A1-5, B1-B5) for the Scheme have been estimated, based on knowledge at the time of writing. GHG emissions for life cycle modules C1-4 (i.e. the End of life stage) have not been estimated, however, as it is not anticipated this structure will be decommissioned within the reference study period of 100 years and may continue to operate, subject to ongoing maintenance and repair requirements.

Life cycle stage A0 has not been included within the tool as there is no relevant section for the GHG emissions to be calculated. These emissions are, however, considered likely to be negligible.

It should also be noted that life cycle modules B6 (operational energy use), B7 (operational water use), B8 (other operational processes) and B9 (user utilisation of infrastructure) have not been quantified due to limited information being available (B6, B7), or not being relevant for the Scheme (B8, B9).

Information relating to the current design (based on the outline design stage) formed the basis of the data inputs to the EA Carbon Calculator (a high-level Bill of Quantities (BoQ)). High level cost estimates were provided alongside this BoQ.

The relevant information from the BoQ and cost estimates was entered into the EA Carbon Calculator, based on the closest 'best-fit' asset description and unit of measure. Many cells within the Carbon Calculator are fixed (non-editable), and instead require pre-selection from drop-down menus. Adjacent cells are pre-populated based on the options selected.

Where an item did not have an exact match, a conservative approach was taken, based on design knowledge at the time and of the asset's components (e.g. 760 kW pump used rather than lower kW value). Agreement was sought with the design team where assets did not have an exact match in the EA Carbon Calculator.

A design life of 100 years was assumed for the Scheme and a reference study period of 100 years was also applied over which to quantify the GHG emissions.

It was assumed that the construction start date was 1 January 2025, and the end date for construction was 31 December 2033.

All emission factors associated with all assets, sub-assets and transport of materials are pre-populated within the EA Carbon Calculator, and as such, Jacobs has assumed that these are correct and appropriate within v6.0 of the EA Carbon Calculator.

It should be noted that any emerging GHG emissions quantification is based on knowledge at the time of writing. If any Scheme element were to change, this may subsequently change the calculated carbon emissions. This includes changes in sub-asset components (e.g., lowering the cement % within concrete), changes in the maintenance/replacement regime, changes in transport distances for the contractor or materials during construction, a faster transition to lower energy fuel sources or change of design of the Scheme (e.g., increasing the size of the walls, lock gates or landscaped bunds).

4.2 Construction Phase

GHG emissions associated with construction are accounted for within life cycle modules A1-5, referred to as capital carbon (as per Figure 4-1).

The BoQ, for the outline design of the Scheme, was provided by the Jacobs design team. The Carbon Calculator was then populated within the 'Assets', 'Sub-Assets', 'Capital Carbon', 'Materials (A1)', 'Transport (A2/A4)', 'Installation (A5)', 'Site Establishment (A5)' and 'Materials Waste (A5)' sections.

Table 4-1 sets out the sub-assets which comprise the Scheme. Table 4-1 also sets out the sub-assets and categories which comprise the Scheme and the relevant details regarding the first intervention (i.e. whether it is a new build or refurbishment of existing assets), the expected design life of the sub-asset and the scale of refurbishment required at the end of the design life to maintain the sub-asset operability. Those columns highlighted as 'tool selection' were selected from drop-down menu within the EA Carbon Calculator.

Table 4-1 Structural Components of the Scheme

Asset Class (tool selection)	Asset Description	Asset Measure	Asset unit (assigned by tool)	Sub-Asset Description	Sub-Asset Category (tool selection)	First intervention (tool selection)	Expected new build / Refurbished life (years)	Refurbishment type (tool selection)
Embankment - New	Flood embankment	34,568	m^3	Flood embankment	Embankment - Fluvial	New Build	130	Minor Refurbishment
Bridge - Vehicle Access	New bridges	1,562	m^2	New bridges	Bridges	New Build	101	Major Refurbishment
Culvert	Culvert extension	109	m^3	Culvert extension	Culvert	New Build	120	Moderate Refurbishment
Non-tidal Wall - Retaining - Concrete	Flood wall	15,066	m^3	Flood wall	Wall - Fluvial	New Build	130	Minor Refurbishment
Drainage - Plastic Pipe	Secondary Drainage	1,112	m^3	Secondary drainage	Drainage	New Build	60	Moderate Refurbishment
				Secondary drainage manholes	Drainage	New Build	101	Minor Refurbishment
Culvert Inlet/Outlet Works	Existing culvert	70	m^2	Ex culvert headwall	Culvert	New Build	120	Minor Refurbishment
Headwall	Headwalls	187	m^2	New Headwalls	Headwall	New Build	101	Minor Refurbishment
Barrier - Demountable	Flood barriers	40	m^2	Flood barriers	Flood gates	New Build	35	Moderate Refurbishment
Flood gates	Flood gates	40	m^2	Flood gates	Flood gates	New Build	35	Major Refurbishment
Flow Measurement - Control Channel Section	Flow control	36	l/s	Flow control	Weir	New Build	120	Moderate Refurbishment
Tidal Gate	Lock gate	360	m^2	Lock gate	Tidal Gate	New Build	60	Major Refurbishment
Pumping Station - Surface Water	Pumping station	12	kW	Pumping station	Pumping Station - Building	New Build	101	Minor Refurbishment
				Pumps	Pump	New Build	30	Major Refurbishment
Revetment Works - Rock Armour	Coastal revetment	2,394	t	Armour stone	Revetment - Hard	New Build	120	Minor Refurbishment
				Bedding material	Revetment - Hard	New Build	120	Minor Refurbishment

Asset Class (tool selection)	Asset Description	Asset Measure	Asset unit (assigned by tool)	Sub-Asset Description	Sub-Asset Category (tool selection)	First intervention (tool selection)	Expected new build / Refurbished life (years)	Refurbishment type (tool selection)
Non-tidal Wall - Retaining - Sheetpiled	Piles for concrete flood wall	67,449	m^2	Piles for flood wall	Wall - Fluvial	New Build	130	Moderate Refurbishment
Non-tidal Wall - Retaining - Sheetpiled	Seepage only piles	2,000	m^2	Seepage only piles	Wall - Fluvial	New Build	130	Moderate Refurbishment
Flap Valve	Flap valve	19	m^2	Flap valve - secondary drainage	Flap Valve	New Build	40	Major Refurbishment
				Flap valve - ex headwall	Flap Valve	New Build	40	Minor Refurbishment
Non-tidal Wall - Retaining - Sheetpiled	Bare sheet pile wall	130,499	m^2	Bare sheet pile	Wall - Fluvial	New Build	130	Major Refurbishment
				Metal plate for bare piled wall	Wall - Fluvial	New Build	130	Moderate Refurbishment
Path/Track/Road	Access track	87,490	m^2	Access track	Paths/tracks/roads	New Build	101	Minor Refurbishment
Other	Ground improvement	15,159	TBC	Ground improve	Other	New Build	101	Minor Refurbishment
Revetment Works - PCC	Flood relief channel	1,524	t	Flood relief channel	RC Channel	Replacement	101	Minor Refurbishment
Path/Track/Road	Site compounds	176,070	m^2	Site compounds	Paths/tracks/roads	New Build	101	Not Possible

Table 4-2 sets out the construction materials associated with the sub-assets described in Table 4-1, material types, material descriptions and the quantity of the materials input to the EA Carbon Calculator tool. The final column of the table presents the GHG emissions calculated by the EA Carbon Calculator tool for the supply and manufacturing of the construction materials and goods (lifecycle modules A1/A3). Table 4-2 has been arranged to show the materials in descending order of GHG emissions (highest to lowest).

Table 4-2 Materials Comprising the Sub-Assets

Sub-Asset Description	Material	Material Type	Material Description	Measure Units	Quantity	GHG emissions (tCO_2e)
Bare sheet pile	Steel	Engineering Steel	N/A	t	12,450	15,811
Piles for flood wall	Steel	Engineering Steel	N/A	t	6,435	8,172
Flood wall	Concrete	Reinforced In-situ Concrete (Fly Ash Replacement)	RC 32/40 (32/40 MPa) - 15% Cement Replacement	m^3	15,066	7,813
Armour stone	Stone	General (Stone)	N/A	m^3	15,966	3,059
Secondary drainage	Plastics	HDPE Pipe	N/A	m^3	1,112	2,942
Ground improve	Cement	36-65% GGBS (CEM III/A)	N/A	m^3	3,032	2,677
Flood wall	Concrete	Reinforced In-situ Concrete (Fly Ash Replacement)	RC 35/45 (32/40 MPa) - 15% Cement Replacement	m^3	3,524	1,908
Site compounds	Aggregate	Recycled & Secondary	N/A	m^3	28,171	895
New bridges	Concrete	Reinforced In-situ Concrete (Fly Ash Replacement)	RC 35/45 (32/40 MPa) - 15% Cement Replacement	m^3	1,562	845
Secondary drainage manholes	Concrete	Reinforced Precast Concrete (CEM 1)	RC 32/40 (32/40 MPa) - 0% Cement Replacement - Fly Ash	m^3	990	582
Lock gate	Steel	Plate - UK (EU) Average Recycled Content	N/A	t	350	581
Flood barriers	Aluminium	General (Aluminium)	Virgin	t	40	512
Flood gates	Aluminium	General (Aluminium)	Virgin	t	40	512
Pumps	Pumps	Submersible	760 kW	Item	12	510
Lock gate	Concrete	Reinforced In-situ Concrete (Fly Ash Replacement)	RC 40/50 (40/50 MPa) - 15% Cement Replacement	m^3	870	493
Access track	Aggregate	Recycled (no heat)	N/A	m^3	27,333	373
Metal plate for bare piled wall	Steel	Plate - UK (EU) Average Recycled Content	N/A	t	223	370
Flood wall	Bricks	General (Bricks)	N/A	m^3	857	365

Sub-Asset Description	Material	Material Type	Material Description	Measure Units	Quantity	GHG emissions (tCO_2e)
Flood relief channel	Concrete	Reinforced In-situ Concrete (CEM 1)	RC 32/40 (32/40 MPa)	m^3	635	345
Seepage only piles	Steel	Engineering Steel	N/A	t	159	202
Access track	Asphalt	Asphalt, 3.5% binder content	N/A	m^3	1,800	193
Bedding material	Aggregate	General - mixed	N/A	m^3	11,025	184
Flood wall	Stone	General (Stone)	N/A	m^3	893	171
New Headwalls	Concrete	Precast Concrete (CEM 1)	RC 32/40 (32/40 MPa)	m^3	187	75
Pumping station	Concrete	Precast Concrete (CEM 1)	RC 32/40 (32/40 MPa)	m^3	177	71
Culvert extension	Concrete	Reinforced Precast Concrete (CEM 1)	RC 32/40 (32/40 MPa) - 0% Cement Replacement - Fly Ash	m^3	109	64
Flood embankment	Soil/Clay	Imported (excludes transport to site)	Material other than topsoil, rock or artificial hard material	m^3	34,568	47
New bridges	Asphalt	General	N/A	m^3	312	36
Ex culvert headwall	Concrete	Reinforced In-situ Concrete (Fly Ash Replacement)	RC 32/40 (32/40 MPa) - 15% Cement Replacement	m^3	36	19
Flow control	Concrete	Reinforced In-situ Concrete (Fly Ash Replacement)	RC 32/40 (32/40 MPa) - 15% Cement Replacement	m^3	36	19
Flap valve - ex headwall	Metal	Flap Valves	DN 500	item	30	0.1
Flap valve - secondary drainage	Metal	Flap Valves	DN 200 & DN 300	item	187	0.07
Total						**49,847**

Figure 4-2 summarises the approximate split of capital carbon associated with the materials (i.e. the GHG emissions from the production and manufacturing of the construction materials) as described in Table 4-2. Those materials with less than 1% contribution to the total emissions have been grouped into the ‘Other Various Sub-Assets’ group.

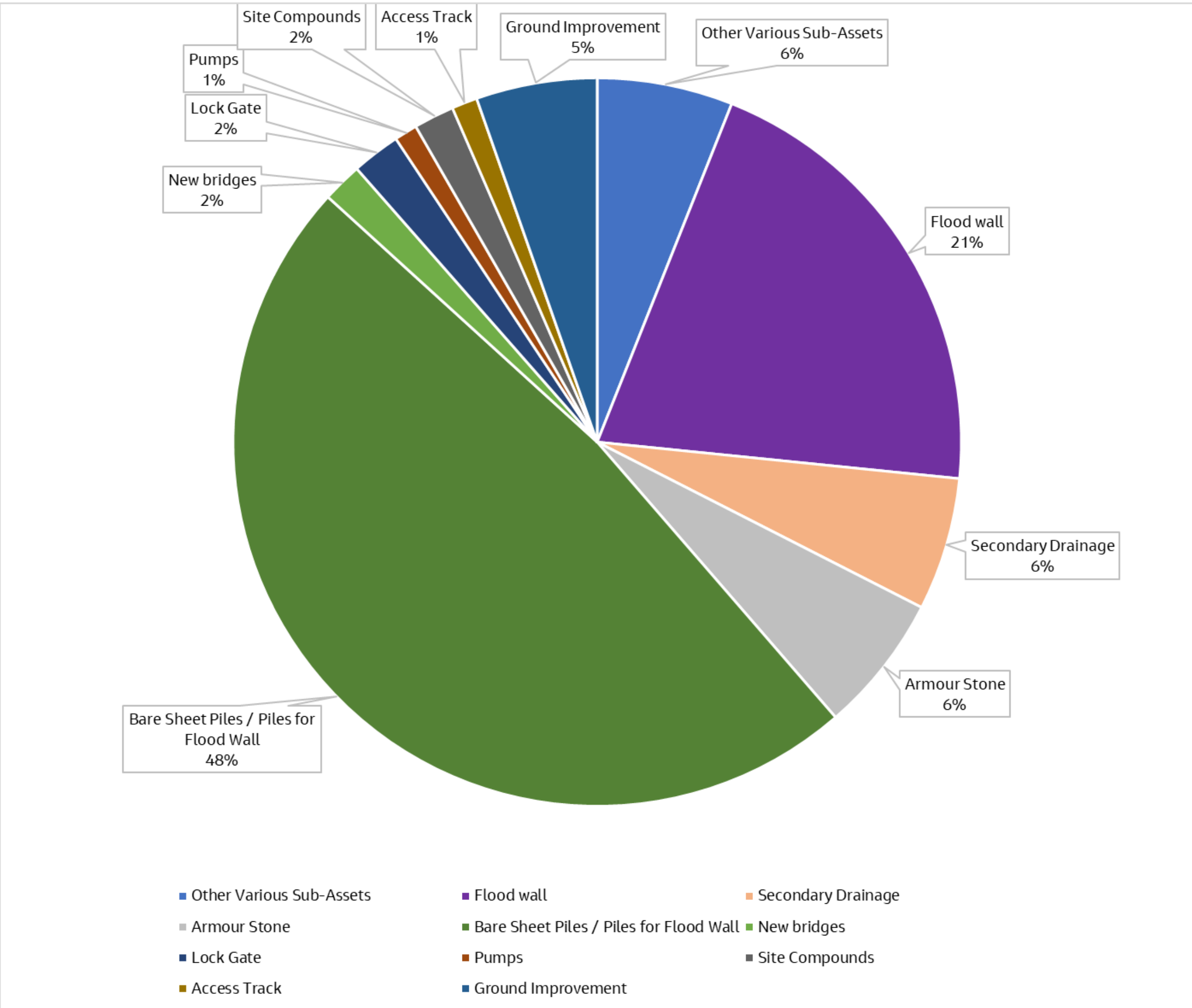

Figure 4-2 Percentage Split of GHG emissions (tCO_2e) Associated with the Sub-Assets of Table 4-2.

GHG emissions associated with the transport of materials (lifecycle module A2) were also estimated based on knowledge from other schemes. The Carbon Calculator categorises the following distances (from manufacturer/supplier to site):

- Local – 50 km
- Regional – 100 km
- National – 300 km
- European – 1,500 km

These conservative transport distances were applied to each of the sub-assets, based on the likely source of goods during the construction phase. It was assumed that most materials could be provided from local suppliers, except for the Lock Gate which will be supplied from Europe.

The GHG emissions associated with the transport of contractors (construction workers and staff) and non-contract people (life cycle module A4 'Transport of Contractor People' and 'Transport of Non-Contractor People') has been estimated at approximately 2,115 tCO_2e. Transport of plant (life cycle module A4) was estimated at 2 tCO_2e.

Waste quantities, based on likely wastage from site (e.g., cut-offs, excess material) were estimated for each material, using professional judgement. Additionally, for each of the sub-assets, an evaluation was undertaken of its waste disposal route (reused/recycled/removed to landfill), based on knowledge of similar materials on other projects. It was assumed all waste transport distances were regional (i.e. 100 km). This was estimated to result in GHG emissions of approximately 271 tCO_2e (module A5). Waste from other construction processes related to the demolition and removal of existing structures and site clearance was estimated to result in GHG emissions of approximately 686 tCO_2e.

Plant use on site (module A5) will also contribute to the GHG emissions associated with the Scheme. Based on the programme of works provided by the design team, it was estimated that approximately 4,500,000 litres of diesel will be used during construction, contributing approximately 15,256 tCO_2e, with a further 766 tCO_2e from site establishment (representing life cycle stage A5 'Site Establishment' and 'Plant Use'). It should be noted that this version of the EA Carbon Calculator does not fully account for the likely increase in uptake of electric/alternative fuel source plant over the coming years, so this figure is conservative. Diesel information was provided from the design team with the following assumptions:

- Assumes 15 pieces of equipment (e.g., excavator) working 20 days per month for 10 years at an average consumption rate of 125 litres per day.
- This will be across all Flood Cell locations and assumes a level of consistent working (i.e., working in Flood Cells concurrently), for the duration of the anticipated construction programme, including an additional year over and above the nine-year anticipated construction duration to allow for any enabling works and programme delays.

It is estimated that there would be GHG emissions of 69,611 tCO_2e during construction of the Scheme (life cycle modules A1-5), based on current knowledge at the time of writing.

4.3 Operational Phase – Use, Maintenance, Repair, Refurbishment, Replacement and Operational Energy Use

Emissions associated with operation of the Scheme are accounted for within life cycle modules B1-6 (as per Figure 4-1).

The Carbon Calculator allows for estimates to be provided on 'Use (B1)', 'Maintenance (B2)' and 'Repair (B3)' and 'Operational Energy Use (B6)'. For 'Use (B1)', this is based on the visits made by operational staff to operate the parts of the Scheme which require manual intervention such as the demountable barriers. Information on mode of transport, fuel type, number of people and number of days per year the operational activity is required was entered into the EA Carbon Calculator. Table 4-3 sets out the operational activities for the Scheme. The operational visits were estimated to results in total GHG emissions of approximately 45 tCO_2e over the operational lifetime of 100 years.

In addition to operational visits, there would be energy use (i.e. electricity) to operate the pumping stations and pumps associated with the Scheme ('Operational Energy Use (B6)'). Using the EA Carbon Calculator, the total GHG emissions for the operational phase energy use would be approximately 2,214 tCO_2e, based on an assumed annual power consumption of 81,200 kWh.

For 'Maintenance (B2)', each activity can be described in terms of its likely material and plant requirement, in categories of Low/Medium/High, as well as frequency of intervention (e.g., >1 per year, once per year, every two years, every three years, every four years, every five years or exceptional). Table 4-4 sets out the maintenance regime for the Scheme, based on the sub-asset from earlier sections. It was assumed a local contractor (<50 km distance from the Scheme), will be used. Given the outline design stage at the time of writing, a full operational and maintenance regime was not available. However, based on the assumed operational maintenance activities and material and plant requirements, the estimated total GHG emissions was 3,093 tCO_2e.

Table 4-3 Anticipated GHG Emissions Associated with the operation of the Scheme

Asset description	Use Description	Mode of Transport and Fuel Type	No. of people	No. of days per year	Return distance (km)	GHG Emissions (tCO_2e)
Flood wall	Maintain / Inspect	Car / hybrid	2	10	20	0.06
Flood barriers	Erect	Van / diesel	4	10	20	0.25
Flood gates	Close	Van / diesel	4	10	20	0.25

Table 4-4 Anticipated GHG Emissions Associated with the Maintenance of the Scheme

Sub-Asset description	Maintenance Description	Materials	Plant	Annual Intervention Frequency	Interventions Per Year	GHG Emissions (tCO_2e) Per Intervention
Flood embankment	Grass cutting	Low	Low	> 1 per year	2	2
Pumping station	Servicing	Low	Low	Every year	1	0.1
Flap valve - ex headwall	Servicing	Low	Low	Every year	1	0.02
Flood gates	Servicing	Low	Low	Every 2 years	1	0.9
Lock gate	Servicing	Medium	High	Every 5 years	1	197

Table 4-5 Anticipated GHG Emissions Associated with the Repair of the Scheme

Sub-Asset description	Repair Description	Materials	Plant	Annual Intervention Frequency	GHG Emissions (tCO_2e) Per Intervention
Access track	Repair surface	Medium	Low	Every 3 years	6

Table 4-5 sets out the replacement regime for the Scheme, based on the sub-asset from earlier sections. It was assumed an average distance of 50 km would be required to replacement any asset. The repairs were estimated to result in total GHG emissions of approximately 140 tCO_2e over the operational lifetime of 100 years.

The GHG emissions for 'Replacement (B4)' and 'Refurbishment (B5)' are automatically calculated by the EA Carbon Calculator based on the information provided for each sub asset including the initial capital carbon and the expected new build/replacement life and refurbishment type at the end of its life. The estimate GHG emissions for replacement and refurbishment were 1,925 tCO_2e and 3,562 tCO_2e, respectively.

In total, it is estimated that there would be GHG emissions of 10,979 tCO_2e during the operation of the Scheme (over the 100-year reference period), based on current knowledge at the time of writing.

4.4 Summary

It is anticipated that the whole life GHG emissions for the Scheme (not including the end-of-life stage) would be approximately 80,589 tCO_2e.

Table 4-6 summarises the GHG emissions associated with the Scheme construction and operation.

Table 4-6 GHG Emissions Associated with the Scheme

Scheme Stage	GHG emissions (tCO_2e)
Construction	69,611
Operation	10,979
Whole Life Emissions	80,589

Figure 4-3 shows the estimated whole life carbon over the lifespan of 100 years for the Scheme.

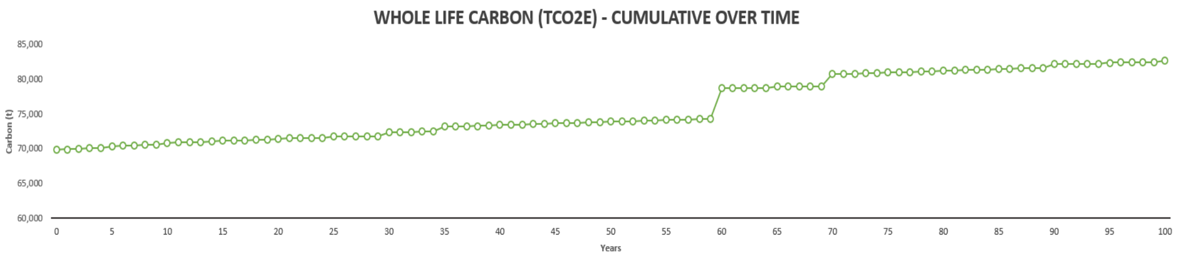

Figure 4-3 Whole Life Carbon for the Scheme Cumulatively Over its Lifespan

5. Abbreviations and References

Table 5-1 Abbreviations

Term	Description
$\mu g/m^3$	Microgrammes per cubic metre
µm	Micrometre
AQMA	Air Quality Management Area
AQO	Air Quality Objective
BoQ	Bill of Quantities
CO_2	Carbon dioxide

Term	Description
CO_2e	Carbon dioxide equivalent
Defra	Department for Environment, Food and Rural Affairs
EA	Environment Agency
EEC	European Economic Community
EU	European Union
GHG	Greenhouse Gas
HDV	Heavy duty vehicle
IAQM	Institute of Air Quality Management
km	Kilometre
kW	Kilowatt
LAQM	Local Air Quality Management
LCA	Life Cycle Assessment
LNR	Local Nature Reserve
l/s	Litres per second
m	Metre
m^2	Square metre
m^3	Cubic metre
NO_2	Nitrogen dioxide
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
SAC	Special Area of Conservation
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
SSSI	Site of Special Scientific Interest
t	Tonne
tCO_2e	Tonnes carbon dioxide equivalent
UK	United Kingdom

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