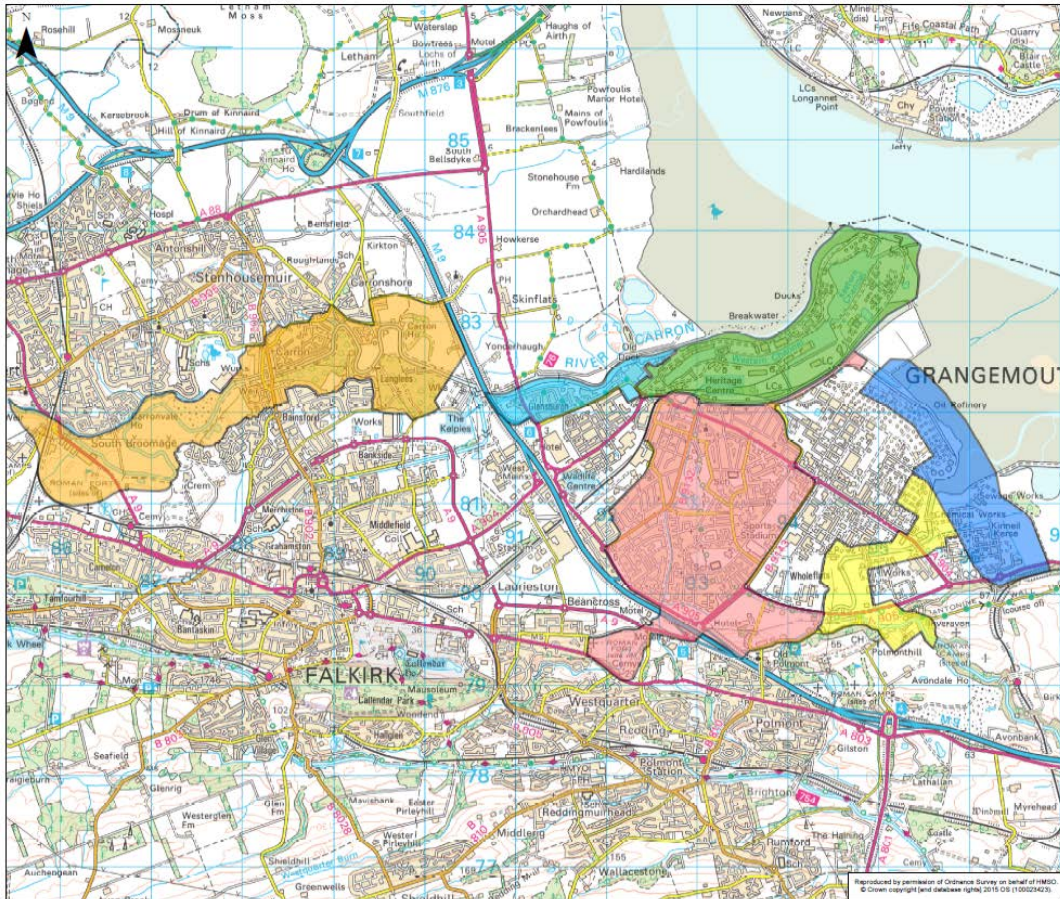


ENVIRONMENTAL IMPACT ASSESSMENT:
SCREENING / SCOPING REPORT

Grangemouth Flood Protection Scheme



Prepared for Falkirk Council

October 2018

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Document History

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Jacobs has prepared this report in accordance with the scope and instructions of Falkirk Council, our client, for their sole and specific use. Any other persons or organisations who use any information contained herein do so at their own risk.

Acronyms

AEP	Annual Exceedance Probability	QA	Quality Assurance
AGLV	Areas of Great Landscape Value	RBD	River Basin District
AQMA	Air Quality Management Area	RBMP	River Basin Management Plans
BAP	Biodiversity Action Plan	RCAHMS	Royal Commission for Ancient and Historic Monuments in Scotland
CAR	Controlled Activities Regulations	RIGS	Regionally Important Geological Site
CEMP	Construction Environmental Management Plan	RSPB	Royal Society for the Protection of Birds
CIEEM	Chartered Institute of Ecology and Environmental	RTS	Regional Transport Strategy
CMP	Catchment Management Plan	SAC	Special Area of Conservation
COSHH	Control of Substances Hazardous to Health	SBL	Scottish Biodiversity List
DBA	Desk based assessment	SEA	Strategic Environmental Assessment
DMRB	Design Manual for Roads and Bridges	SEPA	Scottish Environment Protection Agency
EC	European Commission	SHEP	Scottish Historic Environment Policy
EclA	Ecological Impact Assessment	SG	Supplementary Guidance
EHO	Environmental Health Officer	SLA	Special Landscape Areas
EIA	Environmental Impact Assessment	SM	Scheduled Monument
EPA	Environmental Protection Act	SIMD	Scottish Index of Multiple Deprivation
EPS	European Protected Species	SNH	Scottish Natural Heritage
EU	European Union	SPA	Special Protection Area
FPS	Flood Protection Scheme	SPP	Scottish Planning Policy
FRC	Flood Relief Channel	SSSI	Site of Special Scientific Interest
FRM	Flood Risk Management	TAG	Transport Assessment Guidance
GIR	Ground Investigation Report	TPO	Tree Preservation Order
HER	Historic Environment Record	UNESCO	United Nations Educational, Scientific and Cultural Organization
HES	Historic Environment Scotland	UWWTD	Urban Waste Water Treatment Directive
HRA	Habitat Regulation Assessment	WEWS	Water Environment and Water Services
HSE	Health, Safety and Environment	WFD	Water Framework Directive
IEA	Institute of Environmental Assessment	WHO	World Health Organisation
IEEM	Institute of Ecology and Environmental Management	ZVI	Zone of Visual Influence
IEMA	Institute of Environmental Management and Assessment		
IfA	Institute for Archaeologists		
LA	Local Authority		
LATS	Local Access and Transport Strategy		
LDP	Local Development Plan		
LFRMP	Local Flood Risk Management Plan		
LPA	Local Planning Authority		
LTS	Local Transport Strategy		
LVIA	Landscape and Visual Impact Assessment		
NFM	Natural Flood Management		
NFU	National Farmers Union		
NPF	National Planning Framework		
NTS	Non-Technical Summary		
PAN	Planning Advice Note		
PEA	Preliminary Ecological Appraisal		
PPG	Pollution Prevention Guidelines		
PVA	Potentially Vulnerable Area		

Introduction

1.1 Overview

Falkirk Council (FC) has appointed Jacobs (formerly CH2M) to identify and design flood protection measures for the Grangemouth area, which together form the Grangemouth Flood Protection Scheme (FPS) (*“the Scheme”*).

Grangemouth lies within the local authority area of Falkirk and is located some 30 km to the west of the city of Edinburgh along the southern coast of the Firth of Forth (see Figure 1-1). Figure 1-2 illustrates the specific areas affected by flood risk (flood cells) where flood protection measure shall be developed. Figures A4 to A10 in Appendix A indicate the proposed location of defences within each flood cell. It is noted that defences for Flood Cell 4 have yet to be confirmed and will be subject to further option appraisal and on-going consultation over the coming months.

This Environmental Impact Assessment (EIA) Screening / Scoping Report has been prepared to support the statutory consenting procedures for the Scheme (see following sub-sections) and will be followed by a full EIA Report in 2019.

The rest of this introductory chapter summarises:

- the need and aim for the Scheme,
- the purpose of this Scoping Report, and
- a summary of the results of the scoping exercise.

The subsequent chapters provide detail on the statutory EIA requirements, the methodology adopted for the scoping and main EIA stages and an initial appraisal of the Scheme as currently proposed with respect to the environmental disciplines set-out in the relevant regulations.



Figure 1-1: Site location

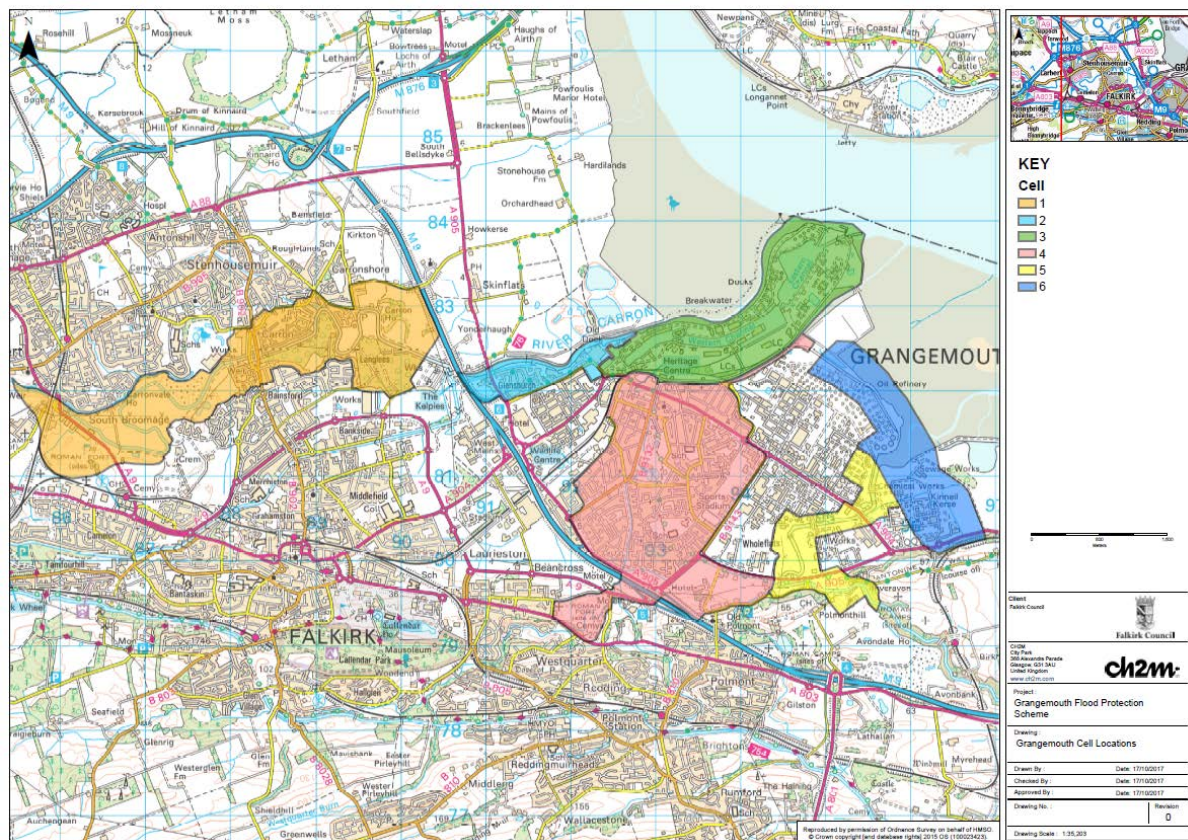


Figure 1-2: Flood Cells where FRM measures are proposed

1.2 Need for the Scheme

1.2.1 Statutory Context

The National Flood Risk Assessment¹ was completed in 2011 and identified the Grangemouth area within the Forth Estuary Local Plan District as a Potentially Vulnerable Area (PVA) with respect to flooding. Thereafter, the Scottish Environment Protection Agency (SEPA) identified the Grangemouth Flood Protection Scheme (FPS) as the highest priority Scheme in their National Flood Risk Management Strategy (FRM; published by SEPA in 2015)².

The subsequent Local Flood Risk Management Plan published in June 2016 (the Plan)³ includes details on the Scheme, which is identified as the highest priority Scheme of 42 identified across Scotland, and is listed as having the following objectives:

- Reduce risk to people in Bonnybridge, Denny, Carron and Grangemouth from river and coastal flooding.
- Reduce economic damages to residential and non-residential properties in Grangemouth caused by river flooding and coastal flooding.
- Reduce economic damages to residential and non-residential properties in Falkirk caused by flooding from the River Carron.

¹ SEPA 2011 [online] Available at: <http://map.sepa.org.uk/nfra/map.htm> (Accessed March 2017)

² Online. Available at: http://apps.sepa.org.uk/frmstrategies/pdf/lpd/LPD_10_Full.pdf (Accessed May 2018)

³ Online. Available at: http://www.edinburgh.gov.uk/downloads/file/7455/draft_local_flood_risk_management_plan (Accessed March 2017)

- Reduce economic damages to residential and non-residential properties in Carron and Carronshore caused by flooding from the River Carron and coastal flooding.

The Scheme is now being formally advanced by Falkirk Council under the provisions of the Flood Risk Management (Scotland) Act 2009.

1.2.2 Flood Risk and Past Events

Figures A1 and A2 in Appendix A show the areas at risk from flooding from the Rivers Carron and Avon, the Westquarter Burn and Grange Burn as well as flood risk along the Forth Estuary shoreline. Figure A3 indicates the distinct 'flood cell areas' that have been identified where flood protection measures are required, which include industrial, rural and residential areas in and around Grangemouth.

The main features deemed as being at risk of flooding from future events include:

- Residential and commercial properties
- Falkirk Council infrastructure
- Utility infrastructure
- Commercial port
- Petro-Chemical Plant
- Environmentally sensitive sites

While the proposed FPS shall be designed to protect against future flood events that will be more severe than most flood events experienced to date, some of the more recent flood events that have occurred in the area in the last decades include:

- 3 January 2018: predicted tide level of 3.93 m AOD caused water level in the Grange Burn to rise significantly and come within centimetres of bank top and bridge structure.
- Winter 2013/14: a near miss occurred when a storm surge was predicted to combine with the high tide, this resulted in water levels in the Grange Burn coming within millimetres of the bank top and bridge structure.
- 13 December 2006: widespread flooding throughout the Falkirk area with businesses, residential properties and gardens affected. A large bus depot on Stirling Road was impacted.
- 30 September 1959: Grangemouth Docks flooded from the sea with highest tides on record at 4.47 m.

1.3 Scheme Aims

The aim of the Scheme is to protect over 3,000 residential and non-residential properties as well as national infrastructure from fluvial flood risk (overtopping or breach) from the Grange Burn and the Rivers Carron and Avon and coastal flood risk (storm surge) from the Forth Estuary. Some secondary measures shall also be integrated into the Scheme to protect against seepage (groundwater), pluvial (high intensity rainfall) and secondary (water mains or sewers) flood sources.

Following the development of an outline design for the Scheme and the associated EIA, the Scheme shall be confirmed by Falkirk Council in 2019 and subject to statutory (public) consultation period. Once approved, the Scheme will then undergo detailed design and any further consenting, with the anticipated programme for construction anticipated to cover an approximate 5-10 year period starting around 2022.

The Scheme objectives are presented in Section 3.2 of this report, which were / are used to inform the options appraisal process.

1.4 Purpose of this Report

Given the sensitivity of Grangemouth's natural and built environment (including nature conservation and heritage designations of international and national importance), the scale of proposed works, and the Scheme's close proximity to residents, it is considered that the Scheme will have the potential to generate significant environmental impacts (see Section 2.2 for further details on EIA screening).

The purpose of this Scoping Report is to provide consultees with information on the options appraisal and the project team's preliminary review of the potential environmental risks and opportunities of the preferred option to help confirm whether the Scheme is indeed EIA development according to legislation and to gain agreement on the appropriate scope of the EIA. The report has been produced to:

- provide information to statutory bodies and interested parties to illicit their views on the proposed Scheme;
- request a 'screening opinion' from Falkirk Council Planning Department on whether a statutory EIA will be required;
- agree the baseline and the scope of the EIA with planners and consultees; and
- identify and agree issues that are to be 'scoped-in' or 'scoped-out' of further assessment in the EIA Report;
- outline our proposed methodology for undertaking the EIA; and
- provide a formal record of the scoping stage and the options appraisal.

1.5 Scoping Summary

Table 1-1 below provides a summary of the scoping exercise undertaken for the project. While none of the EIA factors appraised shall be fully scoped-out of the EIA, it is noted that the Noise & Vibration, Air Quality & Climate and Traffic and Transportation chapters of the EIA Report shall be limited to appraising potential impacts on receptors during construction only. With regard to Chapter 9: Land-use, Geology and Contamination, impacts relating to contamination will be considered in detail in the EIA Report, with any issues relating to geology being included as the GI is concluded. Table 1-1 lists the factors that have been scoped in and those that have been scoped out.

Table 1-1: Summary of Scoping Outcomes

Topic	Potentially significant construction impacts	Potentially significant operational impacts
Population, Recreation and Amenity	Yes: Medium-term disruption and access to key facilities and green spaces etc.	Yes: Assumed to be overall +ve impact against scenario without defences in place and major flood event.
Biodiversity	Yes: Potential impacts on SPA, protected and important species.	Yes: Potential impact on footprint of SPA, protected and important species.
Noise & Vibration	Yes: potential impacts upon local receptors during construction period.	No
Landscape and Visual Amenity	No. (mitigation measure to reduce visual and townscape impacts in urban areas during construction phase shall be explored)	Yes: Visual and townscape impacts
Water Environment	Yes: Potential for impacts on hydrology, geomorphology and contamination of the water environment during works.	Yes: Potential for impacts on hydrology, geomorphology and contamination of the water environment during works.

Topic	Potentially significant construction impacts	Potentially significant operational impacts
Land-use, Geology and Contamination	Yes: Potential to release contaminants during construction.	No: Slight risk of operational phase contamination, but assumed risks will be addressed during detailed design and construction.
Air Quality and Climate	No: However, recommendation for further consideration relating to dust impacts during construction and air contamination.	No: However, climate impacts and resilience shall be considered in outline.
Cultural Heritage	Yes. Disturbing archaeological assets.	Yes: Adverse impacts on the setting of UNESCO WHS, Scheduled Monuments and listed Buildings.
Traffic and Transport	Yes: Potential impacts on the local traffic network resulting from temporary closures and transport / construction vehicle movements.	No

The following sections of this report set-out the following:

- Statutory Context and EIA Methodology (to describe the legislation governing the requirement and methodology required in relation to the Scheme design).
- Emerging Scheme Design (brief overview of the proposed flood protection measures and the location of each measure)
- Technical chapters (covering environmental factors set-out in section 2.3, reviewing baseline, key issues and scope of further assessment)
- Summary (summarising scoping exercise, indicating which factors have been scoped-in or out of the EIA process.
- Appendices (including figures, tables and supporting survey reports)

Statutory Context and EIA Methodology

2.1 EIA Regulations and Screening Method

This Environmental Impact Assessment (EIA) Scoping Report has been completed for the as part of Jacobs' (formerly CH2M) commission to Falkirk Council (FC) to address flood risk across the catchment. The purpose of the report is to request a screening / scoping opinion from FC planning authority and to set out the agreed approach to the EIA.

The consenting process for flood protection Schemes in Scotland is statutorily defined within the provisions of the Flood Risk Management (Scotland) Act 2010 and The Flood Risk Management (Flood Protection Schemes, Potentially Vulnerable Areas and Local Plan Districts) (Scotland) Regulations 2010 (as amended in 2017⁴); hereafter 'the FRM Regulations').

The FRM Regulations have a specific focus on the EIA process to be adopted for the Scheme, and paragraph 2A(3) of the FRM Regulations sets out the environmental factors that must be considered as part of the EIA process. For the current Scheme, the range of environmental factors considered at this screening / scoping stage are:

- *Population & Human Health;*
- *Biodiversity;*
- *Noise & Vibration;*
- *Landscape & Visual Effects;*
- *Water Environment (Hydrology, Geomorphology, Water Quality & Coastal Processes);*
- *Land-Use (including agricultural land as material assets), Geology & Contamination (including Soils);*
- *Air & Climate;*
- *Traffic & Transportation; and*
- *Cultural Heritage (including historic material assets).*

For each factor, consideration is given to the location of the Scheme, its characteristics and the potential for significance of impacts with reference to the criteria set-out in Schedule 1 of the FRM Regulations. Where feasible, consideration is also given to direct and indirect effects as well as any potential for interaction between effects (referred to as cumulative effects).

Any expected effects deriving from the vulnerability of the Scheme to risks of major accidents and disasters is also considered within the appropriate sections of the report.

2.2 EIA Screening

Given the sensitivity of the study area's natural and built environment (including nature conservation and heritage designations of international and national importance) and the Scheme's close proximity to residents at certain locations, it was considered likely that there will be a potential for significant environmental impacts, and the Scheme is accordingly regarded as *EIA development* under the FRM Regulations. Chapters 4 - 12 set out the appraisal in detail for each of the environmental disciplines.

⁴ The Flood Risk Management (Flood Protection Schemes, Potentially Vulnerable Areas and Local Plan Districts) (Scotland) Amendment Regulations 2017 [online] Available at: <http://www.legislation.gov.uk/ssi/2017/112/contents/made> (Accessed November 2017)

An EIA Report will therefore be produced to document the findings of the EIA process and will include mitigation and monitoring measures aimed at addressing potentially significant adverse impacts upon the environment.

The following sub-sections present the current (or anticipated) environmental baseline for each of the relevant environmental factors set-out above, identify the key anticipated impacts and appraise the scope of further study and method required to complete the EIA.

2.3 EIA Scoping Method

Scoping aims to highlight the key issues that are anticipated to be associated with the development and enables the finalisation of the scope of the EIA by taking the concerns of stakeholders into account. The view of the determining authority can be sought through a scoping opinion. Once contacted, the determining authority is obligated to contact statutory consultees to gain their views.

While not required under the FRM Regulations, this report has been produced as part of the EIA process for the Scheme to be issued to Falkirk Council and the statutory EIA consultative bodies including Scottish Environment Protection Agency (SEPA), Scottish Natural Heritage (SNH), Scottish Water (SW), Marine Scotland (MS –relevant additional consultee) Historic Environment Scotland (HES –relevant additional consultee) and the Health and Safety Executive (HSE) for their consideration and comment. By taking these views into account at an early stage of the project, any potential impacts can be investigated, predicted and assessed, and where necessary and practicable, means to avoid them can be built into the design.

Chapters 4 to 12 of this report describe the environmental baseline for each EIA discipline in relation to the Scheme, which has been established through desk study, walkover site visits and consultation. Within each subsection, a conclusion is given as to whether the factor has been scoped-in or scoped-out of further assessment, subject to the likelihood for occurrence of significant effects. Each subsection also presents the proposed methodology for further assessment where required as part of the EIA process.

At this early stage in the project, an evaluation is made as to whether it is likely that a particular impact may be *significant* or otherwise following outline appraisal against established criteria and / or professional judgement. The methodology to be adopted for the assessment of significance in the EIA Report is discussed in the following sub-section.

Falkirk Council planning department and the consultative bodies are invited to comment on the environmental baseline, the scoping conclusions, the planned content and assessment method of the EIA and to provide additional relevant environmental information where available.

All comments and information received from the respondents will be used to inform the EIA method adopted and the scope of information to be presented in the EIA Report.

2.4 EIA Report Methodology

2.4.1 Format of the EIA Report

The environmental information produced as part of the EIA will be submitted within an EIA Report. The EIA Report will comprise a series of technical reports, figures and appendices combined within a single stand-alone document (and made publicly accessible to view online or as a hard copy at the Falkirk Council Office).

The information provided within the EIA Report will comply with Schedule 2 of the Flood Risk Management Regulations: “Information for Inclusion in EIA Reports”. A table summarising the impacts, mitigation and enhancement recommendations and residual impacts for each EIA factor will be included in the concluding section of the EIA Report to facilitate ease of access and transferability of the findings and recommendations of the EIA (e.g. to inform the conditions set by the deemed planning process).

A Non-Technical Summary will also be drafted that summarises the Scheme and location, a summary of the baseline and impacts for each of the EIA disciplines and provide an overview of the EIA process and resulting conclusions in *lay* terms.

In accordance with section 6(4) of the FRM Regulations, the EIA Report and technical chapters shall be completed by competent experts in each of the relevant fields, and a statement to the effect will be included in the introductory chapter. Regarding 10A of the FRM Regulations, monitoring measures that are proportionate to the nature, location and size of the scheme and the significance of its effects on the environment shall be set-out within each of the EIA technical chapters and summarised along with proposed mitigation for ease of transferability to contractor tender / contractor documentation.

2.4.2 Consultation and Public Engagement

A key objective of the project approach is to ensure that all parties affected by the project as well as those with a substantial interest in its effects have the opportunity to either engage or stay informed about the project design. The project has and will be subject to on-going consultation with locally affected residents, landowners, elected members and the following formal consultative bodies and stakeholder groups including (but not limited to):

- Scottish Environment Protection Agency (SEPA),
- Scottish Natural Heritage (SNH),
- Historic Environment Scotland (HES),
- Marine Scotland (MS),
- Health and Safety Executive (HSE),
- Transport Scotland,
- Falkirk Council Planning Authority,
- Grangemouth Community Council, and
- Bainsford, Langlees and New Carron Community Council
- Bo'ness Community Council
- Larbert and Stenhousemuir Community Council
- Lower Braes Community Council
- Polmont Community Council
- Communities Along the Carron
- Friends of Rannoch Park
- Friends of Zetland Park
- Falkirk Community Trust
- Falkirk Historic Society

A core stakeholder workshop was held 20th March 2017 during which the environmental baseline was discussed in the context of potential measures as then proposed. The workshop was attended by a range of specialists from Falkirk Council, the consultative bodies and other stakeholder groups. Feedback from the workshop helped inform the baseline, identify further constraints associated with the potential measures as well as potential opportunities. A further options appraisal workshop was held on 25th April 2017.

A workshop was also arranged with an industrial stakeholder group, which included the main refinery site operators and focussed on technical constraints to the alignment, construction and

maintenance of the Scheme. The meeting was held on 25th April 2017 with further meetings being held on various occasions with individual site operators.

An initial meeting was also held on 21st April 2017 with SNH to discuss issues relating to Habitat Regulations Appraisal and impacts on the Firth of Forth Special Protected Area (SPA).

Following consultation with local landowners, public exhibitions were then held in February and April 2018 to introduce the Scheme to, among others, local residents affected by flooding. Feedback from the event was also considered in the design process for the Scheme.

Further stakeholder workshops and public exhibitions will be held to promote transparency and public engagement and to consider any further information provided at the events that was hitherto not considered by the design team. A summary of the consultation process shall be provided within a separate chapter of the EIA Report.

2.4.3 Establishment of Baseline Conditions

The environmental baseline for each of the environmental factors has been established in part to inform this report and will be updated / expanded as required for the main assessment. The environmental baseline information used was / will be gathered from numerous sources including: detailed field surveys, modelling exercises, desk studies, consultations and literature reviews. The methods used to define the baseline conditions for each environmental factor will be described in each of the relevant EIA factor chapters.

2.4.4 Assessing Impact Significance

2.4.4.1 Introduction

The supporting guidance used to determine the significance of specific impacts may vary between environmental disciplines, but the overarching criteria used to define the significance of impacts in the EIA Report will focus on the SEPA guidance document '*WAT-SG-67 - Assessing the Significance of Impacts - Social, Economic, Environmental*'⁵. The following sub-sections summarise the criteria that will be used to establish the overall significance accordingly.

2.4.4.2 Determining the value of receptor or resource

The general criteria that will be used to evaluate the value or sensitivity of receptors or resources are presented in Table 2-1. While these criteria offer an indicative method for assessing the significance of impacts, it is acknowledged that the perception of impacts is largely dependent upon the nature of the impact and the nature of the affected receptor. As such, further justification for the assessment of the value or sensitivity of a receptor or environmental resource will be provided within each of the relevant factor based assessment chapters of the EIA Report.

Table 2-1: General criteria for determining the value of environmental receptors/resources

Criteria	Value
International importance	Very High
National importance	High
Regional/ county importance	Medium
District/ parish importance	Low (refers to the receptor's value on a national scale. Locally, the receptor may still be considered important)
No listed importance	Negligible

⁵ SEPA 2015: '*WAT-SG-67 - Assessing the Significance of Impacts - Social, Economic, Environmental*' [online] Available at: https://www.sepa.org.uk/media/149801/wat_sg_67.pdf (Accessed Jan 2018)

2.4.4.3 Determining the magnitude of environmental impacts

Environmental impacts will be categorised as positive, negative or negligible. For the purposes of the EIA, the proposed magnitude of an environmental impact will range from very small to very large with reference to the duration and scale of the impact in terms of its extent, complexity, reversibility, temporary/permanence and severity. The probability of an impact occurring at a certain magnitude will be discussed further in the consideration of the residual impacts.

The general proposed criteria to be used for determining impact magnitude are outlined in Table 2-2 below, although these criteria may be qualified further within the relevant assessment chapters of the EIA Report.

Table 2-2: General criteria for ranking the magnitude of an identified impact

Duration of impact	Scale of impact (extent & severity)				
	Very small	Small	Medium	Large	Very large
Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Very short (up to 1 year)	V Small	V Small	V Small	Small	Medium
Short (up to 6 years)	V Small	V Small	Small	Medium	Large
Long (more than 6 years)	V Small	Small	Medium	Large	V Large

The impact magnitude ascribed within the matrix are broadly defined as follows:

- Negligible – impact is only very slightly detectable/ noticeable or is undetectable and of no significance.
- Small/very small– impact is slightly detectable/ noticeable; likely to be of temporary duration; likely to be reversible; local influence.
- Medium – impact is fairly easily detectable/ noticeable; could have either a temporary or permanent duration; reversible or irreversible; unlikely to exceed local influence.
- Large/very large – impact is easily detectable/ noticeable; likely to be of a long-term or permanent duration; could have irreversible implications; influence exceeds the local area.

The environmental impacts of the construction and operation stages will be included in the assessment. While EIA should consider the demolition stage, it is not anticipated that the Scheme will be demolished in the foreseeable future, as the proposed engineered measures are anticipated to be maintained for over 100 years, with future extensions or improvement being developed as required. The decommissioning phase of the Scheme is therefore not considered relevant for the EIA.

2.4.4.4 Assessing impact significance

The overall significance of environmental impacts will be assessed within the EIA Report using the criteria given in the impact matrix in Table 2-3 below, which assesses the magnitude of the impact against the value of the receptor. The significance of impacts will be identified as negligible to major and will be qualified within each of the EIA factor chapters.

While the focus of the EIA will be on the most significant impacts to aid decision-making, it is acknowledged that significance criteria applicable to each environmental factor will be subjective to that discipline and current guidance, and it is not considered appropriate to compare the significance of impacts between disciplines.

In general, where it is not possible to quantify impacts, a qualitative assessment will be carried out based on available knowledge and professional judgement. Where uncertainty exists, this will be noted in the relevant assessment chapter.

Table 2-3: General criteria for determining significance of environmental impacts

Magnitude of impact	Value / sensitivity of receptor			
	Very high	High	Medium	Low
Very large (adverse)	Major adverse	Major-moderate adverse	Moderate adverse	Moderate-minor adverse
Large (adverse)	Major-moderate adverse	Moderate adverse	Moderate-minor adverse	Minor adverse
Medium (adverse)	Moderate adverse	Moderate-minor adverse	Minor adverse	Minor adverse
Small (adverse)	Moderate-minor adverse	Minor adverse	Minor adverse	Minor adverse
Very small (adverse)	Minor adverse	Minor adverse	Minor adverse	Minor adverse
Negligible	Negligible	Negligible	Negligible	Negligible
Very small (positive)	Minor positive	Minor positive	Minor positive	Minor positive
Small (positive)	Moderate-minor positive	Minor positive	Minor positive	Minor positive
Medium (positive)	Moderate positive	Moderate-minor positive	Minor positive	Minor positive
Large (positive)	Major-moderate positive	Moderate positive	Moderate-minor positive	Minor positive
Very large (positive)	Major positive	Major-moderate positive	Moderate positive	Moderate-minor positive

2.4.5 Cumulative Impacts

The FRM Regulations require consideration of interactions between environmental factors. Impacts that result from incremental changes caused by other past, present or reasonably foreseeable actions together with the proposed Scheme are known as cumulative impacts.

Two types of cumulative impact shall be assessed in the EIA Report:

- Same project: EIA factor-specific impacts that combine to produce further or exacerbated impacts, e.g. restricted access and dust from construction may combine to exacerbate physical or mental health and safety risks associated with the construction period.
- Other projects: Impacts from other projects combine with FPS to exacerbate individual impacts or create new ones, e.g. future developments affecting traffic which, when considered together, produce significant cumulative impacts.

Table A1 in Appendix A includes a list of proposed or planned developments that are provisionally identified as having a potential cumulative effect with the Scheme works. The table also includes allocated development areas in the upcoming Falkirk Council Local Development Plan.

It is difficult to assess the probability, nature and significance of cumulative impacts given the uncertainties involved in such potential interactions. Therefore, the assessment of cumulative impacts will rely on qualitative assessment using professional judgement, with each member of the EIA team addressing potential indirect cumulative impacts in each of the specialist chapters and, where appropriate, proposing commensurate mitigation and / or monitoring as appropriate.

2.4.6 Mitigation and Enhancement

The Institute of Environmental Management and Assessment (IEMA) defines three key types of mitigation and how they should relate to the design and build process as follows:

- Primary mitigation is defined as an intrinsic part of the project design, i.e. mitigation that has been developed and adopted by the design team, and it should be included in the project description and relevant plans. An example may include the use of glass panels along a flood wall to reduce the impact on views.
- Secondary Mitigation is that which has been identified at a later stage in the EIA/design process and needs to be incorporated into the proposed Scheme design to achieve the anticipated outcome. Such measures may be imposed as part of (deemed) planning consent as conditions, and in relation to the primary mitigation measure above, could relate to the type, size and location of glass panels required to ameliorate an identified adverse impact of significance on views.
- Tertiary mitigation includes actions that will required to be undertaken to meet other existing legislation, or actions that are considered to be standard practices used to manage commonly occurring environmental effects. Such mitigation may be included as recommendations to the contractor for inclusion e.g. in any Construction Method Statements or a Construction Environment Management Plan (CEMP)⁶.

The EIA Report will provide a summary of the primary mitigation adopted within the outline design as a result of the EIA, consultation and design process. Each of the factor-based EIA chapters will explore any primary mitigation that has not been adopted in the design but may feasibly be explored further at the detailed design stage. Secondary mitigation will be proposed as recommendations to the (deemed) planning process to address potential impacts, e.g. as planning Conditions that inform the detailed design and construction stages. Where appropriate, tertiary mitigation will be cited to potentially inform any tendering documentation.

The EIA Report will identify all known residual impacts that may remain following the effective implementation of recommended mitigation measures. In addition, opportunities to improve or enhance the environment will be recommended where appropriate.

⁶ IEMA 2015 'Delivering Quality Development' [online] Available at: <http://www.iema.net/assets/newbuild/documents/Delivering%20Quality%20Development.pdf> (Accessed July 2017)

Emerging Scheme Design

3.1 Introduction

The main elements of the Scheme will comprise direct flood defences (flood walls or embankments), flood storage (a potential upstream dam structure) tidal barriers/ gates and, potentially, some surface water management and drainage network measures to provide a 1 in 200-year standard of protection. While currently undefined, it may also incorporate some localised natural flood management (NFM) measures.

3.2 Scheme Objectives

A number of Project Objectives were established by the project design team to inform the FPS design process and to help the Scheme accord with Falkirk Council Local Development Plan Vision and Supporting Policies, particularly on sustainability⁷. For example, the Strategic Environmental Assessment for the main Issues Report of the upcoming Falkirk Local Development Plan (LDP2) identifies the “increased occurrence of extreme flooding events due to climate change and the adequacy of existing flood defence infrastructure”⁸.

The objectives are grouped under the topic headings as follows:

1.0 General

- To develop a Flood Protection Scheme (the Scheme) in accordance with measures set out in the Forth Estuary Flood Risk Management Strategy and Local Flood Risk Management Plan to reduce flood risk at Grangemouth (1.1)
- The Scheme will be promoted under the 2009 Act (1.2)
- The Scheme will consider all possible practical options for reducing flood risk (1.3)
- The Scheme will provide multiple benefits to the local community (1.4)

2.0 Social

- The Scheme meets the goals and values of Falkirk Council, namely by: (2.1):
 - further developing a thriving sustainable and vibrant economy;
 - continuing to improve the health, safety and wellbeing of citizens and communities;
 - increasing efforts to tackle disadvantage and discriminations;
 - enhancing and sustaining an environment in which people want to live and visit;
 - promoting public service, performance and partnership.
- The Scheme is aligned with Falkirk Council's priorities set out in the council's Corporate Plan and Service Plans (2.2)
- The Scheme is compliant with Falkirk Council's Community Plan and the Single Outcome Agreement (2.3)
- Community Benefits will be incorporated into the Scheme (2.4)

⁷ As set out in Section 1.4 of Falkirk Local Development Plan 2015 [online] Available at: <https://www.falkirk.gov.uk/services/planning-building/planning-policy/local-development-plan/docs/adopted-plan/01%20Adopted%20Plan.pdf?v=201508041042> (Accessed March 2017)

⁸ FALKIRK Local Development Plan2 Main Issues Report Environmental Report 2017 [online] Available at: <http://www.falkirk.gov.uk/services/planning-building/planning-policy/local-development-plan/plan-two/docs/sea/01%20Environmental%20Report.pdf?v=201702091209> (Accessed April 2018)

3.0 Economic

- The Scheme has a Benefit Cost Ratio (BCR) greater than one (3.1)
- An Economic Assessment is undertaken to evidence the economic benefit and cost associated with the Scheme, this assessment is produced prior to the outline design stage (3.2)
- The preferred Scheme represents the best value for money for the Council (3.3)
- The Scheme is delivered in line with the National Planning Framework Action Programme for the Grangemouth investment zone (3.4)
- The Scheme aims to increase development activity in the Falkirk / Grangemouth corridor such as Falkirk TIF initiative (3.5)
- The Scheme provides a platform for the regeneration of Grangemouth (3.6)

4.0 Environmental

- The Scheme achieves a neutral impact on the environment (4.1)
- The Scheme incorporates appropriate natural flood management (NFM) measures (4.2)
- The Scheme maximises environmental benefits (4.3)
- The Scheme is delivered sustainably with the followings aims (4.4):
 - minimise construction waste;
 - maximise reuse of materials;
 - adopt low carbon construction strategies;
 - minimise Carbon Footprint of the Scheme.

5.0 Hydraulic

- The Scheme reduces overall flood risk (5.1)
- The Scheme delivers the required level of protection (5.2)
- The Scheme will not materially increase flood risk to residential and non-residential properties in Grangemouth (5.3)

6.0 Technical

- The Scheme is technically viable (6.1)
- Residual flood risk will be documented and identified to Falkirk Council (6.2)

The objectives were agreed by the Council and used to inform a complex matrix based assessment of potential options, which included scoring criteria that were developed and agreed by a panel of representatives from the Council and other organisations.

3.3 Early Discounted Options

3.3.1 Long list discounted options

At the initial optioneering stage, a long list of potential options (and their sub-scenarios) were analysed at a high level and with reference to the Scheme objectives to discount those that were not considered to be feasible or reasonable, with the remainder being short-listed for more detailed appraisal.

Examples of reasons for discounting options from the long list included:

- failure to meet the majority of scheme objectives

- lack of hydraulic benefit;
- very high capital costs (>£100M per option);
- significant environmental, social or cultural heritage impact;
- lack of space to construct defences;
- technical constraints; and
- significant difficulties in construction of defences.

Some of the (additional) long list options that have been largely discounted as stand-alone options (some are considered further as part of other main options) are identified as follows:

Coastal Control Structures

Includes the following measures:

- Revetments
- Groynes
- Breakwaters
- Artificial Reefs
- Gates and Tidal Barriers

Due to the land take required and sensitive environmental classification of the Forth Estuary, coastal control measures are not thought to be practical as a standalone measure. However, revetments and a tidal barrier are currently being considered as part of a measure that is incorporated into the options in Cell 4.

Wave Attenuation

Includes the following measures:

- Beach Recharge
- Shingle Re-profiling
- Sand Dune Restoration
- Coastal Vegetated Shingle Restoration
- Machair Restoration

The above is deemed not practical due to the proximity to the port of Grangemouth and potential adverse impact on port operations.

Surge Attenuation

Potential for restoration of intertidal habitat, however, any creation of intertidal habitat would be viewed as mitigation / compensatory habitat to the direct / indirect impact on the Forth Estuary SPA site. From a flood management perspective, surge attenuation measures would not reduce flood levels due to the large land take required and fluvial influence on watercourse.

Sediment Management

Includes the following measures:

- Sediment removal (dredging) or other in-channel management
- Sediment traps
- Bank Restoration

No evidence of excessive sediment deposition in the channels, not sustainable without ongoing management plan, not cost effective; tidal influence on lower reaches of water courses makes

sediment removable unsustainable. All the existing banks are vegetated, due to high land use pressure (urban environment) there is limited available space for bank restoration.

Online and Offline Storage

Generally online and offline storage has been discounted as a standalone option due to insufficient space (due to land use pressure) to create storage areas capable of storing the volume of flood water required. However, online storage has been considered on the Westquarter Burn (tributary of the Grange Burn), more detail can be found in Section 3.9 of this report.

Modification of Conveyance

Includes the following measures:

- Channel modifications – deepen / widen channel
- Relief / Diversion Channel
- Realign Channel
- Culvert Modifications
- Removal of hydraulic constrictions
- Bridge Modifications

Due to the urban environment measures of modification to conveyance are limited. Bridge conveyance (and modification) are considered in the following short list section. The flood relief channel already exists on the Grange Burn and forms part of proposed options.

Fluvial Control Structures

Includes the following measures:

- Sluice gates / penstocks / flap valve
- Weir
- Trash Screens
- Pumping Stations

Due to the size and predicted flows on the water courses in the scope of works, it is not practical or feasible to install fluvial control measures. Some of the fluvial control measures will be re-assessed as secondary drainage measures.

Sustainable Urban Drainage Systems - SUDS

SUDS are deemed to offer no benefit in reducing flooding from fluvial or tidal sources due to the large predicted flows. SUDS will be re-assessed for the secondary drainage aspect of the scheme.

Watercourse Maintenance

Falkirk Council undertake regular watercourse inspections, and maintenance activity to ensure compliance with the FRMA.

Property Level Protection - PLP

PLP is not deemed practical as a standalone measure, however, when combined with other measures PLP will be re-assessed.

Flood Forecasting / Warning

SEPA have implemented a flood forecasting and warning system on the Rivers Carron, Avon and Grange Burn and the Forth Estuary.

Self Help

Includes raising awareness, development of Flood Action Group and Business continuity plans. These measures will not be standalone items but addressed through the scheme and promoted by Falkirk Council.

Emergency Plan

As a standalone item, it will not address flood risk. Falkirk Council already have an emergency flood plan; however, this will need to be updated to account for the scheme defences.

3.3.2 Short list discounted options

Flood Storage Areas – River Carron

Following an initial desk study using LIDAR survey data, two potential flood storage areas were identified directly upstream from the Carron Dams site and upstream from Stirling Road. These sites were identified due to natural morphology of the floodplain, which would allow water to be impounded if a dam structure was introduced across the channel. Approximately 3 km of structures (embankments) would also have been required around the FSA's to impound water in the FSA's and not increase flood risk elsewhere. Several constraining factors determined the size and shape of the storage areas including:

- Infrastructure – multiple A and B-Class roads are located around the boundary of the FSA's;
- Proximity to residential and commercial properties;
- Proximity to electrical Sub-Station;
- Culvert under M876 at Checkbar;
- Camelon Cemetery; and
- Land-fill site, next to 'Carron Works' site;

From analysing all the relevant information relating to flood storage on the River Carron, the project team put a proposal to the Project Board to not pursue this option on the grounds of:

- high construction costs when compared to the cost of direct defences only downstream;
- substantial feasibility risks from utility companies;
- requires feasibility studies to be undertaken by SGN, National Grid and Scottish Power – cost estimate for initial feasibility studies is £100K, but likely to increase. Due to the significant risks associated with diverting and working close to major utility apparatus, there is the potential for feasibility studies to identify no suitable alternative locations to divert utility apparatus, and
- proximity of FSA 1 to Scheduled Monument (Roman Camps) would require Scheduled Monument consent.

Bridge Removal on River Carron

From the initial baseline model runs, the hydraulic capacity of the Stenhouse Road and Carron Road (B902) Bridges were identified as causing a hydraulic jump (restricting flow under the bridge causes the water level in the channel to rise upstream of the bridges) to flows. Three scenarios were modelled relating to the size of the bridge openings:

- removing the bridges,
- installing a relief culvert (3 x 2.5m), and
- raising the bridge decks.

All three scenarios had a positive (reduction) impact on water level in the channel upstream, however, the reduction was not sufficient to stop water in the channel over topping the existing banks. The feasibility of all three scenarios would have a significant impact on the local road network

(numerous utilities are located on Carron Bridge). To reduce water levels in the channel (and avoid the need for direct defences) upstream of the bridges would require the bridge openings to be significantly enlarged.

Bridge Removal on Grange Burn

Numerous bridges cross the Grange Burn through Grangemouth, due to the confined urban environment there is little opportunity to alter the level of the bridge decks as any changes to the bridge deck level would require the elevation of the surrounding roads to change which is not practicable.

Pipe Bridge Removal

Numerous pipe bridges cross the Rivers Carron, Avon, Grange Burn and Flood Relief Channel, due to the

- size (up to DN 900);
- some pipes are strategic mains, others are related to the petrochemical plant and are pressurised up to 50-bar; and
- number of pipe bridge crossings;

It is not feasible to move or divert pipes. For the purposes of this option appraisal all pipe bridge crossings are to remain in-situ. The proposed flood defences will be integrated with existing pipe bridges.

3.3.3 Natural Flood Management (NFM)

Through the Flood Risk Management (Scotland) Act 2009; the Flood Risk Management Strategies identify NFM as not appropriate for PVA 10/11 (Grangemouth). NFM measures are not being considered as a standalone option as part of the FPS, however, they will be considered on the grounds of habitat creation and biodiversity improvements. The calculated peak flows for the catchments of the Rivers Carron, Avon and Grange Burn identified limited opportunities for NFM. The primary reasons for not including NFM as a standalone option are:

- difficult to quantify the reduction in flood risk;
- difficult to quantitatively assess the benefits and include in Scheme cost benefit ratio;
- no clear guidance on funding NFM measures;
- lower reaches (large sections of Grangemouth residential and commercial areas and petrochemical plant) of all three catchments are tidal, NFM provides no reduction in flood levels here;
- require buy-in from land owners and cultural change in land management practices, and
- limited impact of NFM reducing peak flows in the Rivers Carron, Avon and Grange Burn due size of catchment and predicted flows,

Runoff Control

Includes the following measures:

- Woodland planting
- Land Management – soil and bare earth improvement, change of agriculture in field drainage
- Cross slope woodlands
- Creation / restoration of wetlands / pond
- Upland drain blocking

- Gully woodland planting

Rejected due to the relatively short length and flat morphology of the catchments; land use within the catchments is predominantly moorland with arable farming along the lower reaches. The local Flood Risk Management Strategy identifies runoff control as not being practical for the size of water courses in the scope of the works.

River / Floodplain Restoration

Includes the following measures:

- Floodplain reconnection
- Placed large woody debris and boulders
- Floodplain woodland
- Riparian woodland
- Reach restoration
- Creation of wash lands (off-line storage)

The potential for floodplain reconnection through small scale channel realignment of a section of the Rivers Carron and Avon was considered in the long-list options. Large scale river and floodplain restoration measures are not deemed to be suitable principally due to land use pressure. The local Flood Risk Management Strategy identifies River / Floodplain restoration as not being practical for the water courses within the scope of works.

Further discussions with Scottish Government / SEPA / SNH and land owners is required, with reference to the River Carron catchment, which may result in NFM being considered for part of the Scheme design at the outline design stage, or on some of the smaller tributaries that join the main watercourse (Rivers Carron, Avon and Grange Burn).

It is however difficult to quantify the financial benefit of implementing NFM measures, as NFM on its own will not remove the need for flood protection measures in Grangemouth, but could offer multiple benefits through the creation of habitat and biodiversity improvements.

3.4 Measures Proposed

3.4.1 Introduction

A final outline design of the Scheme has not yet been agreed, however, a wide range of potential options has been explored and assessed through an optioneering process and the remaining area still subject to optioneering process relates to Flood Cell 4 (see Figures A7 and A8 in Appendix A).

The EIA Report shall include a full summary of the optioneering process undertaken for the Scheme, while an Options Appraisal Report shall form part of the suite of design documents submitted to the consultative bodies and the public once the outline design process is complete.

With the exception of Flood Cell 4, the measures presented here are likely to form part of the final Scheme, subject to more detailed appraisal, public and consultee feedback and any technical, environmental or economic constraints identified during the EIA process. For Flood Cell 4, the baseline model is currently being revised to account for updated, upstream flow paths in the Westquarter and Polmont Burns to gain a better understanding of the catchment. Potential floodplain storage and flow paths south of the M9 are therefore being explored and consultation is underway with Falkirk Council, HES and other stakeholders to determine the most appropriate option or combination thereof to progress.

The main defences under consideration are illustrated in Figures A4 to A10 in Appendix A and include a combination of the following engineered interventions:

- Flood walls: Where space is restricted and embankments aren't possible, concrete flood walls with sheet pile seepage control are proposed. Where required, flood gates or ramps will be used to facilitate access through the walls.
- Earth embankments: Where possible, clay-core embankments will be preferred over walls due to cost, sustainability (associated carbon emissions), biodiversity and landscape impacts. Likewise, flood gates or ramps will be used to facilitate access through the embankments.
- Flood storage areas: Where possible, upstream and/or online flood storage Cell 4 - including a tidal barrier option, flow control structures and an embanked dam.

The following subsections outline the measures as proposed for each of the flood cells and in the context of the surrounding location. The specific heights at each section will be subject to refinement as the design progresses, and potential impacts on views and landscape shall be considered in more detail within the Landscape and Visual Effects chapter of the EIA Report.

3.5 Flood Cell 1 – Upper Carron

3.5.1 Introduction

Figure A4 in Appendix A sets out the defences proposed (wall or embankment) with heights ranging from 0.5m – 2.5m above existing embankment / ground levels.

The following sub-sections provide detail on each section.

3.5.2 Stirling Road

Flooding at this section adversely affects the large bus depot to the south of the main road as well as commercial premises and two residential properties between Stirling Road and the river.

The defences proposed in this section are approximately 520 m in length along Stirling Road from GR: NS 86147 81668 to NS 86547 81329 (Figure 3-1).

The currently proposed alignment follows the northern verge of the main road (Figure 3-2), which may require the removal of an established hedgerow along the property boundary.

It is noted that the defences as currently proposed would not protect the riverside properties from flooding, however, further ground investigation works will be undertaken in this area to assess whether the alignment can feasibly be situated along the watercourse (Figure 3-3).



Figure 3-1: Cell 1_1 Stirling Road (Yellow arrows indicate position and direction of photos)



Figure 3-2: View looking northwest along Stirling Road (GR: NS 86389 81473)



Figure 3-3: View looking east along property boundary (GR: NS 86308 81557)

3.5.3 Bainsford

The second section is approximately 2.0 m high, located in the village of Bainsford (north Falkirk) and runs approximately 264 m from GR: NS 88077 82032 to NS 87988 82263 (Figure 3-4).

The alignment at this location follows the boundary of a housing estate, with the southerly extent likely to form an embankment along the edge of the existing footpath. At the corner of the housing estate, it is anticipated that the defences will tie into higher ground, rather than follow the edge of the housing estate as presented in Figure 3-4.



Figure 3-4: Cell 1_2 Bainsford (Yellow arrow indicates position and direction of photo)



Figure 3-5: View looking northwest along footpath (GR: NS 88048 82105)

3.5.4 Bainsford / Carron

The third series of defences straddle the River Carron between Bainsford and Carron and vary in height (0.5 – 2.5 m; Figure A4 in Appendix A). The section to the south of the river is approximately 390 m long and runs from NS 87998 82293 to NS 88363 82382 (Figure 3-6). The sections on the north of the Carron cover approximately 430 m from GR: NS 88007 82357 to NS 88429 82453.

Along the southern section at Bainsford, there is an existing embankment, which will be assessed to identify whether it needs maintained or replaced. To the east, the alignment follows the riverside footpath and will comprise a raised embankment or flood wall, which will tie in to the Stenhouse and New Carron Road Bridges. At the Stenhouse Road bridge, there is a culverted outfall which drains through a small burn into the Carron (Figure 3-7).

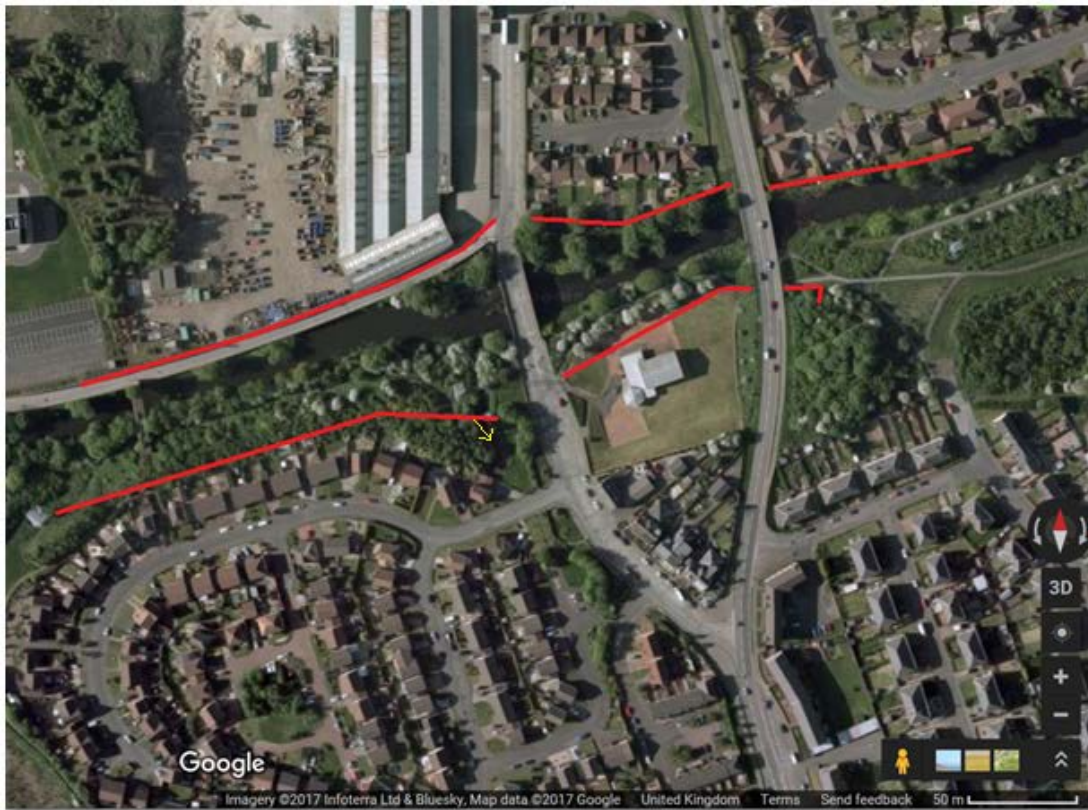


Figure 3-6: Cell 1_3 Bainsford / Carron (Yellow arrow indicates position and direction of photo)



Figure 3-7: View looking southeast toward outlet of culverted watercourse (GR: NS 88193 82328)

3.5.5 Carron

The final sections in Cell 1 are to the east of Carron and vary in height from approximately 1.0 to 1.5 m (Figure 3-8). The first section is approximately 350 m long and 1.0 m high and starts behind the Carrondale Nursing Home (Figure 3-9; GR: NS 88959 82730) and follows the bank of the river to the mouth of the Chapel Burn (Figure 3-10; GR: NS 89032 82963), where it turns west and follows the

burn to tie into the bridge at Carronshore Road (GR: NS 88873 83010). The final section is approximately 710 m long and 1.5 m high and traverses a meander in the river from near Gillfillan place (GR: NS 89265 82760) to Dock Street (GR: NS 89476 82755), where it turns north and follows the river bank at a height of c. 1.0 m around the meander to GR: NS 89750 82854 (Figure 3-11).



Figure 3-8: Cell 1_4 Carron (Yellow arrows indicate position and direction of photos)



Figure 3-9: View looking south along bankside properties (GR: NS 88993 82824)



Figure 3-10: View looking east along Chapel Burn (GR: NS 88979 82996)



Figure 3-11: View looking northeast along rear of properties at Carron (GR: NS 89491 82920)

3.6 Flood Cell 2 - Carron Lower

Figure A5 in Appendix A and Figure 3-12 below set out the defence alignment as proposed (wall or embankment) with heights ranging from 1.0 m – 1.5 m above existing embankment / ground levels. From the west, the defences will form a continuation of those developed as part of the completion of the Forth and Clyde Canal (Figure 3-13). The alignment will then follow an existing desire line along the rear of industrial properties and potentially through land currently occupied by a building that may be demolished (Figure 3-14).

The alignment then follows the estuary line at the rear of various industrial properties and across Grangemouth Marina (Figure 3-15).



Figure 3-12: Flood Cell 2 Carron Lower (Yellow arrows indicate position and direction of photos)



Figure 3-13: View looking west along defences at new section of Forth and Clyde Canal (constructed after aerial shown in Figure 3-12) (GR: NS 91437 82319)



Figure 3-14: View looking east toward building that may be demolished (GR: NS 91807 82244)



Figure 3-15: View looking east toward industrial buildings and Grangemouth Marina (GR: NS 92272 82651)

3.7 Flood Cell 3 - Harbour

Figure A6 in Appendix A and Figure 3-16 below indicate the proposed defence alignment at this section, which ranges in height from 0.5 to 1.5 m above existing embankment / ground levels. The northern section of defences stretches some 2.5 km along the existing estuary embankment at North Shore Road (Figure 3-17 GR: NS 92842 82661), where the defence height shall be approximately 1.5 m. From GR: NS 93645 82753, the defence height will be approximately 0.5 m and will rise to 1.5 m until the point where it ties into higher ground at GR: NS 94650 83877.

The second section of proposed defences are some 1.6 km in length and will start at GR: NS 94861 83943. The proposed defence follows the contour of the peninsula into the mouth of the Grange burn and terminates at GR: NS 94819 82858 (Figure 3-18), with heights rising from 1.0 to 1.5 m in height.



Figure 3-16: Flood Cell 3 Grangemouth Docks (Yellow arrows indicate position and direction of photos)



Figure 3-17: Viewpoint 5 looking southwest along the channel at harbour west (GR: NS 94331 83484)



Figure 3-18: View looking northeast along the estuarine water of the Grange Burn (GR: NS 94819 82858)

3.8 Flood Cell 4 – Option A: Westquarter Burn & Grange Burn (preferred option)

3.8.1 Introduction

As illustrated in Figure A7 in Appendix A, the first option for flood defences within Cell 4 comprise floodwalls and earth embankments ranging in height from 0.5 to 1.5 m in height (above existing embankment / ground levels) as well as a tidal barrier, dam (4.4 m high) and emergency flood storage area. The following sub-sections present the various defence alignments across this flood cell.

3.8.2 Grangeburn Road

The first section of the Cell 4 is located north from Bo’Ness Road and comprise two defence structures, a floodwall/embankment and tidal barrier (Figure 3-19). The floodwall/embankment is approximately 0.6 km long and 1.0 m above the existing embankment level and starts at GR: NS 94013 82174, extending along the Grange Burn Road. It is anticipated that the existing trees will require removal. The wall/embankment terminates at GR: NS 94540 82474, just short of the proposed Tidal Barrier, which is located at GR: NS 94578 82536.



Figure 3-19: Cell 4 Grangeburn Road (Blue tiled dot indicates position of tidal barrage)

3.8.3 Grangemouth Town Centre

The second section of the Cell 4 is located within the central part of the Grangemouth Town, south from Bo Ness Road and near Zetland Park, as illustrated in Figure 3-20. This section comprises three individual floodwall/embankments, with heights ranging from 0.5 to 1.0 m in height above existing levels.

Two floodwall/embankment structures approximately 170.0 m long and 1.0 m higher than existing bund level will extend along both sides of the Grange Burn. The structure to the east of the burn runs along Abbots Road from GR: NS 92935 81809 to NS 92892 81656. To the west, the wall/embankment extends along the Park Road from GR: NS 92962 81864 to NS 92919 81703.

There is also a small structure of approximately 70.0 m in length and 0.5 m in height extending along the Abbots Road from GR: NS 92864 81551 to NS 92845 81485 (Figure 3-21). Defences here are likely to require the felling of some of the distinctive mature trees lining the burn.



Figure 3-20: Cell 4 Grangemouth Town Centre and Zetland Park (Yellow arrow indicates position and direction of photo)



Figure 3-21: View looking north along Grange Burn at Abbot's Road (GR: NS 92846 81487)

3.8.4 Rannoch Park

Figure 3-22 illustrates the location of defences to the north of the M9 carriageway and along the Rannoch Park. There are three defence structures proposed as part of this section, including a flood control structure and floodwall/earth embankment. The flood control structure shall be located at the confluence of the Grange Burn and the Polmont Burn at GR: NS 92623 79850 (Figure 3-23). The northern defence wall/ embankment is approximately 550 m long along Rannoch Road and runs from terminating at GR: NS 93140 79772 (Figure 3-24). The southern wall/embankment extends from GR: NS 92850 79737 to NS 93135 79761 for approximately 340 m, and follows the line of the A905 road. Both walls/ embankments shall be approximately 1 m high above existing levels.



Figure 3-22: Cell 4 Rannoch Park (blue dot indicates flow control structure) (Yellow arrows indicate position and direction of photos)



Figure 3-23: View looking south toward location of proposed flow control structure (GR: NS 92621 79866)



Figure 3-24: View looking west along the Grange Burn at Rannoch Park (GR: NS 93143 79762)

3.8.5 Wholeflats Road

As shown in Figure 3-25, the proposed walls/embankments within the fourth section are located on the banks of the Grange Burn Flood Relief Channel (FRC) and run along the Inchyra Road and Wholeflats Road (A905) to the point where the burn discharges into the River Avon. The longest structure shall be 1.5 m above existing embankment level and follows the line of the A905 road for approximately 710 m, from GR: NS 93185 79756 to NS 93773 79928.

The next section of approximately 130 m in length and 1.0 m in height extends to the south of Wholeflats road, along Smiddy Brea from GR: NS 9478579785 to NS 9482279844. A high-pressure pipeline crosses the alignment here (Figure 3-26).

The section around the northeast section of the Macdonald Inchyra Hotel will be 1.5 m above existing levels and approx. 210 m long from NS 93630 79663 to NS 93524 79765 (Figure 3-27).

The next section along Wholeflats Road will be 0.5 m above the height of the existing embankment for approximately 595 m from GR: NS 93861 79900 to NS 94350 79775 (Figure 3-28).

The final section to the southeast will be 400 m long and 0.5 m high and will protect various properties and an equestrian centre along Millhall Burn at Reddoch Road (Figure 3-29) and the Grange Burn FRC (Figure 3-30) (GR: NS 94215 79712 to NS 94294 79622).



Figure 3-25: Cell 4 Wholeflats Road (A905) (Yellow arrows indicate position and direction of photos)



Figure 3-26: Location where proposed defences cross high-pressure pipeline (GR: NS 93702 79905)



Figure 3-27: view looking east along alignment at Inchyra MacDonald Hotel (GR: NS 93534 79769)



Figure 3-28: View looking east along Grange Burn FRC at Wholeflats Road (GR: NS 93726 79926)



Figure 3-29: View looking east along Millhall Burn at Reddoch Road (GR: NS 94286 79619)



Figure 3-30: View looking north along Grange Burn FRC at the end of Reddoch Road (GR: NS 94361 79780)

3.8.6 Westquarter Burn Storage

Defences proposed for the fifth section of the Cell 4 comprise an embanked spillway and flood storage area, as illustrated in Figure 3-31. The proposed embankments here will be up to 4.4 m in height and will be some 140 m long (GR: NS 92203 79405 to NS 92319 79299). The embankments will tie-in to existing topography to allow for the emergency storage of water from the Westquarter Burn during more extreme events. Figure 3-32 provides a photomontage view toward the embankment from a raised section to the northwest of the storage area (GR: NS 92269 79556).



Figure 3-31: Alignment of embankments (purple) and extent of (emergency) flood storage area (blue hatch) (Yellow arrow indicates position and direction of photo)



Figure 3-32: Photomontage view looking south showing alignment of embankment (purple line) (GR: NS 92269 79556)

3.9 Flood Cell 4 – Option B: Grange Burn

As illustrated in Figure A8 in Appendix A, the proposed flood defences for the second option within the Cell comprises floodwalls and earth embankments of heights ranging from 0.5 to 1.5 m above the existing embankment or ground levels. Locations of the individual structures are discussed in more details in the following sub-sections.

3.9.1 Grangeburn Road

The first section of the Cell 4 is located north from Bo’Ness Road and comprises two floodwalls / earth embankments that extend on banks of the Grange Burn, as shown in Figure 3-33. The shorter structure is 1 m high and runs along the South Shore Road for approximately 280 m from GR: NS 93033 82120 to NS 93309 82103 (47Figure 3-34). The longer wall / embankment is split into two sections and follows the line of the Grangeburn Road (Figure 3-35). The first section will increase the height of the existing embankment by 1 m and will extend from the crossroads of Bo’Ness Road and Grangeburn Road (GR: NS 93000 81993) to a bridge at Powdrake Road (GR: NS 93000 81993) for a length of approx. 830 m. The second section is 1.5 m high and starts immediately after the bridge (GR: NS 93000 81993) and runs for approximately 1.15 km along the north-east boundary of the Oil Refinery, where it terminates at GR: NS 94752 82657 (Figure 3-36).



Figure 3-33: Cell 4 Grangeburn Road (Yellow arrows indicate position and direction of photos)



Figure 3-34: View looking east along Grange Burn and S Shore Road (GR: NS 93033 82115)



Figure 3-35: View looking east along Grange Burn and Grange Burn Road (GR: NS 93031 82091)



Figure 3-36: View looking east along Grange Burn at end of Grange Burn Road (GR: NS 93763 82096)

3.9.2 Grangemouth Town Centre

The second section of the Cell 4 is located within the central part of the Grangemouth Town, south from Bo'Ness Road and adjacent to the Zetland Park, as illustrated in Figure 3-37. This section comprises embankments or floodwalls, with heights ranging from 0.5 to 1.5 meters either above existing embankment height (along the burn) or from ground level (around the park).

The western embankment of the Grange Burn shall be raised by 1.5 m and extend along Abbots Road for approx. 870 m from Bo'Ness Road (GR: NS 92975 81988) south along the burn to the Grangemouth Sports Complex (GR: NS 92975 81988) (Figure 3-38).

The eastern section shall run from Bo'Ness Road (GR: NS 93001 81973) along Park Road into Zetland park boundary for approx. 1.6 km, with heights ranging from 1.0 to 1.5 m above existing embankment or ground level. It is noted that the majority of the alignment along the Grange Burn or the perimeter of the park coincides with avenues of mature trees, which may require removal at some locations (Figure 3-39).

Within the park, ramps or floodgates would have to be developed at access gates (Figure 3-40).



Figure 3-37: Cell 4 Grangemouth Town Centre and Zetland Park (Yellow arrows indicate position and direction of photos)



Figure 3-38: View looking south along Abbots Road at Grange Burn (GR: NS 92912 81723)



Figure 3-39: view looking south along tree-lined footpath next to Drummond place (GR: NS 92988 81605)



Figure 3-40: view looking south toward park access at Abbotsgrange Road (GR: NS 93080 81192)

3.9.3 Burnbank Road and Rannoch Park

Figure 3-41 illustrates the alignment along Grange burn from Burnbank Road into Rannoch Park. There are two defence walls / embankment proposed as part of this section, ranging from 0.5 to 1.0 m above the height of existing embankments. The embankment section along the west bank of the Grange Burn at Burnbank Road (Figure 3-42) will measure approx. 820 m (GR: NS 92653 80612 to GR: NS 92613 79836). The embankment along the east of the Grange Burn runs from GR: NS 92639 80778 to (GR NS 92631 79862). The embankment within Rannoch Park (Figure 3-43) terminates before Inchyra Road at GR: NS 93140 79772. This defence structure is approx 1.5 km long and between 0.5 and 1.0 m high.



Figure 3-41: Burnbank Road and Rannoch Park (Yellow arrows indicate position and direction of photos)



Figure 3-42: View south along existing embankment at Burnbank Road (GR: NS 92654 80547)



Figure 3-43: View looking east along existing embankment at Rannoch Park (GR: NS 92730 79892)

3.9.4 Wholeflats Road

Figure 3-44 illustrates the variation in defences of this option, where the proposed walls/embankments follow the banks of the Grange Burn FRC at approximately 0.5 m above existing embankment height and follows the line of Inchyra Road to Wholeflats road (A905) for approximately 710 m from GR: NS 93185 79756 to NS 93773 79928.

The final section to the southeast will be 250 m long and 0.5 m above existing levels and will protect various properties and an equestrian centre along Millhall Burn at Reddoch Road (Figure 3-29) and the Grange Burn FRC (Figure 3-30) (GR: NS 94348 79674 to NS 94185 79782).



Figure 3-44: Cell 4 Wholeflats Road (A905) (Yellow arrows indicate position and direction of photos)

3.10 Flood Cell 5 – River Avon

3.10.1 Introduction

Figure A9 in Appendix A sets out the defences proposed (wall or embankment) showing approximate maximum heights above existing levels (0.5 m – 2.0 m) along the River Avon and at Wholeflats Road.

Defences in this flood cell are predominantly located within the refinery and will protect this infrastructure and equipment. The alignment mainly follows the banks of the Avon

3.10.2 Wholeflats Road

Figure 3-45 illustrates the proposed defences along Wholeflats Road (A905), which extend approximately 197 m from GR: NS 94663 79776 to NS 95115 79840 with approximate heights ranging from 1.0 to 2.0 m above existing levels.

A small section of approximately 70.0 m in length and 0.5 m in height extends to the north of Wholeflats road from GR: NS 9478579785 to NS 9482279844.

Another 38.0 m section is proposed to the south of the River Avon from GR: NS 9478479722 to NS 9482079710 with a height of 1.5 m. This section will tie into bridge C51/20 (Figure 3-46) and may be constrained by a high-pressure pipeline that crosses the river at the bridge (Figure 3-47).



Figure 3-45: Cell 5_1 Wholeflats Road (A905) (Yellow arrows indicate position and direction of photos)



Figure 3-46: View looking east at bridge C51/20 (GR: NS 94781 79722)



Figure 3-47: High pressure pipeline excavation warning (GR: NS 94776 79789)

3.10.3 River Avon at Wholeflats Road

The second section varies between approximately 0.5 m to 1.0 m high, it is offset to the west of the River Avon and runs approximately 1.2 km from GR: NS 94439 79689 to NS 94837 80441 (Figure 3-48). The southernmost section follows the river bank to the rear of the stables (Figure 3-49).

On the eastern banks of the River Avon the proposed defence is up to 0.5 m high, approximately 620 m long between NS 94773 79794 and NS 94656 80336, and a small 27.0 m section between GR: NS 94823 80368 and NS 94848 80376.



Figure 3-48: Cell 5_2 River Avon at Wholeflats Road (Yellow arrow indicates position and direction of photo)



Figure 3-49: View looking south along river bank at rear of Smiddy Mill stables (GR: NS 94405 79718)

3.10.4 River Avon

The defences proposed on the second stretch of the River Avon are shown in Figure 3-50. The defences run along the banks of both sides of the River Avon. On the northern side (between GR: NS 94864 80449 and NS 95570 81192) the alignment stretches approximately 457 m, with heights ranging from 1.0 – 1.5 m above existing levels.

On the southern side of the river, the defences are split into three sections between approximately GR: NS 94876 80388 and NS 95442 80505, between GR: NS 95536 80565 and NS 95565 80822 and GR: NS 95554 80842 and NS 95719 80932 ranging in height between 0.5 m to 2.5 m. A photo of the easterly section is presented in Figure 3-51.



Figure 3-50: Cell 5_3 River Avon (Yellow arrow indicates position and direction of photo)



Figure 3-51: View looking west toward refinery (GR: NS 95974 80976)

3.11 Flood Cell 6

3.11.1 Introduction

Figure A10 in Appendix A sets out the defences proposed (wall or embankment) with heights (1.5 m – 3.0 m above existing levels) along the oil refinery and the river mouth of River Avon and Forth.

This section is publicly accessible and is predominately used by dog walkers. Defences here would protect the sewage works and parts of the refinery around the mouth of the Avon.

The following sub-sections provide detail on each section.

3.11.2 Oil Refinery

The defences proposed in this section are approximately 1.4 km in length along the boundary of the oil refinery and the mouth of the River Avon and Forth from approximately GR: NS 95103 82439 and NS 95544 81097 at heights between 1.5 m and 3.0 m above existing levels (Figure 3-52).

The coast line here demarcates the boundary of the Firth of Forth SPA (see Chapter 5: Biodiversity) and parts of the existing salt marsh and mud flats are used as roosting and feeding habitat, while an outfall discharges cooling water into the estuary (Figure 3-53 and Figure 3-54).

Toward the southern section, defences are aligned along an existing embankment, which borders the tidal mud flat (Figure 3-55).



Figure 3-52: Cell 6_1 Oil Refinery (Yellow arrows indicate position and direction of photos)



Figure 3-53: View looking southeast along the existing embankment and the section of saltmarsh (GR: NS 95113 82424)



Figure 3-54: View looking northwest over the cooling water outfall channel (GR: NS 95312 82197)



Figure 3-55: View looking north along the bank of the River Avon (GR: NS 95828 81394)

3.11.3 Sewage Works

The defences proposed for this section are located to the south of the mouth of the River Avon within the vicinity of the sewage works (Figure 3-56). The defences extend some 1.26 km from NS 95739 80922 to NS 96754 80815 varying in height from 3 – 2 m.



Figure 3-56: Cell 6_2 Sewage Works (Yellow arrows indicate position and direction of photos)

The easterly section will tie into an existing embankment to the northeast of the sewage plant (Figure 3-57), while to the west of the plant, the defence alignment follows the edge of the access track (Figure 3-58).



Figure 3-57: View looking southwest toward existing embankment and sewage plant (GR: NS 96313 81086)



Figure 3-58: View looking south along defence alignment at sewage plant (GR: NS 96139 81188)

Population and Human Health

4.1 Introduction

Population and Human Health is a new environmental factor that has been introduced to EIA via amendments to the EIA Directive⁹ and the transposed 2017 FRM Regulations. In addition, Section 2A (4) of the FRM Regulations introduce a requirement to assess “*expected effects deriving from the vulnerability of the Scheme to risks, so far as relevant to the Scheme, of major accidents and disasters.*”

Current guidance on what specific issues should be assessed states that “*The Directive does not define ‘population and human health’ but an understanding of the scope of these terms is clearly important in delineating the types of issues that must be covered to ensure that health is properly and proportionately considered*”¹⁰.

A summary of the principles to be considered that are identified within the guidance (pg. 17) is as follows:

Comprehensive approach to health: Consider physical, mental and social wellbeing and their inter-relationships.

Proportionate: Focus on whether the potential impacts are likely to be significant, with effort focussed on identifying and gaining commitment to avoiding or reducing any adverse effects and enhancing beneficial effects.

Consistency: Should be in accordance with up-to-date policy, guidance and scientific consensus.

Equity: The distribution of health impacts across the population should be considered, paying specific attention to vulnerable groups.

Reasonableness: The assessment process should follow an acceptable, explicit logic path and retain common sense in applying relevant guidance.

In accordance with these principles, the following factors are considered in determining the scope of assessment for this EIA Topic:

- Human Health - defined in relation to the extent to which the FPS may influence risk of disease, ill-health, injury or death are considered in the context of long term reduction in direct and indirect risks to humans associated with flood events and potentially consequent disaster risks as well as safety risks during construction.
- Well-being – in relation to the avoidance of stress or anxiety associated with flood events and any adverse impacts relating to disruption and access during construction to facilities (e.g. hospitals, health centres) and recreation opportunities (e.g. fishing, footpaths, green spaces). Identifying opportunities to mitigate or off-set adverse impacts of the Scheme by realising enhancement opportunities within the construction footprint and across the public realm. Opportunities to enhance and encourage the use of green spaces and active transport may also be explored.

⁹ EC 2015 ‘Review of the Environmental Impact Assessment (EIA) Directive’ [online] Available at: <http://ec.europa.eu/environment/eia/review.htm> (Accessed 11/09/2017)

¹⁰ IEMA 2017 ‘Health in Environmental Impact Assessment A Primer for a Proportionate Approach’ [online] Available at: <https://www.iema.net/assets/newbuild/documents/IEMA%20Primer%20on%20Health%20in%20UK%20EIA%20Doc%20V11.pdf> (pg. 5; Accessed 11/09/2017)

- Economy – high-level appraisal of the potential economic impacts of the Scheme (e.g. future damages avoided; opportunities for local employment; potential disruption to businesses during construction).
- Inequality – high-level appraisal of deprivation indicators to appraise impact on particularly deprived populations across the study area.

With regard to undertaking a formal Health Impact Assessment (HIA), guidance published by the Health Impact Assessment Network¹¹ propose the criteria to be considered when screening a project, namely:

- *Who may be affected by a proposal?*
- *Will there be differential impacts?*
- *What determinants of health and wellbeing could be affected?*
- *What further evidence is needed to inform recommendations?*

This Chapter therefore includes an initial screening of the project in relation to these questions and provides a view as to whether a formal HIA should be undertaken to support the EIA.

Issues that are of relevance to the themes of this factor and effects on people's health and well-being, but which will be addressed in more detail in other chapters of the EIA Report include:

- Natural heritage impacts (See Chapters 5 And 8);
- Noise and vibration impacts (See Chapter 6);
- Landscape and visual impacts (See Chapter 7);
- Climate change (See Chapter 8 And 10);
- Land-Use, Soils and Land Contamination (See Chapter 9);
- Cultural Heritage Impacts (See Chapter 11); and
- Transportation Network Impacts (See Chapter 12).

4.2 Baseline

4.2.1 Introduction

Baseline socio-economic data for the study area has been gathered as part of a desktop study of available information on factors from a range of sources including online resources including Falkirk Council, The Scottish Government, Visit Scotland and the Scottish Index of Multiple Deprivation (SIMD)¹².

4.2.2 Health and well-being

No evidence of flood-related illness, injury or death could be found for the Grangemouth area in the above-referenced sources or from an online search of media sources. It is noted however that, in recorded or anecdotal history, the local population has not yet been subjected to the severity of flood event that the Scheme design shall protect against (i.e. 1 in 200-year event).

A Scottish Government publication on the social impacts of flooding¹³ lists some of the effects associated with flood events on people's health including:

¹¹ Douglas M. 2009 'How to do Health Impact Assessment: a guide for practitioners' Scottish Health Impact Assessment Network, Scottish HIA Network March 2009

¹² Online. Available at: <http://simd.scot/2016/#/simd2016/BTTTTT/9/-4.0000/55.9000/> (Accessed July 2016; Updated August 2016)

¹³ Werrity et al. 2007 'Exploring the Social Impacts of Flood Risk and Flooding in Scotland' [Online] Available at: <http://www.gov.scot/Publications/2007/04/02121350/8> (Accessed 23/11/2017)

- tangible impacts: relating to material losses such as changes in property values or lost earnings;
- intangible impacts: relating to non-material and/or emotional losses such as trauma, anxiety or stress and associated long-term health impacts (particularly among the elderly or vulnerable), as well as disruption and inconvenience in leaving one's home and dealing with builders or decorators.
- immediate impacts
- lasting impacts.

Anecdotal reports of “*fear and worry*” were reported in local newspapers among victims of the flood event of October 2006¹⁴, while less tangible health impacts have been reported in various newspaper reports and general literature on human impacts of flooding (e.g. stress and anxiety associated with uncertainty, damage, silt and waste in the public realm, insurance claims, disruption to transport). Such concerns may be experienced by people exposed to flood risk across the area, and intangible impacts are more likely to increase as the frequency and severity of flood events increase with climate change¹⁵.

The SIMD data reveal that two parts of the Scheme boundary area that are exposed to flood risk are ranked in the bottom 10% in relation to health, namely, a section of Bowhouse and a section of Bainsford and Langlees in Grangemouth (see Table A2 in Appendix A).

Access to key facilities and recreational opportunities that may be considered to maintain health and contribute to well-being shall be reviewed as part of the EIA. There is only one public service property that is located within a 50 m buffer of the Scheme footprint, Avondale Care Home, located at Beaumont Drive, Carron, Falkirk, FK2 8SN (Grid Ref. NS 88915 82701), while the key recreational facilities and greenspaces within the vicinity of the Scheme include those set-out in Table 4-1 below.

Table 4-1: Summary of Greens Spaces and recreational features that are likely to be impacted by the Grangemouth FPS.

Cell	Recreation feature	Location	Comment
Cell 1	Falkirk Golf Course	35 Stirling Rd, Camelon, Falkirk FK1 4EP Grid Ref: NS 86752 80910	Alignment in proximity of the feature; Potential impacts arising from the construction phase.
	Sport Facilities	A9, Camelon, Falkirk FK2 7YP Grid Ref: NS 86969 80955	Alignment in proximity of the feature; Potential impacts arising from the construction phase.
	Burnside Park & Playing Fields	175-183 Carronshore Rd, Carron, Falkirk FK2 8EW Grid Ref: NS 88711 83022	Alignment in proximity of the feature; Potential impacts arising from the construction phase.
Cell 2	Dalgrain Park & Sport Facilities	12-14 Avon St, Grangemouth FK3 8XL Grid Ref: NS 91162 82103	Alignment in proximity of the feature; Potential impacts arising from the construction phase.
Cell 4	Bowling Green	58 Talbot St, Grangemouth FK3 8HU Grid Ref: NS 92912 81917	Alignment in a proximity of the feature; Potential impacts arising from the construction phase.
	Zetland Park and Playing Fields	35 Abbotsgrange Rd, Grangemouth FK3 9JD Grid Ref: NS 93001 81387	Alignment encroaches into the feature boundaries; Potential impacts arising from the construction and operational phase.

¹⁴ Online. Available at: <http://www.ross-shirejournal.co.uk/News/Worst-flooding-in-40-years-780.htm> (Accessed October 2017)

¹⁵ See e.g. SEPA 2017 [Online]: <https://www.sepa.org.uk/environment/climate-change/> (Accessed April 2018)

Cell	Recreation feature	Location	Comment
	Rannoch Park and Playing Facilities	1 Rannoch Rd, Grangemouth FK3 0JE Grid Ref: NS 92923 79826	Alignment encroaches into the feature boundaries; Potential impacts arising from the construction and operational phase.
	Galaxy Sports Facilities	Wholeflats Rd, Grangemouth FK3 9UY Grid Ref: NS 93945 79796	Alignment encroaches into the feature boundaries; Potential impacts arising from the construction and operational phase.
Cell 5 & 6	River Avon Fishing & Angling	Extent of the River Avalon from the Firth of Fort Estuary (Grangemouth) to	Fishing activities undertaken on the river Avon, however none have been identified within the Cells' boundaries; As such, no direct impacts on Fishing activities are envisaged.

In addition, woodland areas can improve the quality and setting of urban areas and provide woodland recreation opportunities near towns. They also support the delivery of a number of national to local policies relating to e.g. biodiversity, access, health, education and social inclusion.

In accordance with the Scottish Forestry Strategy, woodland areas around the Scheme footprint area are identified as 'woodlands in and around towns (WIAT) priority areas'. The whole site lies within the 1 km buffer area¹⁶ of a WIAT, while Flood Cell 1 lies within a priority area.

With regard to vulnerability to disasters, parts of the FPS are located within the vicinity of COMAH "Top Tier" establishments (Table 4-2)¹⁷, while other areas are within the vicinity of COMAH controlled pipelines. The locations of all pipelines and various consultation zones associated with each of the sites has been established by the design team in consultation with Falkirk Council and the site operators and ongoing workshops are identifying and addressing constraints / risks relating to the Scheme alignment, design, construction and operation.

Table 4-2: List of COMAH sites within the vicinity of the FPS

Establishment Name	Operator Name	Town	Postcode
Grange Docks	NuStar Grangemouth Limited	Grangemouth	FK3 8UD
Grangemouth	INEOS Infrastructure (Grangemouth) Limited	Grangemouth	FK3 9XH
Grangemouth	CalaChem Limited	Grangemouth	FK3 8XG
Grangemouth	Calor Gas Limited	Falkirk	FK3 9UX
Grangemouth	Diageo Scotland Limited	Grangemouth	FK3 8EG
Grangemouth	Flogas Britain Limited	Grangemouth	FK3 8UD
Grangemouth	Versalis UK Limited	Falkirk	FK3 9XE
Grangemouth	INEOS Chemicals Grangemouth Limited	Grangemouth	FK3 9XH
Grangemouth - Kinneil Terminal	Ineos FPS Limited	Grangemouth	FK3 9XH

¹⁶Online. Available at: <https://data.gov.uk/dataset/woodlands-in-around-towns-wiat> (Accessed January 2018)

¹⁷ HSE Online. Available at: <http://www.hse.gov.uk/comah/comah-establishments.htm> (Accessed January 2018)

Establishment Name	Operator Name	Town	Postcode
Grangemouth - North Site	H W Coates Limited	Grangemouth	FK3 8UU
Grangemouth - PLPG Installation	Ineos FPS Limited	Grangemouth	FK3 9AS
Grangemouth - RLPG Installation	Ineos FPS Limited	Grangemouth	FK3 8UB
Grangemouth - South Site	H W Coates Limited	Grangemouth	FK3 8UU
Grangemouth Complex	Petroineos Manufacturing Scotland Limited	Grangemouth	FK3 9XH
Grangemouth Works	Fujifilm Imaging Colorants Limited	Grangemouth	FK3 8XG
Grangemouth Works	Syngenta Limited	Grangemouth	FK3 8XG

4.2.3 Economy

The local economy in Grangemouth is dominated by the chemical sciences sector, which - with an estimated value of approximately £1.5 billion in 2016 and an ambition to achieve up to £5.6 billion by 2020 - represents Scotland's second most valuable export sector after food and drink¹⁸.

With regard to the petrochemical products received and transmitted by pipeline, to and from the facility, there are a number of supply chain industries that presumably rely on the on-going operation of the plant. The economic importance of the facility at the national scale is likely acknowledged in the Forth Estuary Flood Risk Management Strategy published by SEPA in 2015¹⁹, where the economic damages avoided of implementing a Scheme are estimated to reach £6.0 billion.

Locally, the refinery and petrochemicals complex is the principal employer and industry in the area with 1,200 permanent staff, 1,000 contractors²⁰ and several thousand more being employed in the refinery supply chain. However, SIMD data reveal that the FPS shall be within the vicinity of a number of areas that fall into the 10% most deprived in Scotland with regard to employment and income (see Table A2 in Appendix A).

4.2.4 Inequality

According to the SIMD, six sub-areas within the Scheme footprint area count among the 10% most deprived parts of Scotland overall (see Table A2 in Appendix A):

- Grangemouth – Bowhouse (pop. 637)
- Grangemouth – Kersiebank (part thereof; 506)
- Grangemouth – Kersiebank (part thereof; 926)
- Falkirk – Bainsford and Langlees (part thereof; pop. 516)
- Falkirk – Bainsford and Langlees (part thereof; pop. 688)
- Grangemouth – Town Centre (pop. 579)

¹⁸ PBA 2017. The Future Grangemouth Vision 2025 [Online] Available at: <http://www.chemicalsciencesscotland.com/content/uploads/2017/11/Future-Grangemouth-Vision-2025.pdf> (Accessed January 2018)

¹⁹ Online, Available at: file:///C:/Users/DM042434/Downloads/pdf-lpd-LPD_10_Full.pdf (Accessed April 2018)

²⁰ Wikipedia 2017 Online. Available at: https://en.wikipedia.org/wiki/Grangemouth_Refinery (Accessed April 2018)

The specific index relating to income reflects the overall classification for these areas, as does health, but to a lesser extent.

4.3 Key Issues and Potential Effects

4.3.1 Health Impact Assessment Screening

With regard to undertaking a formal Health Impact Assessment, guidance published by the Health Impact Assessment Network²¹ propose the criteria to be considered when screening a project, namely:

- **Who may be affected by a proposal?** – The Scheme is likely to affect residents, visitors and workers across Grangemouth who might otherwise be affected by flood risk (positive impact) and who will be subject to risks and disruption associated with the construction phase (negative impact).
- **Will there be differential impacts?** – The Scheme is located within areas of differing levels of deprivation relative to the national indices, and impacts (positive and negative) are likely to affect more and less deprived groups to varying degrees. Following various site visits to the residential areas where works are proposed and an appraisal of SIMD data (only two sub-areas fall within the 10% most deprived category), it is considered unlikely that there will be a significant and relatively disproportionate adverse or positive impact upon more and less deprived communities respectively.
- **What determinants of health and wellbeing could be affected?** – The determinants likely to be affected are intangible and related to reductions in flood related stress and increases in stress associated with disturbance during construction.
- **What further evidence is needed to inform recommendations?** – It is considered that a study aimed at identifying the scale of (positive) impacts on health associated with the Scheme as a result of the reduced risk of exposure to flooding is unlikely to reveal any impacts of particular significance with respect to SEPA guidance²². Such a study has been undertaken in a more general sense in relation to flood affected communities across the UK²³, and the results indicate that health impacts are unlikely to be significant with respect to the level of risk associated with the operation of the Scheme, which will reduce the level of flood risk and associated direct and indirect health impacts associated with flood events. Health risks associated with the construction of the Scheme are not considered to be significant, assuming standard health and safety practices and guidance are observed by contractors and provision is made to ensure flood risk is not increased during the construction period. Disaster risk is considered below, and it is assumed that appropriate procedures will be put in place to ensure any risks are minimised and, consequently, not significant in terms of EIA.

It is therefore considered that a formal Health Impact Assessment for the Scheme is not required, as the Scheme is unlikely to produce significant (adverse) health impacts and will reduce the overall likelihood of health impacts occurring.

The following sub-sections set-out the scope of assessment that will be undertaken for the Scheme as part of EIA.

²¹ Douglas M. 2009 'How to do Health Impact Assessment: a guide for practitioners' Scottish Health Impact Assessment Network, Scottish HIA Network March 2009

²² SEPA 2015: 'WAT-SG-67 - Assessing the Significance of Impacts - Social, Economic, Environmental [online] Available at: https://www.sepa.org.uk/media/149801/wat_sg_67.pdf (Accessed Jan 2018)

²³ JBA (2005) Scoping Study into the cost of flooding using the August 2004 event as a case study. Edinburgh: Scottish Executive.

4.3.2 Health and well-being

While direct health and safety impacts associated with flooding are rare in the UK, the effect of more severe flood events is not certain and the risk of illness, injury or mortality may increase. As the FPS shall be designed to provide protection against much more severe flood events than those yet experienced by the flood-affected communities around Grangemouth, much of the risk of direct and indirect health and safety impacts associated with a major flood event (up to 1 in 200-year event) will be removed, and the Scheme may have a resultant significant positive effect in relation to direct effects.

For smaller flood events, exposure to flood water contaminated with sewage, animal waste, harmful bacteria or chemicals can be potentially damaging to health. As such, some indirect health impacts may also be avoided.

The Scheme will also alleviate adverse mental and socio-economic impacts with respect to stress, loss of income, and reduced recreation opportunities or amenity provision following flood events (e.g. Penning-Rowse et al 2013²⁴).

However, disturbance during construction (e.g. noise, dust, traffic) and reduced access to recreation facilities (e.g. where greenspaces are used as construction compounds or have restricted access, i.e. at Zetland Park or Rannoch Park) may have health and well-being impacts that may be significant, albeit locally and at a small scale, depending on their nature, location and duration.

With regard to vulnerability to disaster risk, where flood events occur during construction works, particularly where existing defences are temporarily removed before being replaced, flood risk may increase and affect key facilities related to the safe operation of the COMAH facilities and pipelines. The Scheme design and construction method will therefore have to consider how to mitigate such risks as well as those posed by undertaking construction activities near high pressure pipelines. Assuming appropriate provisions are put in place by the contractor and COMAH procedures are updated accordingly, no significant effects are anticipated in relation to this risk and further assessment is scoped-out of the EIA. Where deemed necessary, appropriate provisions may be recommended in the CEMP.

4.3.3 Economy

With regard to more severe flood events, if the refinery experiences a shutdown, the consequent closing of the Forties pipeline system results in some 70 North Sea oil platforms being shut down or reducing production, while supply of petroleum products to the rest of the country are reduced at an estimated cost to the UK economy of approximately £50 million per day of closure²⁵. Regular flooding can have a long-term detrimental effect on property and discourage investor or property developer confidence in flood risk areas, and lead to gradual economic decline (JBA 2005)²⁶.

The Scheme will therefore have a positive effect (i.e. by reducing risk) associated with the local (and national) economy as a result of damages avoided (and any Government emergency costs), losses in turnover as well as potentially reduced insurance premiums for commercial and residential properties. Positive effects may also include increased income, e.g. from temporary construction employment, reduced disruption to commercial activity and increased land/property values. As such, further assessment of potential effects resulting from severe flood events is scoped-out of further assessment in the EIA.

The construction period will however have adverse effects in the medium-term on local businesses affected by disruption. While difficult to identify the magnitude of any such adverse impacts, the EIA

²⁴ Penning-Rowse E, Priest S, Parker D, Morris J, Tunstall S, Viavattene C, Chatterton J, Owen D (2013) Flood and Coastal Erosion Risk Management: A Manual for Economic Appraisal; Routledge Press, ASIN: B013J92TXY

²⁵ Online. Available at: https://en.wikipedia.org/wiki/Grangemouth_Refinery (Accessed January 2018)

²⁶ JBA (2005) Scoping Study into the cost of flooding using the August 2004 event as a case study. Edinburgh: Scottish Executive.

will focus on construction phase mitigation with a view to reducing the magnitude and duration of disruption and access to local businesses.

4.3.4 Inequality

The positive impacts associated with the operation of the Scheme and the reduced risk may have a significant positive effect on those communities identified as falling within the 10% most deprived in the SIMD.

Conversely, the impacts on health and well-being and economy associated with the construction period are likely to have a confounding effect on people living within these areas. However, as stated previously, the effect of works will be spread across a number of communities of varying levels of deprivation, and it is considered unlikely that more deprived communities will be affected to a significantly greater degree than less deprived communities. As such, this area shall be scoped out of the EIA.

4.4 Proposed Studies and Consultation for EIA

A desk-based appraisal of the baseline, potential impacts and assessment of significance of effects shall be undertaken to inform any mitigation or enhancement measures that may be incorporated into the design, construction method or operation of the Scheme.

Consultation is ongoing with site operators and, indirectly, HSE in relation to design and construction constraints associated with the consultation areas and in accordance with the Control of Major Accident Hazards Regulations 2015.

Consultation is also ongoing with Falkirk Council contaminated land and health and safety officers to ensure that any potential environmental risks associated with the construction and operation of the Scheme are identified and addressed accordingly. Further details on the scope of assessment relating to contamination risk shall be provided in the Water, Contamination and Air chapters of the EIA Report (see Chapters 8-10 in this report).

Further consultation with the Council will be undertaken to identify any other concerns and previously unidentified potentially adverse impacts upon the population and human health. Likewise, feedback from the public consultation events shall be considered and used to inform the assessment and any mitigation or enhancement opportunities for the Scheme.

4.5 Proposed Methodology

4.5.1 Health and well-being

While a formal HIA is not considered necessary, an appraisal of potential impacts on health and well-being will be undertaken as part of the EIA to inform any potential design changes, mitigation or enhancement measures that may be incorporated into the design, construction method or operational maintenance regime for the Scheme.

The identification of community/ recreational facilities or opportunities (e.g. Zetland Park, public footpaths, fishing opportunities) potentially affected by the proposed Scheme shall be carried out through a combination of desk study and consultations with the public, landowners, Falkirk Council and other relevant third parties (e.g. sporting or angling clubs etc.).

SEPA²⁷ and the HSE²⁸ are the competent authorities tasked with overseeing and enforcing the COMAH Regulations, while the key partners that coordinate and deliver COMAH emergency

²⁷ See: <https://www.sepa.org.uk/regulations/control-of-major-accident-hazards-comah/> (Accessed January 2018)

²⁸ See: http://www.hse.gov.uk/foi/internalops/hid_circs/technical_general/spc_tech_gen_44.htm#HSE-as-statutory (Accessed January 2018)

procedures²⁹ are represented through the Major Incident Control Committee (MICC), which fulfils the requirements of the COMAH regulations for emergency plans by:

- *Containing and controlling incidents to minimise the effects and to limit damage to persons, the environment and property.*
- *Implementing the measures necessary to protect persons and the environment from the effects of major accidents.*
- *Communicating the necessary information to the public, emergency services and relevant authorities.*
- *Assisting with the restoration and clean-up of the environment following a major accident.*³⁰

It is understood that the MICC shall be consulted as part of the design process to discuss the potential impacts the Scheme may have on emergency procedures and how any potential impacts may be avoided or mitigated.

A summary of the consultation outcomes between the design team and the relevant organisations shall be reported in the EIA Report.

4.5.2 Local Economy

Economic information relating to the proposed Scheme shall be based on the latest economic appraisal (benefit/cost analysis) undertaken for the Scheme options. The potential benefits (in terms of damages avoided minus Scheme cost) shall be assessed using 'The Benefits of Flood and Coastal Risk Management: A Manual of Assessment Techniques' (Penning-Rowsell *et al.* 2013), which includes methods to assess the following types of damages:

- Damages to residential properties and the expense of post flood clear up.
- Damages to vehicles affected by flooding.
- Damages to non-residential properties and the expense of post-flood clear up.
- Indirect damages to non-residential properties due to loss of business.
- Expense incurred by the emergency services during and following the flood event.

The EIA Report shall summarise the final cost/benefit analysis and assess whether the positive long-term effect on the economy is likely to be significant or otherwise.

The chapter will also identify and recommend potential mitigation measures to address potentially adverse medium-term effects on local businesses that may be affected by disruption during construction, such traffic management, maintaining access and providing suitable signage and public information.

4.5.3 Assessment criteria

The importance, magnitude and significance (or otherwise) of potential impacts shall be established in accordance with SEPA supporting guidance³¹ and that set-out in Section 2.4 of this report.

The chapter will discuss potentially significant impacts in the context of both primary mitigation (i.e. measures that have already been embedded into the Scheme design) along with any further recommendations aimed at addressing potentially significant adverse impacts beyond that

²⁹ Including: Site operators, Falkirk Council, Police Scotland, Scottish Fire and Rescue Service, Scottish Ambulance Service, Forth Valley NHS, Scottish Water, Health and Safety Executive, Scottish Environment Protection Agency, Scottish Gas Network, Scottish Power and The Scottish Government.

³⁰ See: <http://www.falkirk.gov.uk/services/council-democracy/policies-strategies/emergency-planning/docs/major-accident/grangemouth/1%20Important%20public%20safety%20information.pdf> (Accessed January 2018)

³¹ SEPA 2017: 'WAT-SG-67 - Assessing the Significance of Impacts - Social, Economic and Environmental [Online] Available at: https://www.sepa.org.uk/media/149801/wat_sg_67.pdf (Accessed January 2018)

embedded in the design (secondary mitigation) or to provide enhancements with a view to informing the detailed design process.

Cumulative effects shall be considered in relation to the combination of different effects identified in other chapters and interactions with other developments. Residual impacts of significance will then be listed followed by recommendations for the monitoring of potentially significant issues during construction and operation.

Biodiversity

5.1 Introduction

This chapter describes the ecological baseline in the FPS Study Area, as informed by surveys and desk study undertaken to date, with proposals for further surveys to inform the assessment of impacts on biodiversity. The approach to be adopted for the EIA and Habitats Regulations Appraisal (HRA) is also set out, along with an overview of the consultation process.

5.2 Baseline

5.2.1 Introduction

Baseline data have been collated for the site, comprising the land located within Flood Cells 1 to 6, as a minimum. The study area has been extended beyond the site boundaries where appropriate. Details of extended survey areas can be found in the relevant survey reports (see Appendix B).

An Environmental Key Issues Report was prepared in 2011, which was supported by an ecological survey of the area that may be affected by works. Ecological surveys were then completed in part of the site in 2013 and 2014. These were reported in the Ecological Appraisal Walkover report (June 2013) and a note to inform the Ground Investigations work at Rivers Avon and Carron (2014) following a check for protected mammal species (badger *Meles meles* and otter *Lutra lutra*).

Existing biological records were provided by Falkirk Council in August 2016 to inform the ecological baseline:

- Phase 1 Habitat Survey (2008): A Phase 1 Habitat Survey was undertaken for the project area in 1994, which was updated in 2008 by AMEC on behalf of Falkirk Council. The habitat maps were studied to inform the recent Phase 1 Habitat Survey (Section 4.2).
- Species records: These were provided for the local area for the past 10 years. Within the study area, kingfisher *Alcedo atthis*, otter, and salmon *Salmo salar* were recorded for the River Carron, Avon Burn and Westquarter Burn (which flows into the Grange Burn). Other protected species recorded nearby included water vole *Arvicola amphibious* and great crested newt *Triturus cristatus*.

These surveys identified the habitats present, taking note of their potential to support protected species (otter, badger, breeding birds, bats). Signs of protected species were also recorded, with surveys identifying the presence of some notable species including kingfisher, sand martin *Riparia riparia* and some invasive species including American mink *Neovison vison*.

Another Extended Phase 1 Habitat Survey and a Mammal Survey were undertaken in June 2016 (see Appendix B), the results of which are detailed below.

A series of ornithological surveys of the Forth Estuary between Dunmore and Blackness were carried out from August 2015 to April 2017 (see Appendix B). These surveys covered two non-breeding seasons (2015-16 and 2016-17), and one breeding season (2016).

5.2.2 Designated sites for nature conservation

The study area is of importance to nature conservation, as reflected in the number of designations present:

- Firth of Forth Estuary Special Protection Area (SPA): An SPA is a designation under the European Directive on the Conservation of Wild Birds³². Under the Directive, developers

³² Directive 2009/147/EC (Birds Directive) on the conservation of wild birds

have a duty to safeguard the habitats of migratory birds and certain particularly threatened birds.

- Firth of Forth Estuary Ramsar Site: The Ramsar Convention is an international treaty for the conservation and sustainable use of wetlands.
- Firth of Forth Estuary Site of Special Scientific Interest (SSSI): A SSSI is a statutory designation for its national nature conservation interest.
- The Avon Gorge SSSI also lies to the south-east of the site, overlapping with Cell 5 at Inveravon.
- The Carron Dams SSSI and LNR is located outwith the site to the north of Flood Cell 1.
- Various locally important conservation sites: Figures A11 and A12 in Appendix A show the location of locally designated conservation sites including Sites of Importance to Nature Conservation (SINCs), Wildlife Sites and Local Nature Reserves.

5.2.3 Habitats

Jacobs appointed Echoes Ecology to carry out an extended Phase 1 Habitat Survey of the whole area being considered for the proposed Grangemouth FPS. Habitats within the site, and where possible up to 100 m outwith the boundary, were surveyed between February and May 2016 and mapped. A Habitat Suitability Index (HSI) assessment for great crested newt was also completed on all suitable water bodies within the site, and where possible up to 500 m outwith the boundary.

The site contains the following Falkirk Local Biodiversity Action Plan (LBAP)³³ priority habitats: intertidal mudflats, saltmarsh, broadleaved and mixed woodland, swamp, rivers and streams, and standing open water. More detail on the extended Phase 1 survey results can be found in Appendix B: Grangemouth FPS Extended Phase 1 Habitat Survey Report, Echoes Ecology Ltd.

There is habitat within the site and its surroundings that is considered suitable to support protected and notable species, such as over-wintering birds, breeding birds, bats, great crested, reptiles, badger, otter and water vole.

Ornithological surveys, as well as badger, water vole and otter surveys, have been conducted on site and are summarised below.

5.2.4 Protected and Notable Species

Echoes Ecology Ltd was appointed to carry out the first series of surveys for otter, water vole and badger to determine the potential for, or presence of, these species within the site (see Appendix B: Grangemouth FPS Mammal Survey Report, Echoes Ecology Ltd). The surveys were undertaken during February to May 2016 and, where possible, buffers of 100 m for badger and 250 m for otter and water vole outwith the site were surveyed. Due to the delay between the mammal survey and the construction works commencing (more than 18 months), pre-construction mammal surveys will be required to confirm whether the situation regarding badger, otter and water vole on site has changed in the interim.

5.2.5 Ornithological Surveys (2015-2017)

A series of ornithology surveys of the Forth Estuary between Dunmore and Blackness were initiated in August 2015 and completed in summer 2017 (Appendix B - Ornithology Survey Report 2015-2017, MacArthur Green). This section provides a summary of the work undertaken and results obtained from the surveys.

The ornithology surveys focussed on recording the following:

³³ <https://www.falkirk.gov.uk/services/environment/environmental-management/docs/biodiversity/Biodiversity%20Action%20Plan%202011-2014.pdf?v=201606141419> (Accessed march 2017)

- Abundance and spatial distribution of target species at different stages of the tidal cycle;
- Temporal distribution and abundance of target species between years, seasons, months, and time of day;
- Behaviour of birds at different stages of the tidal cycle (e.g. feeding, roosting);
- Baseline human activity levels and types of activity within the survey area;
- Any evidence of anthropogenic or other disturbance within the survey area, and reactions of birds to such disturbance; and
- Breeding bird distribution and abundance.

A total of 87 target species were recorded during the survey period. Of these, 25 were qualifying interests of the SPA (of a total of 27 SPA qualifying interests).

Considering the sectors directly adjacent to the likely coastal defences of the proposed FPS, seven species were recorded in numbers of national importance: shelduck *Tadorna tadorna*, dunlin *Calidris alpina*, redshank *Tringa tetanus*, bar-tailed godwit *Limosa lapponica*, black-tailed godwit *Limosa limosa*, greenshank *Tringa nebularia*, and red-breasted merganser *Mergus serrator*. In addition, other species such as curlew *Numenius arquata*, lapwing *Vanellus vanellus*, pink-footed goose *Anser brachyrhynchus* and Sandwich tern *Sterna sandvicensis* were recorded within sectors in populations significant within an SPA context, and further non-SPA species were found in numbers of estuary level importance. Details of these records, along with key roost sites, are provided in the report in Appendix B.

5.2.6 Invasive Species

Non-native, invasive species including Japanese knotweed *Fallopia japonica* and Himalayan balsam *Impatiens glandulifera* were recorded on site.

5.2.7 Further Surveys

A number of additional surveys will be undertaken through spring / summer 2018 to establish the current ecological baseline and inform the EIA and other consenting procedures including the HRA and protected species licensing including:

- **Preliminary Ecological Appraisal** of the new / previously unsurveyed areas.
- **Great crested newt (GCN) surveys:** Following the results of the HSI, eDNA surveys for GCN shall be undertaken of the 14 ponds in spring 2018 by an Ecologist who holds a GCN licence and follow best practice guidance (Biggs et al., 2014).
- **Bats:** Update surveys shall be carried out throughout the survey area at trees with bat roost potential or at structures. Where required, follow-up bat activity surveys shall be carried out thereafter.
- **Badgers:** Update surveys shall be carried out to update the baseline.
- **Otters, Water Vole and Badgers:** Update surveys shall be carried out of all suitable water courses and water bodies within the site plus a buffer of up to 250m around the site, where access permits (including the new areas of works). Furthermore, camera trapping of one potential otter holt and camera trapping and/or sticking and sand traps of 26 potential badger sett entrances shall be carried out based on previous results. All surveys to follow best practice guidance (Scottish Badgers, 2005; Scottish Natural Heritage, 2008; Dean et al., 2016 and Strachan et al., 2011)
- **Breeding birds (inland):** As previous ornithological surveys were focussed on SPA qualifying species, breeding bird surveys shall be carried out all areas of the proposed works plus a buffer of up to 100 m around the site, where access permits.

- **National Vegetation Classification (NVC):** Once the Scheme alignment is confirmed, consultation with SEPA will identify the requirement for NVC and/ or Ground Water Dependent Terrestrial Ecosystems (GWDTE) survey (where appropriate) at targeted areas to record the best quality habitats across the study area. These surveys will be undertaken as required in summer due to more floristic species being apparent.

5.3 Key Issues and Potential Effects

5.3.1 Designated Sites

Further assessment will be required on the potential impacts upon the Firth of Forth SPA/SSSI/RAMSAR and the Avon Gorge SSSI, as they are located either adjacent or within the site as well as being hydrologically linked.

The proposed Scheme involves working alongside the Firth of Forth SPA, Ramsar and SSSI. The potential for effects on the qualifying features of the designated sites will be given careful consideration.

Potential impacts could include:

- Silt, dust and other debris falling into the river or being washed into the rivers or estuary by surface run-off. This has the potential to choke beds of aquatic vegetation, fish spawning areas and aquatic invertebrate habitat, which is particularly important to birds associated with the SPA.
- Pollution from machinery working close to the waterbodies such as fuel and other liquid (brake fluid, hydraulic fluid) causing fish mortality or stress on fish populations and aquatic invertebrates.
- Pollution from construction works such as concrete pouring causing fish mortality or stress on fish and aquatic invertebrate populations.
- Damage or disturbance to the river bed habitats and changes to aquatic conditions such as flow, channel substrate and water quality.
- Noise and visual disturbance to qualifying bird and/ or fish species during construction.

The Firth of Forth SPA/SSSI/Ramsar lies directly adjacent to and in some places within the site boundary. The Avon Gorge SSSI lies at the south-east of the site, overlapping slightly with Flood Cell 5 at Inveravon. The Firth of Forth SPA/SSSI/Ramsar overlaps with and is hydrologically connected to the site. Further assessment of potential impacts upon these designated sites as a result of the works as part of a detailed Habitats Regulations Appraisal.

Carron Dams is over 100m from the site with no hydrological link to the site. Therefore, it will not be impacted upon by the works.

In addition to assessing impacts on the designated sites in the EIA Report, a Habitats Regulations Appraisal (HRA) will be undertaken to consider any potential to affect the Firth of Forth Estuary SPA and more distant SPAs or Special Areas of Conservation (SACs), whose mobile species may also be present in the study area (e.g. fish population from the River Teith SAC). Consent to work within the SSSI is also anticipated.

5.3.2 Habitats

LBAP priority habitats

Potential impacts set out in the above sub-section also apply to LBAP priority habitats, including the saltmarsh and mudflats around the Firth of Forth as these are notified features of the SSSI, and the continuous section of semi-natural broad-leaved woodland along the River Avon, which links up to the Avon Gorge SSSI.

The EIA Report will consider the potential impact of the Scheme on LBAP priority habitats and develop any appropriate mitigation, compensation or enhancement that may be designed into the project and to provide recommendations for a Habitat Management Plan to detail how the habitats on site will be protected and monitored during and after works.

GWDTes

Further botanical surveys (NVC survey) or hydrogeological screening may be required to confirm the presence and location of GWDTes within the site. The EIA Report will specify which studies have been undertaken and set-out any appropriate mitigation as required.

5.3.3 Protected and Notable Species

There is potential to affect a number of protected species through the construction and operation of the proposed Scheme. The main issue during construction would be the potential for disturbance of animals and damage of their resting places.

Bats: As there are structures and mature trees on site that may hold potential for roosting bats, further survey of these features may be required where works are to come within 30 m of them. The EIA Report will report on any further surveys on bats and detail any pre-construction requirements and potential enhancements that may be incorporated into the Scheme design.

Great Crested Newt: Great crested newt eDNA surveys will be undertaken of 14 of the ponds discussed in the previous section (Pond 3, 4, 5, 6, 7, 12, 13, 14, 15, 16, 17, 18, 19 and 28).

5.3.4 Invasive Species

Non-native species were identified within the site and there is a risk of spread at all stages of the construction period, including the ground investigation stage. The EIA Report will document any further survey work undertaken on invasive species and set-out appropriate mitigation to avoid their spread and to establish the scope of any non-native species management plan.

5.4 Proposed Studies and Consultation

The further studies proposed set-out in the previous section. Consultation is ongoing with Falkirk Council, SNH and SEPA. The scope of the ecological surveys, EcIA and HRA were discussed at a meeting on 30th May 2015. A site visit was then undertaken with the Jacobs Project Management team, EIA Manager and Ecologists (Jacobs and Echoes Ecology) to view the site and to identify potential issues.

The desk study is being updated, with data sources including:

- Falkirk Council
- Forth Fisheries Trust (fish);
- Falkirk Invasive Species Forum (invasive species);
- SNH Sitelink;
- NBN Gateway;
- Local recorder for the Botanical Society of the British Isles (BSBI); and
- Royal Society for the Protection of Birds (RSPB).

5.5 Proposed Methodology (EIA & HRA)

5.5.1 Introduction

The proposed methodology is based on best practice as described in Guidelines for Ecological Impact Assessment in the UK and Ireland (Chartered Institute of Ecology and Environmental Management

(2016) (hereafter 'CIEEM Guidelines')³⁴. The assessment will be undertaken in accordance with British Standard 42020:2013 (British Standards Institute, 2013)³⁵. This specific guidance differs slightly in approach and terminology from the general criteria described in Section 3.5. Although the valuation of receptors and determination of the magnitude (and other characteristics) of impacts are still key parts of the process, the assessment of significance does not rely on the matrix approach as described in Section 2.4.3.

5.5.2 Determination of Importance

The CIEEM (2016) guidelines advise on how to determine importance of features such that detailed impact assessment is carried out on those features that are both considered important and potentially affected by the proposed Scheme.

Determining the importance of ecological features relies heavily on professional judgement and includes consideration of factors such as size, conservation status and quality of the feature, as well as the policy and legal significance. The potential value of the feature should also be taken into account.

The importance of habitats and species will be measured against published selection criteria where available. Reference will also be made to the Falkirk Local Biodiversity Action Plan. It should be noted that in some cases it is possible for a feature to be of relatively low value in nature conservation terms, yet subject to legal protection. Examples might include the majority of common wild bird species (all of which are subject to some protection) and, badgers, which are subject to protection primarily on animal welfare grounds.

The CIEEM Guidelines recommend that the importance of each ecological feature is described in terms of its geographic frame of reference. The following definitions will be used for the geographic frame of reference for the value of ecological features:

- International i.e. qualifying species and habitats of Ramsar and SPA;
- National, i.e. SSSIs;
- Regional e.g. habitats or populations of species considered to be of value within the Central Lowlands of Scotland;
- Local, e.g. habitats or species populations considered to be of value within approximately 2km of the site.

5.5.3 Assessment of Effects

The characterisation of impacts will make reference to the:

- extent;
- magnitude (quantified where possible);
- duration (short-term, long-term, temporary or permanent);
- reversibility;
- timing/frequency; and
- if the effect is positive or negative

Both direct, indirect and cumulative impacts will be considered. All aspects of construction and operation of the proposal will be considered, as will the potential for cumulative effects with other developments, particularly in relation to the potential for 'in combination' effects on the Firth of Forth.

³⁴ Online. Available at: <https://www.cieem.net/news/293/guidelines-on-ecological-impact-assessment-second-edition> (Accessed 24/10/2017)

³⁵ Available from <https://shop.bsigroup.com/ProductDetail/?pid=000000000030258704>

According to CIEEM Guidelines, in terms of ecological impact assessment a “‘significant effect’ is an effect that either supports or undermines biodiversity conservation objectives for ‘important ecological features’ or for biodiversity in general. Conservation objectives may be specific (e.g. for a designated site) or broad (e.g. national/local nature conservation policy) or more wide-ranging (enhancement of biodiversity). Effects can be considered significant at a wide range of scales from international to local.”.

The guidance puts emphasis on the fact that significant effects are sufficiently important to require assessment and reporting so that the decision maker is adequately informed of the environmental consequences of permitting a project.

Significant effects should be qualified with reference to an appropriate geographical scale, often depending on the level of statutory or non-statutory legislation the ecological feature is designated under (e.g a significant effect on a SSSI, is likely to be nationally significant, and significant effects on a SPA may be internationally significant). However, the guidance also states that: “the scale of significance of an effect may not be the same as the geographic context in which the feature is considered important. For example, an effect on a species which is on a national list of species of principal importance for biodiversity may not have a significant effect on its national population. It should be noted that effects may be significant at the local scale, particularly in view of policies for no net loss of biodiversity.”

To determine significance, the effects of the proposed Scheme on the conservation objectives (for designated sites) and conservation status (for species and habitats) should be considered, as well as any predicted changes to ecosystem structure and function.

The result of the assessment is a judgement on whether the effect on an important ecological feature is significant; and if so, the geographical level on which it is significant. As a result, it is recommended that mitigation and compensation measures are consistent with the geographical scale at which the effect is significant.

The significance of the effects of the proposal will be assessed before and after mitigation and enhancement. Any significant effects remaining after mitigation, compensation and enhancement (the residual effects) are the factors to be considered by the Council in determining the consent of the Scheme.

5.5.4 HRA (Appropriate Assessment)

The Firth of Forth SPA is designated under Council Directive 79/409/EEC on the conservation of wild birds (the Birds Directive), and therefore forms part of the Natura 2000 network of designated sites.

The Habitats Directive (Article 6 (3)) states that:

“...any project not directly connected with or necessary to the management of a Natura 2000 site but likely to have a significant effect thereon, either individually or in combination with other plans or projects, shall be subject to appropriate assessment of its implications for the Natura 2000 site’s conservation objectives.”

As such, a Habitats Regulations Appraisal (HRA) shall be carried-out in line with Regulation 48 of the Conservation (Natural Habitats &c.) Regulations 1994 (as amended) to determine whether the Scheme will adversely affect the site integrity of the Firth of Forth SPA. The HRA will follow the format set out in the Scottish Natural Heritage (SNH) HRA proforma.

Noise & Vibration

6.1 Introduction

The Grangemouth Flood Protection Scheme (FPS) will be passive in nature and there will be no noise or vibration impacts anticipated with its operation other than the planned maintenance works.

The construction of the FPS has the potential to generate noise and vibration impacts, which can give rise to complaints and, in certain circumstances where adequate site control measures are not applied, can result in work being stopped by the Local Authorities applying their statutory powers. Excessive vibration caused from construction activities, such as piling, can also cause damage to surrounding buildings, utilities and potentially industrial pipelines.

This section therefore focuses on the temporary noise and vibration impacts on receptors located within the vicinity of anticipated works areas within the study site.

6.2 Baseline

6.2.1 Baseline Methodology

A series of non-consecutive noise levels were measured in the vicinity of the works at locations agreed with the Falkirk Council Environmental Health Officer (EHO).

The long-term noise surveys were undertaken using a Castle Mirus Sound Level Meter (serial number 35769) with a Svantek SV18 Pre-amplifier (serial number 41663) and a Svantek 7052E ½" microphone (serial number 58860). The meter was calibrated using a Castle GA607 Sound Level Calibrator (serial number 035748).

Noise measurements were taken in accordance with the methodology set-out in British Standard 7445-1: 2003 'Description and measurement of environmental noise Part 1 Guide to quantities and procedures', with the microphone between 1.2 and 1.5 m above local ground level.

All measurement locations were also at least 3.5 m away from any reflecting surface and, as a result, it can be considered that all measurement locations are 'free-field'.

6.3 Baseline Results

6.3.1 Flood Cell 1

The following measurement locations were chosen to reflect the areas where works are expected to take place:

- In the vicinity of the residential receptor opposite the First Group Bus Depot, Stirling Road;
- To the rear of Residential Property, Park Road, Bainsford;
- On open land to the North of Carronside Street, Bainsford;
- On footpath to the South of Rae Court, Carronshore;
- On Riding for the Disabled Land, South of Dock Street, Carronshore.

Results are recorded in Table A2 in Appendix A.

6.3.2 Flood Cell 2

Measurement in this Cell were taken at:

- Public Footpath to the North of Bank Street/Devon Street, Grangemouth.

Results are recorded in Table A2 in Appendix A.

6.3.3 Flood Cell 3

No measurements were undertaken within this Cell as the proposed works lie in excess of 650m from the closest residential receptor and are therefore unlikely to result in any potential noise impact from the works.

6.3.4 Flood Cell 4

The measurement locations in this Cell are as follows:

- to the Eastern Side of Abbots Road in Zetland Park, East of Grange Burn;
- at the West end of Rannoch Road, close to residential flats;
- close to residential properties at the North end of Reddoch Road (Avonside House); and
- close to residential property at entrance to Grandsable Cemetery.

Results are recorded in Table A3 in Appendix A.

6.3.5 Flood Cell 5

The majority of the Flood Cell 5 lies within an industrial area, with the only residential receptors being located south of the A905. It was however agreed with the Falkirk Council EHO that one of the locations utilised for Cell 4, in the vicinity of Avonside House, could be utilised to represent the baseline environment for the residential receptors in this area.

6.3.6 Flood Cell 6

No measurements were undertaken within this Cell as the proposed works lie in excess of 1000 m from the closest residential receptor and are therefore unlikely to result in any potential noise impact from the construction works.

6.4 Key Issues and Potential Effects

6.4.1 Flood Cell 1

Given the proximity of the proposed flood defences to residential properties, there is the potential for temporary noise impacts on the residential receptors within Cell 1. In some locations, properties lie within approximately 7 m of the proposed Scheme. Residential properties may experience vibration impacts dependant on the method of construction and location, albeit only in the short-term.

6.4.2 Flood Cell 2

Some locations are located approximately 30 m from the Scheme in this Cell. Depending on the method of construction, there is a potential for temporary vibration impacts.

Elsewhere within the Cell, the proposed works are close to industrial facilities, but these are not likely to be noise sensitive. While it is not known whether any of the operations are vibration sensitive, given that works may be within 5-10 m of some of the facilities, is some potential for impacts if sensitive equipment is installed within the industrial premises.

6.4.3 Flood Cell 3

Given that the proposed works within Cell 3 lie in an industrial area in excess of 650 m from the proposed Scheme, construction works are unlikely to lead to noise or vibration impacts at residential locations. It is not known at present whether any of the industrial facilities closer to the works are vibration sensitive, but given that works may be within 20 m of some of the facilities, there is little potential for impacts if sensitive equipment is installed within the industrial premises.

6.4.4 Flood Cell 4

At present the full details of the proposed works within Cell 4 are not confirmed, but it is clear that there may be some potential for noise and vibration impacts during construction upon residential properties given the location of the proposed flood defences and their proximity to residential properties.

As residential properties appear to lie as close to the proposed flood defences as 3 m at Reddoch Road, 13 m at Rannoch Road and 14 m at Abbots Road, it is clear that there will be temporary noise impacts upon those residential receptors. Depending on the method of construction, there may also be some potential for temporary vibration impacts.

Elsewhere within the Cell, the proposed works within 40 m of commercial facilities such as hotels, which are likely to be less noise sensitive than residential properties, but impacts may need to be assessed here nonetheless.

6.4.5 Flood Cell 5

Given the location of the proposed flood defences and their proximity to residential properties (~60 m) in this Cell, there is some potential for noise and vibration impacts during construction.

Elsewhere within the Cell, the proposed works will be close to industrial facilities (~15 m), which are not likely to be noise sensitive, but they may be vibration sensitive, particularly where sensitive equipment is installed within the premises.

6.4.6 Flood Cell 6

Given that the proposed works within the cell are in excess of 1000 m from residential properties, construction works are unlikely to cause noise or vibration impacts. Again, where noise sensitive equipment is located with industrial premises, which lie some 20 m from works areas, there may be vibration impacts. There may also be pipelines in the area that have the potential to be vibration sensitive.

6.5 Proposed Studies and Consultation for EIA

It is proposed that a detailed noise and vibration assessment be carried out to include the proposed construction works where they have the potential to affect sensitive receptors. This is likely to be required for noise and vibration in Cells 1,2, 4 and 5, and potentially for vibration in Cells 3 and 6 if, following consultation, it is discovered that industrial receptors in the vicinity are vibration sensitive (including pipelines).

Consultation in relation to the survey procedure and assessment methodology has been carried out with the Falkirk Council EHO, and the procedure that is proposed here has been agreed with them. Further consultation will be required with Forth Ports and other site operators to establish the vibration sensitivity of facilities and pipelines close to the proposed flood defences.

6.6 Proposed Methodology

The assessment will consider temporary increases in noise and vibration associated with construction equipment and activities proposed within the construction site, and the increased level of road traffic noise associated with proposed traffic diversions.

As agreed with the Falkirk Council EHO during the site inspection and consultation, a significance level of 75dB L_{Aeq} for the noise impacts is to be used for the construction noise impacts for locations next to busy main roads and industrial sites, but where the location is remote from a main noise source, a significance level of 70dB L_{Aeq} should be used.

All construction noise and vibration calculations will be undertaken utilising the appropriate calculation methodologies contained in BS5228-1:2009+A1:2014³⁶ and BS5228-2:2009+A1:2014³⁷.

For noise, the construction calculations will be based upon plant and equipment lists agreed with the design engineers. Where required, barrier attenuation provided by existing topographical features or buildings will be taken into account with reference to consequentially reduced the noise levels.

In relation to the calculation of vibration impacts, given the types of work being undertaken and the plant and equipment that will be used, the only relevant calculations that could be undertaken relate to the vibratory piling works and the compaction elements of the earthworks. The calculation methods in BS5228-2:2009+A1:2014 will be used, employing the highest levels of vibratory input envisaged by the calculation methodologies.

6.6.1 Receptor sensitivity - Noise

The identification of the sensitivity of the recognised noise sensitive receptors has been made according to a four-point scale as shown in Table 6-1.

The IEMA Guidelines for Environmental Noise Impact Assessment as well as the Scottish Government Technical Advice Note which accompanies Planning Advice Note 1/2011 include dwellings, schools, hospitals and commercial premises as noise sensitive receptors.

Table 6-1: Classification of the sensitivity of noise sensitive receptors

Sensitivity	Type of receptor
Very High	Concert halls / theatres
High	Residential dwellings, educational premises, medical facilities
Medium	Places of worship, community facilities, museums
Low	Commercial and industrial premises
Negligible	N/A

6.6.2 Impact magnitude - Noise

For this project, consultation with Falkirk Council EHO has established a threshold noise level of 70 or 75dB L_{Aeq}, dependent upon the location and current impacting noise sources, below which it is considered that any impacts would not be significant with regard to the FRM Regulations. This approach has been considered appropriate as the works will be located within an urban area in close proximity to residential properties and it reflects the approach taken for other similar flood protection Schemes in the region.

6.6.3 Impact magnitude - Vibration

There are currently no British Standards that provide a method to predict levels of vibration from construction activities, other than that contained within BS5228-2:2009+A1:2014, which relates to percussive or vibratory piling only (Table 6.6). These criteria set the threshold for potential vibration impacts on structures.

³⁶ 'Code of practice for noise and vibration control on construction and open sites: Noise'

³⁷ 'Code of practice for noise and vibration control on construction and open sites: Vibration'

Table 6-2: Transient vibration guide values for cosmetic damage to buildings

Type of Building	Peak component of particle velocity in frequency range of predominant pulse	
	4Hz to 15Hz	15Hz and above
Reinforced or Framed structures Industrial and heavy commercial buildings	50 mm/s at 4Hz and above	50mm/s at 4Hz and above
Unreinforced or light framed buildings Residential or light commercial buildings	15 mm/s at 4Hz increasing to 20mm/s at 15 Hz	20 mm/s at 15Hz increasing to 50mm/s at 40Hz and above

It is generally accepted that for the majority of human receptors, vibration levels in excess of between 0.14 and 0.3 mm/s peak particle velocity are just perceptible. Whilst there are no defined assessment criteria for construction vibration impacts, BS5228-2:2009+A1:2014 provides useful indications as to how the magnitude can be defined.

Table 6-3: Proposed Vibration Magnitude (based on Human Response)

Calculated Vibration Level	Effect	Magnitude
0 – 0.14 mm/s	No effect	No Impact
0.14 – 0.29 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.	Negligible
0.3 - 0.99 mm/s	Vibration might just be perceptible in residential environments.	Minor Negative
1.0 – 9.99 mm/s	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.	Moderate Negative
10 mm/s +	Vibration is likely to be intolerable for any more than a very brief exposure of this level.	Major Negative

6.6.4 Mitigation and its Effects

In relation to potential impacts from construction noise and vibration, where appropriate, the assessment of potential impacts upon receptors will be based on the criteria described in Section 2.4.3. Furthermore, where mitigation measures are deemed to be required as a result of the assessment to be undertaken, those mitigation measures will be stated and their potential effect discussed on impact magnitudes.

Landscape and Visual Effects

7.1 Introduction

An outline landscape and visual desk-based appraisal, as well as a number of walkover site visits, and consultations have been undertaken to identify the baseline and to provide a high-level assessment on the potential impacts of the Scheme.

The following resources have been used to inform this chapter:

- Landscape Character Areas and general information on the locality;
- Historical data and Designations – World Heritage Site, Scheduled Monuments, Garden and Designed landscapes, Listed Buildings and Conservation Areas, etc;
- Map information, both Aerial and OS; and
- Photographic information.

The extent of the study area for the Landscape and Visual Impact Assessment (LVIA) would be the sites of the flood cells themselves, and the full extent of the wider landscape which is influenced by the flood protection Scheme. This would encompass the affected Landscape Character Areas, as noted below, and any areas identified in the Zone of Theoretical Visibility (ZTV). This will be more clearly defined in the LVIA.

7.2 Baseline

7.2.1 Landscape Character Areas

The Scheme is located in the Stirling to Grangemouth Landscape Character Area (Landscape Character Area no.124, SNH, 1999³⁸), which is in the Midland Valley of Scotland, a relatively low-lying part of the country. It is quite diverse in character ranging from low lying arable farmland to large areas of upland pasture and moorland. The study areas encompass both the Landscape character types of; *Lowland River Valley* reference area E ‘Falkirk to Denny Urban Fringe’ and *Coastal Margins* reference area G ‘Grangemouth to Bo’ness Flats’.

Policy GN02 Landscape from the Falkirk LDP notes that the Council will “*seek to protect and enhance landscape character throughout the council area in accordance with Supplementary Guidance SG09*”³⁹.

Landscape Character Assessment and Landscape Designations, Supplementary Guidance SG09, produced by Falkirk Council (July 2015)⁴⁰, defines the different local landscape characters found in and around Grangemouth in more detail, and the guidance is intended to ensure that the existing landscape is protected and enhanced and it defines how particular local development plan policies should be applied in practice.

Sixteen Local Landscape Character Areas have been defined in SG09 (Figure 7-1). The relevant local landscape character will be discussed within each cell below.

³⁸ <https://www.nature.scot/snh-review-124-stirling-grangemouth-landscape-character-assessment>

³⁹ <https://www.falkirk.gov.uk/services/planning-building/planning-policy/local-development-plan/docs/adopted-plan/01%20Adopted%20Plan.pdf?v=201508041042> p58

⁴⁰ <https://www.falkirk.gov.uk/services/planning-building/planning-policy/supplementary-guidance/docs/supplementary-guidance/adopted-documents/09%20SG09%20Landscape%20Character%20Assessment%20%26%20Landscape%20Designations.pdf?v=201512071400>

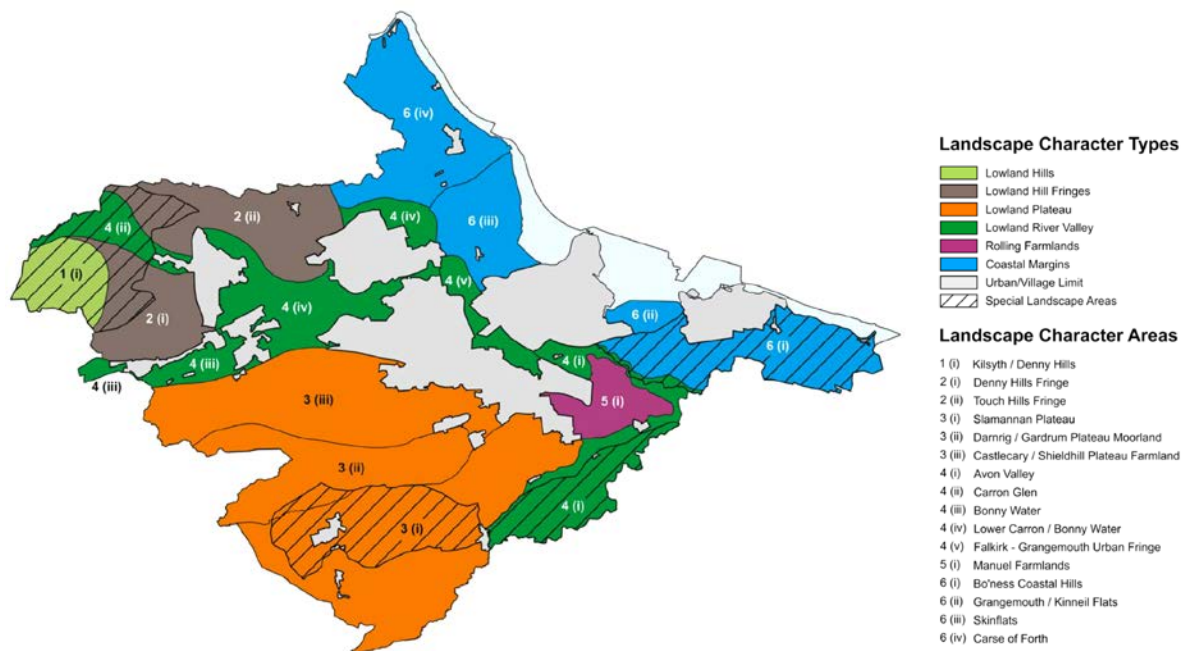


Figure 7-1: Location of the Local Landscape Character Areas and the generic Landscape Character Types with Special Landscape Areas

7.2.2 Designations

Natural Designations

The Firth of Forth, which is located to the north boundary of the Scheme, is designated as a SPA (Special Protection Area), a SSSI (Site of Special Scientific Interest) and a Ramsar site (Wetlands of National Importance). The Carron Dam is a Local Nature Reserve adjacent to the River Carron in Stenhousemuir. These and any other nature conservation designated sites however are covered in Chapter 5: Biodiversity.

Listed Buildings and Scheduled Monuments

There are a number of Listed Buildings within the vicinity of the FPS study area including the Category A Listed Dundas Church on Bo'ness Road, fifteen other Category B, and six Category C Listed buildings (see Figures A11 and A12 and Table A4 in Appendix A). The location of the Category A Listed building was a considerable constraint within the context of the optioneering process.

Part of the study area overlaps the Forth and Clyde Canal Scheduled Monument in cell 2 between the River Carron and the M9 Motorway at the Kelpies. Scheduled Monument Consent (SMC) may be required depending on the nature and extent of works and potential impacts on their setting. Liaison with HES, which may be informed by current planning guidance⁴¹, on works within the vicinity of these sites will be undertaken.

It is anticipated that any potential impacts of the FPS on the fabric and setting of these Listed features will be considered as part of a Heritage Impact Assessment and are in the scope of Chapter 11: Material Assets and Cultural Heritage.

World Heritage Site

There are international heritage designations within or adjacent to the FPS study area. The upstream extents of where works may be on the River Avon could overlap with the UNESCO Antonine Wall World Heritage Site buffer zone, and there is a general presumption against development within the vicinity of the zone that may adversely affect the line, setting or amenity of the Wall. However,

⁴¹ <https://www.historicenvironment.scot/archives-and-research/publications/publication/?publicationId=63064165-053a-4b25-92db-a5f000d1dcbc>

proposals which can lead to a sympathetic use of the Wall for tourism, recreation or interpretation may be supported.

Early consultation is underway with Historic Environment Scotland (HES), to identify flood protection proposals in the area which would be acceptable to the UNESCO status.

In addition to the World Heritage Site designation and associated buffer zone, features associated with the Wall are designated Scheduled Monuments, including:

- Antonine Wall: Millhall Burn to River Avon,
- Antonine Wall: Fort and Shell Middens 240m WSW of the Tower Inveravon,
- Antonine Wall: Nether Kinneil-Inveravon Rampart & Ditch,
- Mumrills Roman Fort located on the Antonine Wall, east of Sandy Loan; and
- Nether Kinneil: Shell Middens 400m ENE of Inveravon.

Garden and Designed Landscapes

There are no Garden and Designed Landscapes within the flood cell areas. The council however has noted in SG09 a number of historic designed gardens and landscapes that do not meet the HES criteria and these are listed in Table 1 “Non - Inventory Designed Landscapes and Sites with Remnant Designed Landscape Features within Falkirk Council Area” (page 91), to ensure that these are protected and that development does not have an adverse effect on the character and setting of these sites and their remaining features. Those within or near the FPS cells on this list are: Avondale House, Carron House and Zetland Park. These are discussed within each relevant cell.

Conservation Areas

There are nine Conservation Areas within the Falkirk Council Area, but none of them interact with the Scheme.

Special Landscape Areas

There are three Special Landscape Areas (SLA) (formally Areas of Great landscape value (AGLV)), within the Falkirk Council area, as noted in SG09. Only one of these touches the edge of one of the cells (Cell 5) ‘*South Bo’ness Special Landscape Area*’, at Inveravon, however this is not close to any of the FPS measures. See Figure 7-1, which shows the locations of the SLAs.

Green Networks

Green Networks, as discussed in Technical Report 7: The Green Network in the Falkirk LDP⁴², run through parts the Scheme, with Key Green Network corridors being located along the River Carron in the Lower Carron area and crossing the Grange Burn and the River Avon in the Falkirk Grangemouth area, see Figure 7-2 below.

If a new development proposal is located within close proximity to the green network there may be opportunities to enhance the green network in tandem with the new development.

⁴² <https://www.falkirk.gov.uk/services/planning-building/planning-policy/local-development-plan/docs/supporting-docs/technical-reports/07%20Technical%20Report%207%20-%20Green%20Network.pdf?v=201406231453>

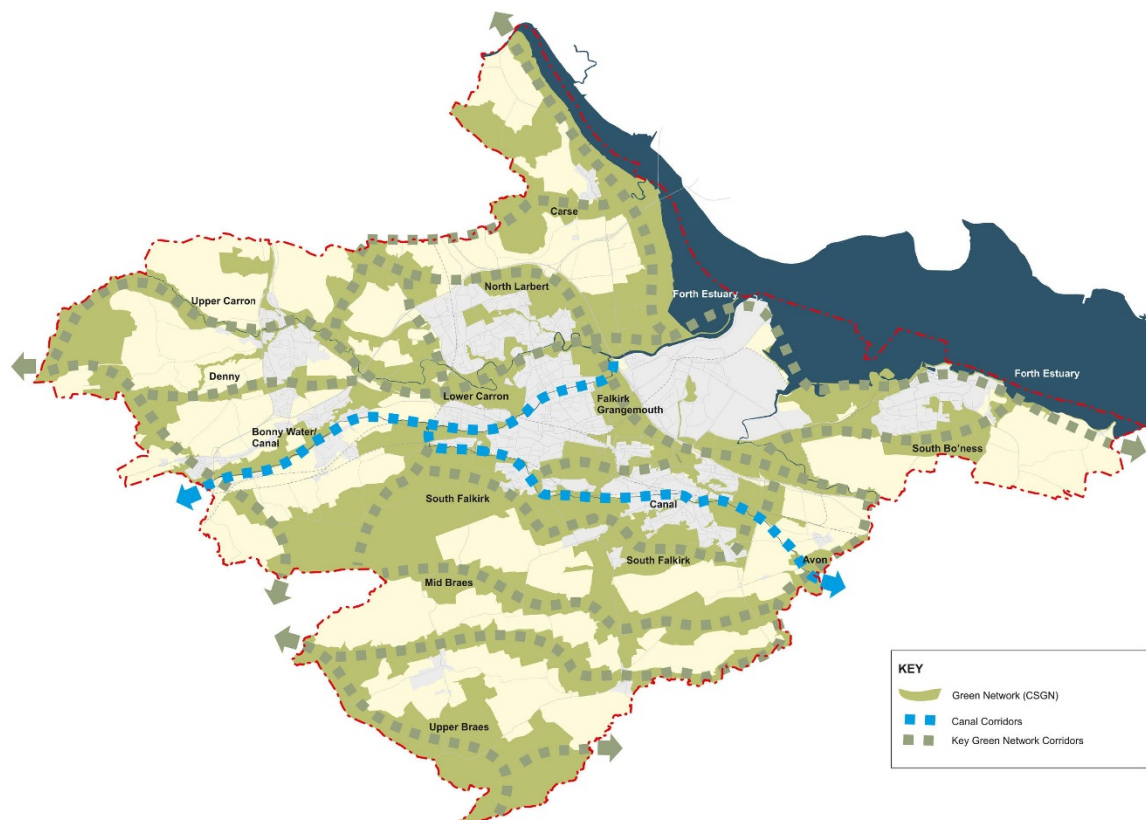


Figure 7-2: The extent of the Green Network in Falkirk Council Area

Falkirk Greenspace Initiative is a partnership between the Falkirk Council, Central Scotland Forest Trust (CSFT) and Scottish Natural Heritage whose primary aim is to improve the landscape and recreational use of the green belt and urban fringes in a comprehensive way. Consideration of the Green Network strategy would need to be reviewed within the Scheme.

7.2.2.1 Cell Specific Landscape Baseline Descriptions

The FPS is proposed for a number of localities in and around Grangemouth, including industrial and residential areas, to address flood risk from the Rivers Carron and Avon, the Westquarter and Grange Burns as well as flood risk along the Forth Estuary shoreline. It is not a continuous measure, and therefore is split into cells which are described individually below.

For the purposes of the scoping the landscape character and visual descriptions have been linked together, however, these will be explored separately within the LVIA.

7.2.3 Flood Cell 1



Figure 7-3: Extents of Flood Cell 1 (©2015 OS: 100023423)

The FPS measures in Cell 1 covers the River Carron corridor, from Stirling Road (A9) near South Broomage in the west, to the M9 motorway in the east (Figure 7-3).

The river meanders from the east at the A9 through the Lower Carron/Bonny Water character area 4(iv) and partially into the Falkirk-Grangemouth Urban Fringe character area 4 (v) to the far east⁴³. The river corridor is particularly sensitive to adjacent infrastructure, and accessibility from the surrounding residential settlements. Views into and out of this area are poorly screened.

The FPS suggested measures split this cell into four main area: Stirling Road; Bainsford; Bainsford/Carron; and Carron. The brief description of the landscape character of these areas are noted below:

Stirling Road

This is a semi-industrial area with the First Group Bus Depot and other trades on the west side of the A9 road, and some smaller businesses and a couple of residential properties on the east side of the road. To the south is a recreational area with access to walking trails, including core path 01/28 (River Carron Path), over and around the River Carron corridor. The tree lined river, with vegetated banks, runs directly adjacent to the road to the north. A number of mature trees are located opposite the bus depot, which help to screen the road and the industrial units from the residential properties.

Bainsford

The river runs through an open parkland area from the west. Residential properties border the parkland, with high fences backing onto the open space. Core path 001/38 'Mungal Riverside' runs along the back of the properties. Four of the residential properties face out to a small grassed open space with a woodland backdrop at the northern edge of the proposed FPS measures.

Bainsford / Carron

The river flows through a wooded area adjacent to the residential estate in the north of the Bainsford/Mungal community. The river is at a lower level to the adjacent banks along this wooded stretch. A large pylon and associated cables is located between the estate and the river. Dawson Mission Church is located between the bridges on Stenhouse Road and the B902 (New Carron Road) to the south of the river, and is currently partially protected with an embankment which a core path

⁴³ Landscape Character Assessment and Landscape Designations SG09, Falkirk Council, July 2015

is located on. Additional residential properties in Carron with the gardens bordering the river to the north are located on this section.

The core paths network (001/38 'Mungal Riverside', 004/1244 'River Carron to rear of Park Road', and 004/1196 'Dawson Mission Path') runs around the edge of the houses in the open parkland and along the southern bank of the river. Additionally, on the north bank of the river is located core path 011/144 'Stenhouse Road to Mill Lade'. The north bank is more industrial in character along this stretch with large business depots and parking areas, and with a high wall bordering 'Nicoles Way' road adjacent to the tree lined river.

There are notable listed buildings very near to the river, particularly, Weir Carron Iron Work (ref: LB13305), a Gravity weir across the River Carron, a former railway bridge across the River Carron (ref: LB13306) and The Grahamston Cast Iron Gate (ref: LB31230). Further details can be found in Chapter 11: Material Assets and Cultural Heritage.

Carron

East Carron/Chapel Burn

This part of the river corridor curves dramatically and consists of a mostly woodland area with some informal paths to the south of the river and a residential estate to the north. The housing is split by the Chapel Burn, which is overgrown. Core path 009/1674 (Carronshore 2000 path) runs alongside the Chapel Burn towards the river. The houses turn their back to the river, with high fences generally separating them from the burn.

Carron House

The river continues to meander, as it curves around the Riverside Stables and parade ground. Beside the stables a residential area borders the parade ground with high timber fences. A few additional residential properties border the river between the Stables and The Avenue, with their gardens open to the waterside. The Avenue runs east up to the B listed Carron House (ref: LB8313), with a pleasant outlook onto the river and the native woodland and marsh to the south, and a high brick boundary wall to the north. Carron House is noted in SG09 as having a 'Non - Inventory Designed Landscapes or Site with Remnant Designed Landscape Feature', and therefore the gardens will potentially need to be considered in relation to this guidance. Core path 009/1702 (The Avenue to Glensburgh Road) runs alongside the River Carron.

7.2.4 Flood Cell 2

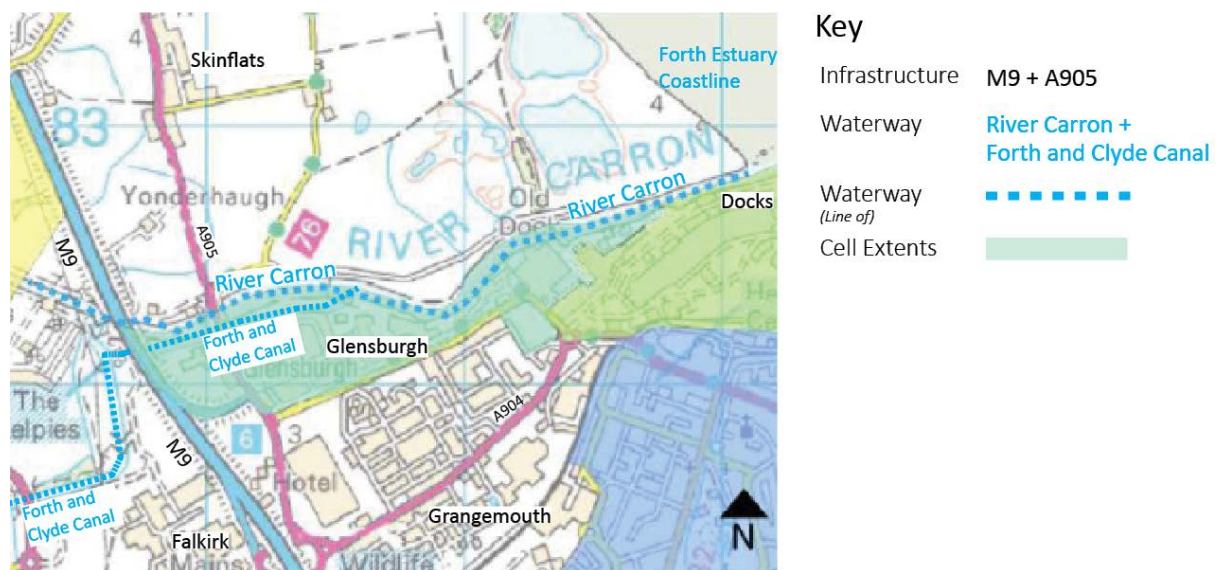


Figure 7-4: Extents of Flood Cell 2 (@2015 OS: 100023423)

Cell 2 follows the River Carron from the M9, near to the Kelpies in the west, to almost the end of the river where it joins the Forth Estuary (Figure 7-4). A new section of the Forth and Clyde Canal runs

from the Kelpies adjacent to the river, and ends in a loch at the river, half way along the cell. To the south of the cell to the west is the Glenburgh residential estate, and to the east are industrial units.

The river meanders through the Skinflats character area 6(iii)⁴⁴. The river widens as it heads towards the Forth with sandy banks on both sides. Overgrown scrub/woodland is located on the southern bank east of the Loch, between the path and the river.

The residential and industrial units turn their backs to the canal and the river, with fences and wall forming the boundaries to the properties. An embankment was constructed as part of the new canal section, to control flooding, which forms a physical and visual barrier to the canal and river from the houses.

The National Cycle Network (NCN) Route 76 runs through the cell, crossing the river at the A905. This route is also part of the core path network, with seven different core paths running through the cell. Core paths 006/1318 and 006/1339 'Rope Walk, Grangemouth Old town' run adjacent to the location of the proposed FPS.

Where the River Carron meets the Forth Estuary there are significant environmental designations including, RAMSAR, SSSI and SPA.

The Forth and Clyde Canal is a Scheduled Monument (ref: SM6768), and any works to or near to the canal would require Scheduled Monument Consent. It is however assumed that the new extension to the canal at the River Carron is not scheduled, but this will be confirmed during the main EIA stage.

Grangemouth Dock, former Workshop Building (ref: LB50868) is the only listed building (Category C) located within the cell, located to the south-east of the cell.

7.2.5 Flood Cell 3

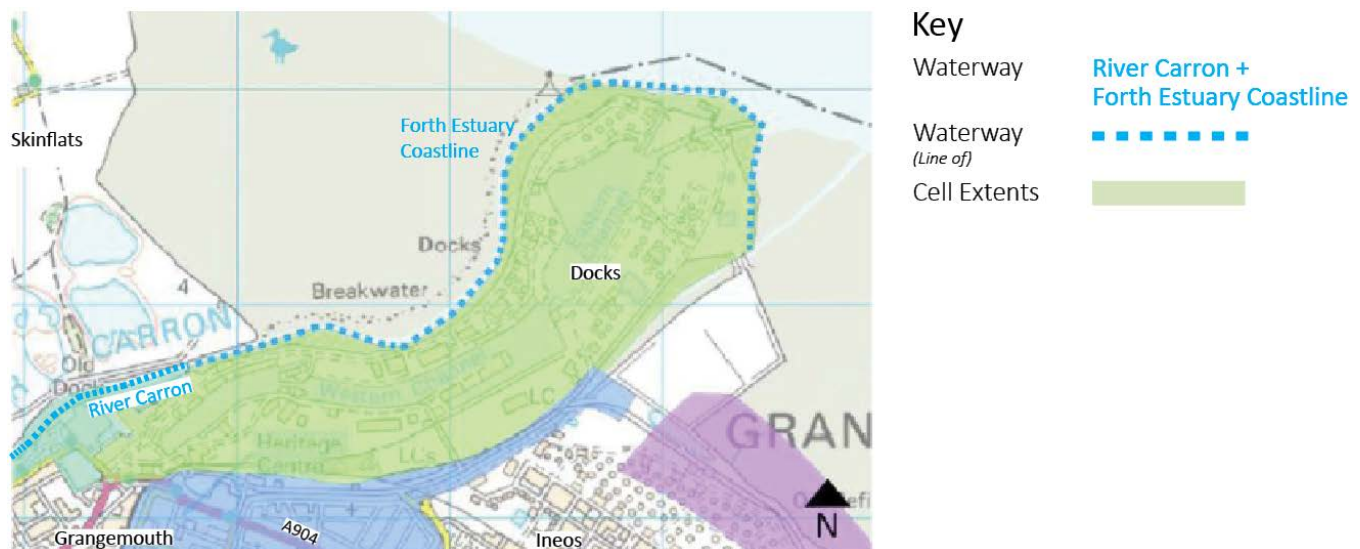


Figure 7-5: Extents of Flood Cell 3 (@2015 OS: 100023423)

Cell 3 covers the harbour area to the north-east of Grangemouth (Figure 7-5). This is an industrial area along the coast of the Forth Estuary and is in private ownership. It consists of industrial buildings, storage containers, water channels and other hard landscape, with little green open space or vegetation. The Grange Burn enters the estuary to the east of the cell.

The area is classed as an 'Urban/Village Limit' Character Type in SG09 (see Figure 7-1), and has no defined Local LCA.

Where the River Carron meets the Forth Estuary there are significant environmental designations including, RAMSAR, SSSI and SPA.

⁴⁴ SG09 Landscape Character Assessment and Landscape Designation, Falkirk Council (July 2015)

There is a listed structure within the cell; the Swing Bridge, Western Channel and Carron Dock (ref: LB34048), although this is not affected by the current FPS measures.

7.2.6 Flood Cell 4

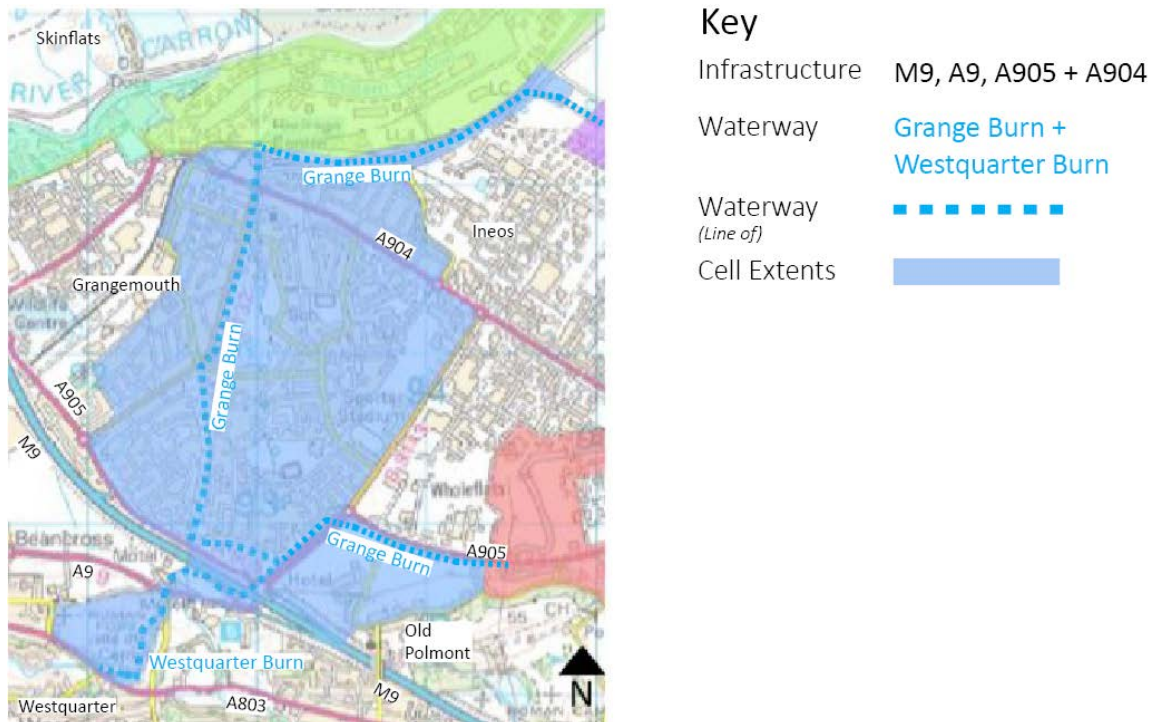


Figure 7-6: Extents of Flood Cell 4 (©2015 OS: 100023423)

Cell 4 encompasses the area from the northern urban extent of Grangemouth following the Grange Burn to the Southern extent of Grangemouth and onto Westquarter (Figure 7-6).

The majority of the cell is considered to be Urban/Village Fringe Character Type (SG09). A small part of Local LCA 4(i) Avon Valley, covers the area of the cell to the south of the A905, which consists mostly of open fields and sports facilities adjacent to the Grange Burn.

The urban town centre of Grangemouth is located in the north of the cell, with the Grange Burn running through the busy residential heart of the town. The southern end of the cell opens up, as it reaches the M9, to a more rural area containing part of the Antonine Wall scheduled monument.

Zetland Park, a 10.75 ha urban park, is the principal open space serving the town, and is a green oasis in a central built-up area. It is noted in SG09 as a Non- Inventory Designed Landscape, and it includes C listed park gates, a war memorial and a B listed fountain, as well as many mature trees. The tree lined Grange Burn runs along the western side of the park. Roads with residential properties and Grangemouth Community Education Unit and sports centre, form the perimeter around the park. Rannoch Park is another smaller, more open park in the south of the town.

The cell includes important infrastructural assets including the M9 motorway to the south, and the A904 and A905. Additionally, many locally important roads within Grangemouth centre have the potential to be impacted by construction and operation of the FPS works including Burnbank Road, Abbots Road and the roads around Zetland Park. Reddoch Road to the south-east of the cell is also perpendicular to the river. The properties located on many of these roads are near to the proposed FPS measures.

There are numerous core paths which run through Grangemouth, as well as NCN route 76. The location and use of the ones which run adjacent to the watercourse and through the parks will be important to consider in the FPS. Core paths 15/522 (Mumrills Road) and 16/570 (Rannock Road to fairy Glen), run alongside the line of the Antonine wall within the south of the cell.

In the south of Cell 4 the site of a Roman Fort and Grandsable Cemetery are located. The Fort is a Scheduled Monument and has a UNESCO World Heritage Site designation status. This designation also covers the entire of the Antonine Wall with a buffer zone for its protection as one of the Frontiers of the Roman Empire. Further details can be found in Chapter 11 Material Assets and Cultural Heritage.

7.2.7 Flood Cell 5

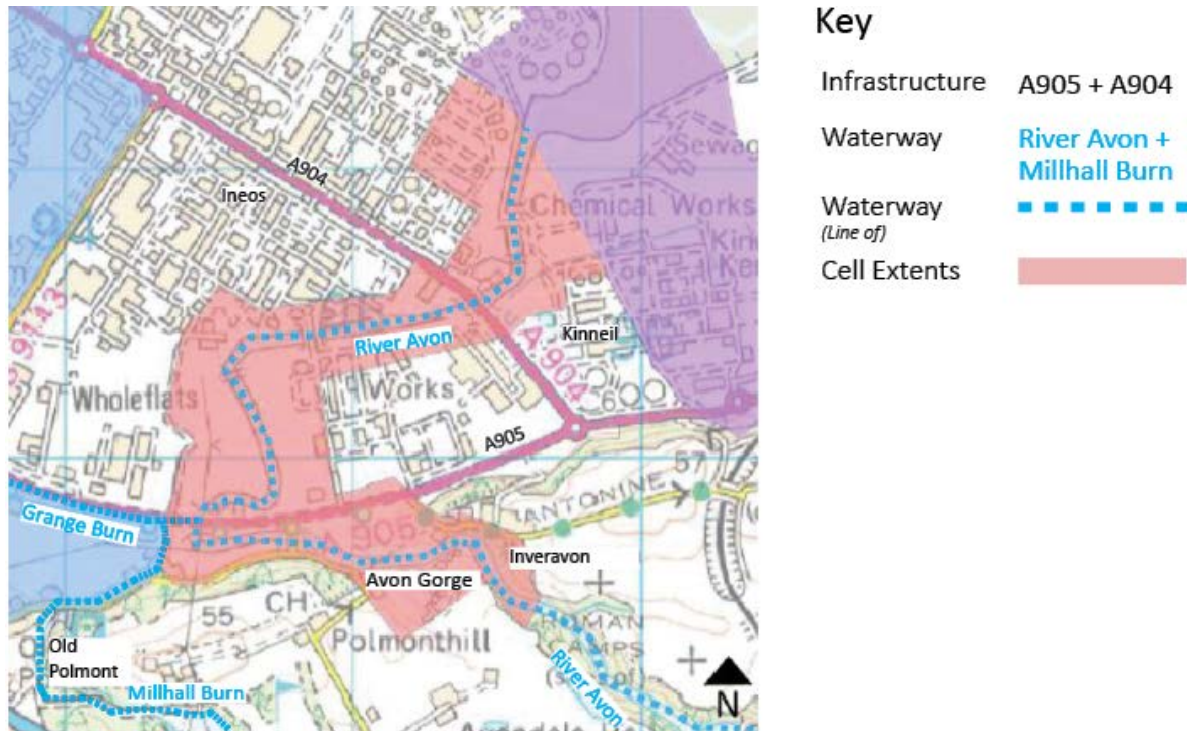


Figure 7-7: Extents of Flood Cell 5 (©2015 OS: 100023423)

The FPS follows the River Avon through Cell 5 (Figure 7-7). The river flows down from the South-East point of the cell at Inveravon and joins the mouth of the Forth Estuary in the north of the cell. Where the River Avon meets the Forth Estuary there are significant environmental designations including, RAMSAR, SSSI and SPA.

The northern part of the cell is considered to be Urban/Village Fringe Character Type (SG09). A small part of Local LCA 4(i) Avon Valley, covers the area of the cell to the south of the A905, which includes the Avon Gorge.

Flood Cell 5 encompasses the South-West industrial fringe of INEOS petrochemicals and a small section of Kinneil Chemical works to suburban Polmonthill with open agricultural land, river channel and individual dwellings. The landscape is perceived as industrial with the A905 providing an edge to the transition into the adjacent suburban areas.

The line of the Antonine Wall runs through this cell, which is a scheduled monument and is protected internationally with UNESCO World Heritage site status. The cell crosses the Antonine wall at Polmonthill and Inveravon. For further details please see Chapter 11: Material Assets and Cultural Heritage. There is also ancient woodland which has been constantly wooded since 1750 and this follows the line of the wall and the River Avon. The Avon Gorge is a designated SSSI due to it being one of the few remaining sites of ancient semi-natural woodland in the Falkirk area. This designation comprises of the steep wooded banks of the River Avon and is 19.12 hectares in area.

There are no core paths through the refinery area. The core path 'Inveravon to Wholeflats Roundabout' (016/648) and NCN route 76 follows the A905 road, near to the FPS. The core path diverts from the A905 and runs in an easterly direction near to the line of the Antonine wall to the

eastern boundary of the cell. Additionally, core path 016/652 (Jinkaboot bridge) crosses the river south of the A905.

Avondale House is noted in the SG09 list of 'Non - Inventory Designed Landscapes and Sites with Remnant Designed Landscape Features'. The House is to the south of the cell, but the gardens will overlook the Scheme. The House is now abandoned, due to fire damaged, and therefore the site is not used, and there are no FPS works proposed adjacent to this property.

The A904 and A905 roads run through the cell, and both cross the river, and Avondale Road and Smiddy Brae to the south of the cell have views of the river looking north.

There are seven opportunities to cross the River Avon within this cell, with three being public access and four within the Petrochemical complex for private use. The Avon Bridge crossing at the A904 is a mid-19th century listed bridge, category C (ref: LB4145).

7.2.8 Flood Cell 6

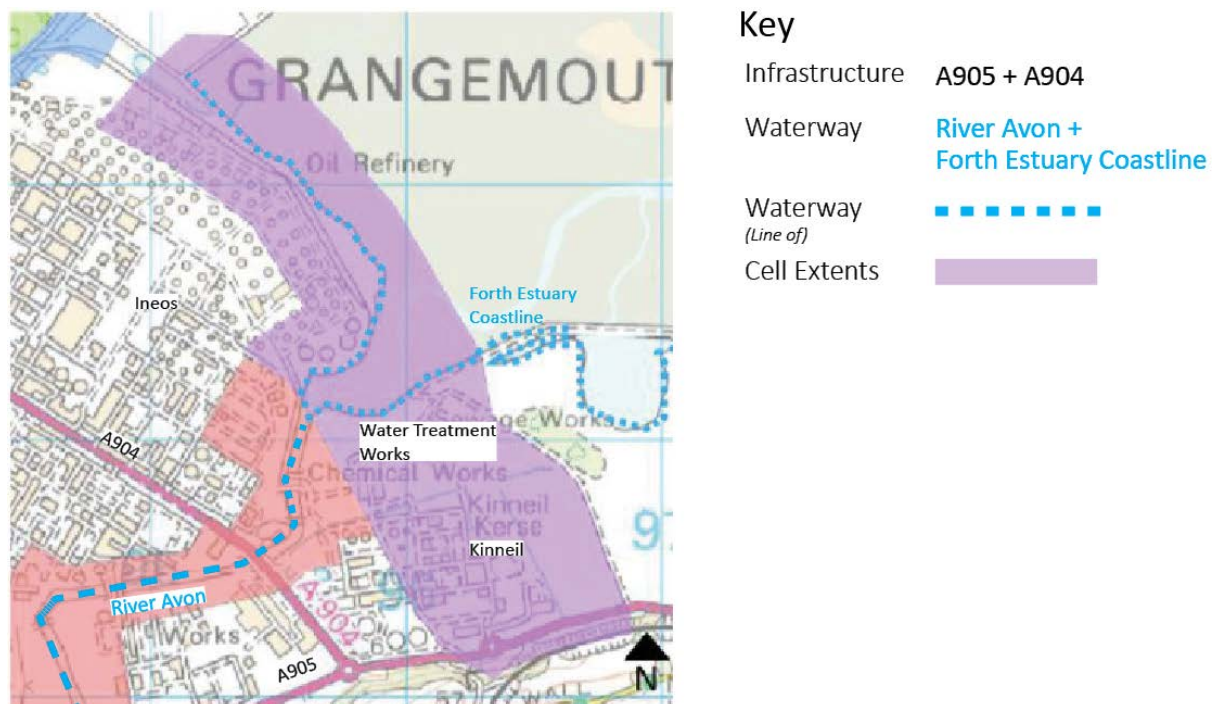


Figure 7-8: Extents of Flood Cell 6 (©2015 OS: 100023423)

Flood cell 6 is an industrial, coastal area which focusses on the industrial fringe and its relationship to the coast of the Forth Estuary (Figure 7-8). The mudflats between the mean low and high-water tides of the Firth of Forth are designated RAMSAR, SSSI and SPA status.

The Local LCA Character Area 6(ii) Grangemouth/Kinneil Flats covers part of the cell, south of the mouth of the river, excluding the INEOS works. The land is reclaimed from the Forth saltmarsh. To the east of the cell is a block of woodland and the Kinneil saline lagoon.

The FPS is located along where the River Avon tributary meets the Forth Estuary, and continues along the coastal edge to the east and west of the river entrance. The industrial edge is that of INEOS Petrochemicals and Kinneil Petrochemicals. There is a Scottish Water treatment works within the centre of the cell parallel to the mouth of the River Avon accessible by a public track.

The A905 road is situated to the south of the cell and is the only A class road within the cell. There are no views of the coast from this road due to the Kinneil site being located between the road and the Forth Estuary.

This cell includes a small part of the buffer zone to the Antonine Wall UNESCO World Heritage Site, which is in the very far south of the cell parallel to the A905 road. The area is however over 1 km from the potential FPS within this cell, and there is no impact to this designation here.

7.3 Key Issues and Potential Effects

The LVIA will review all elements of the proposed design in relation to the impacts on the landscape character and views within the area.

Sensitive receptors include:

- UNESCO World Heritage Site;
- Scheduled Monuments;
- 'Non - Inventory Designed Landscapes and Sites with Remnant Designed Landscape Features';
- Dwellings (including listed buildings) and nearby settlements;
- Core paths/Footpaths/Public rights of way;
- Views from surrounding hills/landscape; and
- Public roads/bridges.

The initial assessment below has been split into the six flood cells, with a brief description of the effects on important locations which will be considered in detail within the EIA Report:

7.3.1 Flood Cell 1

This cell, as noted above, has been split into four distinct character areas along the River Carron.

Stirling Road

The FPS measures within this section are designed as low walls (1m high approx.) along the eastern edge of the Stirling road, from the edge of the open space to the south, up to the residential properties to the north.

The main effect of the installation of a flood wall would be the loss of the green edge to the road, as well as the visual screening to the residential properties east of the road. The trees create a vertical green element to the edge of the road, which would change the character of the space. Mitigation would be required, although there is limited space for additional planting (Figure 7-9).



Figure 7-9: View looking north along Stirling Road with green boundary to the east

A hard edge to the river would also change the character of the space particularly at the north end of the FPS measures (Figure 7-10), and therefore the treatments of the banks and vegetation would be important.



Figure 7-10: North end of Stirling Road looking south down the river with vegetated banks

Bainsford

The FPS measures within this section are designed to be approx. 2m high walls along the edge of the Core path 001/38 'Mungal Riverside'.

The majority of residential properties have their backs to open space along the eastern edge of the parkland, with high fences and are raised above the level of the parkland. Access from Sainford Crescent leads down into the park area and would need consideration to ensure the estate was not segregated from the parkland.

Additionally, there are four properties that face the open green space to the north, which would be adversely impacted by a large wall in front of their houses (Figure 7-11). The exact location and type of this defence would need to be considered carefully to reduce this impact, and not lose the connection with the woodland.



Figure 7-11: Housing faces onto the green open space, with a wooded backdrop

Bainsford/Carron

The FPS measures to the south of the river in the west of this section are unlikely to have much of an effect on the landscape character as the existing embankment is quite high, and the woodland character would likely be unaffected. However, the measures to the east of the Stenhouse Road north of the Dawson Mission could potentially segregate the church from the river and the woodland, due to the proposed 2.5m high wall, potentially changing the character and views of this area for users of the church as well as users of the core path (Figure 7-12).



Figure 7-12: View looking west down the core path, with the Mission Chapel to the left

North of the river (east of Stenhouse Road) the FPS measure are located to the rear of residential gardens. Some of the gardens of these properties are currently open to the river and therefore have a relationship with the watercourse. The high walls would segregate the properties from the river.

The FPS flood wall along Nicoles Way would be slightly higher than the existing wall, which runs along this road. Replacement wall materials would need to be consistent with the landscape character of this area to enable a seamless fit into the landscape.

Interaction with the listed buildings and the pylon are also considerations within the landscape.

Carron

East Carron/Chapel Burn

Residential properties turn their back on the River Carron and the Chapel Burn along this section, with high boundaries, and therefore a new floodwall would not notably change the landscape character. The core path which runs down the Chapel Burn is on the opposite side of the burn from the FPS wall and although would be noticeable (Figure 7-13), it would be screened by existing overgrown vegetation and/or replacement vegetation.



Figure 7-13: Looking north with the chapel Burn on the left

Carron House

The housing to the north of the open area, with the parade ground, has its back to the green space and the river, with a high boundary, and therefore a proposed floodwall in this location would not be significant. Access to the parade ground and stables buildings would need to be considered.

The area further east of this is very sensitive to change as it is principally open to the river from both the rear of the residential properties and from The Avenue (Figure 7-14). The floodwall will segregate the residential properties and the core path from the river, changing the character of this area. However, as it is currently proposed at only 1m high, and therefore able to be seen over, and with the use of appropriate materials, matching in with adjacent walls, the FPS measure could potentially adapt to the character of the area. Carron house and its gardens are behind a high wall, and therefore it is unlikely that the character of this area would be affected.



Figure 7-14: View east along The Avenue

7.3.2 Flood Cell 2

Due to the low-lying character of the area any development is highly visible over a long distance and could potentially interrupt views to the higher ground to the north east to the Forth Estuary and Ochils.

Some of these core path routes are sensitive visual receptors to development due to the generally open and flat character of the area north of the river (Figure 7-15), and the specific location of the walls are important, so not to impact on these views. NCN Route 76 is not likely to be impacted physically, however, views of the FPS from the north across the River Carron may be possible, and therefore materials in keeping with the area would be appropriate.

Due to the industrial nature of the buildings and their uses to the east of the cell, the character of the landscape would be unlikely to change in relation to the FPS measures.



Figure 7-15: View east of the River Carron, with industrial buildings to the right adjacent to the core path

Interaction with the Forth and Clyde Canal and the existing flood prevention measure already in place would require discussion with HES.

7.3.3 Flood Cell 3



Figure 7-16: View east along the mouth of the River Carron, with industrial buildings to the right

Due to the industrial nature of this area (Figure 7-16), and the limited heights of the walls, the landscape character is unlikely to change significantly in this area. There will be a minor detriment to views from the Forth Estuary of the coastline, due to some loss of vegetation, but this could potentially be mitigated as part of the Scheme with replacement vegetation. The heights of the flood defences will dictate the severity of the impact, and this will be explored more in the LVIA.

The listed structures would not be impacted by the Scheme.

7.3.4 Flood Cell 4

The construction of flood walls along the Grange Burn will likely result in the severance of the town as the burn runs directly through the town, and with potentially high walls either side this may change the character significantly, and decrease the permeability of the area. The heights of the flood walls are not yet fixed but proposed heights are noted as from the top of the existing embankment rather than from adjacent ground level.

The mature street trees located within the centre of Grangemouth running along the banks of the Grange Burn (Figure 7-17), and through Zetland Park are visually important elements to the town. These trees create a green network which provide respite from the urban and post-industrial nature of the town and contribute to the landscape character.



Figure 7-17: Trees located adjacent to the Grange Burn on the current flooding protection embankments in Zetland Park

The central avenue trees have a high landscape, visual and amenity value (Figure 7-18). The trees along the burn are likely to be category A (i.e. recommended for retention as they are distinctive to the location, in good condition and will likely survive >40 years), and approx. 30 years old (pending a tree survey). Flood walls in this area may result in a significant loss of trees for the whole town and therefore a dramatic change in the local landscape character. If they were required to be removed as part of the FPS, this would result in a loss of a mature vertical green element within the landscape.

Any changes within Zetland Park would need to follow the guidelines in SG09, in relation to Non-Inventory Designed Landscapes, to ensure that the FPS measures limit changes to the character and setting of the park and its remaining features. Due to the extensive area of existing parkland a long-term management plan would need to be compiled as part of the Scheme.



Figure 7-18: Avenue Trees in Zetland Park

Views from and of public spaces within the town are highly valuable as there is limited access to green spaces. This includes Rannoch Park and Zetland Park, both of which have visual access to the FPS and are important for the amenity, recreation and landscape values.

NCN route 76 runs through Grangemouth and Zetland Park. Users of this route will be affected by any character change and potential rerouting, and even with mitigation measure, this is likely to be a negative impact.

Views of the river from the core paths and numerous roads and properties which are located adjacent to the FPS would need to be considered in the LVIA, and the effects on the users of these spaces will depend on the heights and extents of the flood protection measures.

There are flood protection measures in place along Reddoch Road, such as embankments and edge stabilisation in the form of gabion baskets and walls. These provide protection for the surrounding dwellings from the Millhall Burn and these will remain as they are not proposed to be upgraded as part of the works. As part of the FPS measures, there is a proposed flood wall to the rear of a former Coach House (Figure 7-19), part of the Avonside House dwellings, and as this will replace an existing wall it therefore should not significantly affect the character of the area.



Figure 7-19: Coach House dwelling adjacent to River Avon at the end of Reddoch Road

To the south of the M9 motorway, within the UNESCO World heritage site, there are defined areas of visual importance. The view from the highpoint across the Westquarter carse (boggy grassland; Figure 7-20) is a key point of visual reference on the line of the wall. This area is currently used by visitors to the Antonine Wall and is popular with local dog walkers, as it is adjacent to the core path network and therefore easily accessed. It is imperative that the FPS within this area is dealt with sensitively.



Figure 7-20: Transition from high point to Westquarter carse

7.3.5 Flood Cell 5

There are designated sites on the banks of the Forth where the River Avon meets the Forth Estuary (RAMSAR, SSSI and SPA). There will be some visual impacts and a potential change in character during construction and in operation of the FPS, which will be explored more in the LVIA.

The INEOS Petrochemical and Kinneil Chemical Plants are likely to be visually affected during the construction process and operation. However, this would not bring about a significant character change due to the highly industrial character of the area already (Figure 7-21).



Figure 7-21: Transition from carse to INEOS

The south of this cell includes part of the line of the protected Antonine Wall. Significant changes in character in this area would be detrimental to the legibility and authenticity of the wall. This will be assessed further in the LVIA. For additional details please see Chapter 11: Material Assets and Cultural Heritage.

The River Avon flows through the Avon Gorge SSSI towards the south-east edge of this cell. There are currently no FPS measures proposed within this area, but if there are any significant changes due to the FPS, such as removal of vegetation and changes in levels, there would likely be a negative impact on the character of the area and the quality of the SSSI.

Ancient woodland provides a green edge to the highly industrial nature at the south of the cell, and it provides screening opportunities around the Avon Gorge SSSI. There are however, currently no FPS measures proposed within/near to the Ancient Woodland.

The core path 'Inveravon to Wholeflats Roundabout' (016/648) and NCN route 76, runs parallel to the A905, near to the point where the River Avon travels under the road. This area is quite flat and there are direct views towards the river, both to the north and south of the road from the core path and also travelling along the road. Therefore, any proposed intervention will have an impact to the views and character of this route with the loss of vegetation and construction of flood protection measures. Visual connection to the water and surrounding suburban landscape may be lost.

There are already some flood protection measures in place, including sheet piling and embankment stabilisation measures, along the core path but these are small scale place responsive measures. Larger areas of sheet piling are located near bigger infrastructural elements such as bridges and crossing points. These elements would be reviewed in relation to the proposed FPS, and potentially replaced where required.



Figure 7-22: View looking East along the River Avon at Jinkaboot bridge between A905 and Avondale Road

Views of the river from the A904, A905, and Avondale Road (Figure 7-22) and Smiddy Brae to the south of the cell will potentially be impacted by the Scheme and these will be considered in the LVIA.

7.3.6 Flood Cell 6

Similar to cell 5, the designated sites on the banks of the Forth where the River Avon meets the Forth Estuary (RAMSAR, SSSI and SPA) are in full view from the Firth of Forth and FPS measure along the coastal edge are located within this cell. There will be some visual impacts and a potential change in character during construction and in operation of the FPS. The heights of the flood defences will dictate the severity of the impact, and this will be explored more in the LVIA.

The INEOS Petrochemical and Kinneil Chemical Plants are likely to be visually affected during the construction process and operation. However, this would not bring about a significant character change due to the highly industrial character of the area already.

The public track from the A905 appears to be used locally for access to the edge of the Forth Estuary near to the water Treatment Works and to the SSSI area to the east of INEOS (Figure 7-23). Views from this track would potentially be affected and would need to be considered as part of the LVIA.



Figure 7-23: Public track north of the A905 towards the Scottish water treatment Works, with INEOS on left

7.4 Proposed Studies and Consultation for EIA

Both a separate landscape assessment and a visual assessment will be completed as part of the LVIA chapter of the EIA Report, in consultation with the Falkirk Council's Landscape Architect. This will enable a detailed understanding of the different characters and important views within the proposal areas in Grangemouth and the surrounding area in which the flood Scheme runs through.

It is suggested that the following items are undertaken as part of the LVIA of the proposed Scheme:

- Detailed **baseline assessment** to establish the existing nature of the landscape as a resource, and visual amenity within the study area, with reference to the Stirling to Grangemouth Landscape Character Assessment published by SNH. (no. 124, 1999) and SG09;
- **Consultation** with statutory bodies such as The Falkirk Council, HES and SNH, and other interested bodies such as the Friends of Zetland Park, where applicable;
- Identification and categorisation/value of all **sensitive receptors** including landscape and visual receptors from the world heritage sites, designated monuments/landscapes, listed buildings, public rights of way, residences, commercial properties, settlements and public roads;
- Identification and assessment of **landscape effects** which are likely to occur, including their scale and magnitude, and the likely significance of these effects;
- Assessment of **visual effects** which are likely to occur, including selecting key representational viewpoints in agreement with the council's landscape architect. The change in view from each viewpoint will be assessed and the significance of the effect noted;
- Identification and assessment of any significant **cumulative landscape and visual effects**;
- Full consideration of any **landscape mitigation** proposals to avoid/prevent, reduce or offset any significant effects, including consideration of any advance works. Mitigation proposals likely to include planting of flood embankments as appropriate and careful consideration of appropriate materials for any flood defence walls; and
- Reassessment of **potential impacts after mitigation**.

7.5 Proposed Methodology

The LVIA will cover the construction and operational phases of the flood protection Scheme in accordance with the Guidelines for Landscape and Visual Assessment, 3rd Edition [GLVIA 3] published by the Landscape Institute and IEMA, 2013. The approaches and principles adopted in the guidance will be considered throughout the assessment. The significance of the landscape and visual effects is a key part of the LVIA and the methodology for assessing this will be based upon the criteria described in Section 2.4, which will be further developed to specific landscape principles, and described in detail in the LVIA.

The LVIA in the EIA Report will be split into two sections to discuss and assess the **Landscape** impacts and the **Visual** impacts separately, as both these elements are important in their own right.

Water Environment

8.1 Introduction

8.1.1 Scope

This chapter considers the impacts of the Scheme upon the water environment, including: the hydrology, geomorphology (fluvial and estuarine) and water quality of surface water bodies; the hydrogeology and water quality of groundwater bodies; flood risk; and groundwater dependent terrestrial ecosystems (GWDTEs). The nature of the water environment means that impacts can be identified beyond the boundaries of the works and as such the study areas have been suggested to reflect this.

8.1.2 Study areas

Six Flood Cells have been identified by the project as locations in which works will take place. The study areas for surface waters and groundwater have been determined by the extent of the SEPA baseline surface water body intercatchments and SEPA baseline groundwater bodies that overlap the Flood Cells. See Figure 8-1 and Figure 8-2. However, no modelling for the Scheme has been reviewed and the study area will be adjusted to cover the extent of potential change if required.

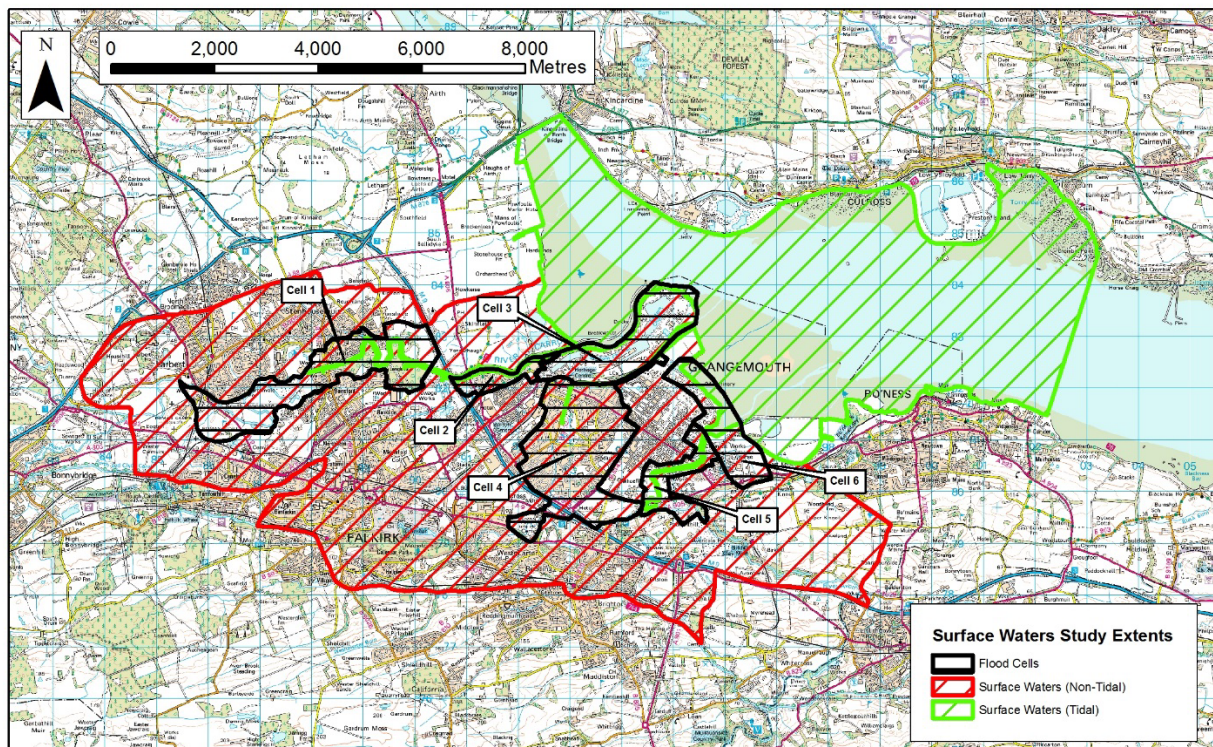


Figure 8-1: Extent of Study Area for Surface Waters

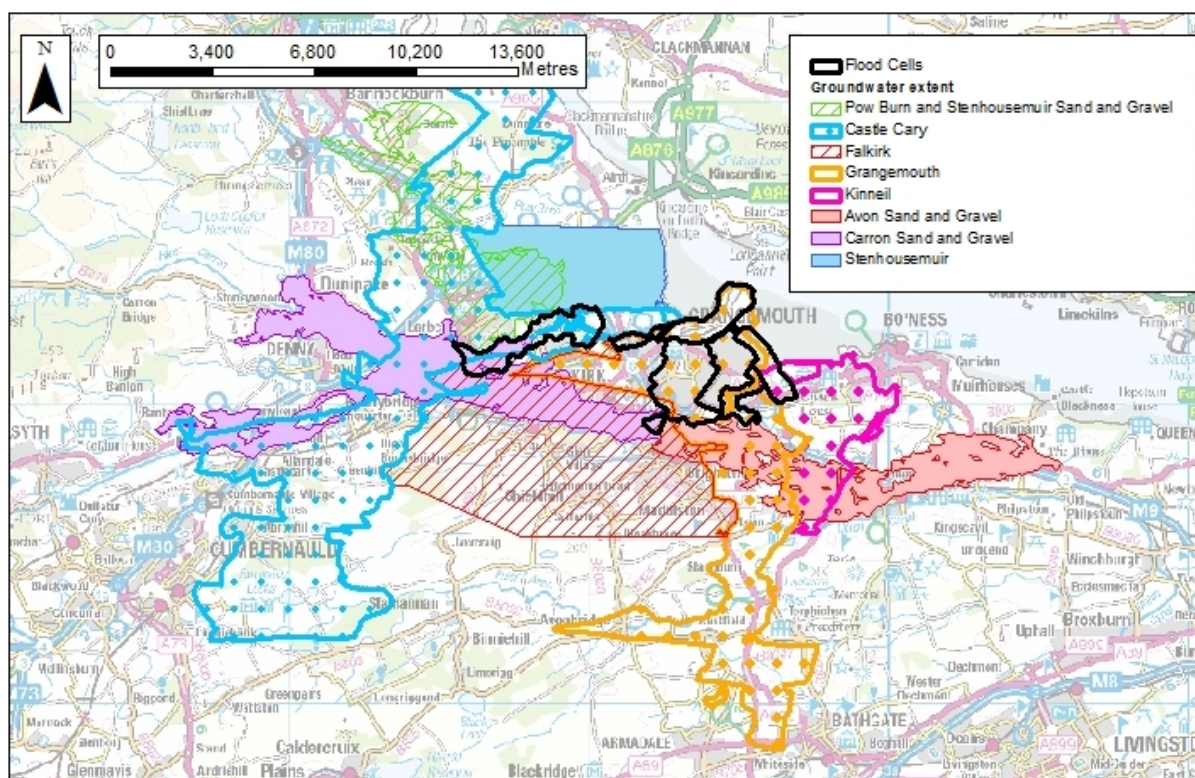


Figure 8-2: Extent of Groundwaters Overlaying Flood Cells

8.1.3 Legislation

8.1.3.1 Water Framework Directive

SEPA introduced a water monitoring and classification system for Scotland, which provides data to support the aim of the Water Framework Directive (WFD) that all water bodies are of 'Good' ecological status, or similar objective, by 2015 (or 2027 if this cannot realistically be achieved). In 2015, revised objectives were set for the 12-year period from 2015 to the end of 2027, together with a strengthened programme for achieving those measures; this is the main legislative driver for the water environment. As part of the WFD, SEPA have derived and reported on a number of baseline water bodies, covering rivers, estuaries, coastal, and groundwater water bodies.

Table 8-1 shows the impacted baseline surface water bodies within the study area and the condition of each, the baseline information for these is discussed further in the following section.

Table 8-2 presents the baseline groundwater bodies present within the study area and the condition of each with the baseline data for these presented in the following section.

Table 8-1: Surface and transitional water bodies present within the study area (SEPA, 2018a)

Waterbody Name	River Carron (Bonny Water confluence to Carron Estuary)	Middle Forth Estuary	Grange Burn/ Westquarter Burn	River Avon (Logie Water Confluence to Estuary)	Island Farm Lagoon - Skinflats. Firth of Forth
ID	4200	200436	3300	3100	200324
Relevant Flood Cells	1	1, 2, 3, 5, 6	3, 4	5	2

Waterbody Name	River Carron (Bonny Water confluence to Carron Estuary)	Middle Forth Estuary	Grange Burn/ Westquarter Burn	River Avon (Logie Water Confluence to Estuary)	Island Farm Lagoon - Skinflats. Firth of Forth
SEPA Description	River Carron (Bonny Water confluence to Carron Estuary) is a river, in the River Carron (Falkirk) catchment of the Scotland river basin district. The main stem is approximately 6.8 Km in length.	Middle Forth Estuary is a transitional water body, in the Scotland river basin district. It is 38.2 square Km in area.	Grange Burn/ Westquarter Burn is a river in the Forth Estuary (South) Coastal catchment of the Scotland river basin district. The main stem is approximately 16.3 Km in length.	River Avon (Logie Water confluence to Estuary) is a river, in the River Avon catchment of the Scotland river basin district. The main stem is approximately 15.5 Km in length.	Island Farm Lagoon - Skinflats. Firth of Forth is a transitional water body, in the Scotland river basin district. It is 0.1 square Km in area.
Artificial Water Body (AWB) or Heavily Modified Water (HMWB)	-	HMWB On account of physical alterations that cannot be addressed without a significant impact on navigation, and from an increased risk of subsidence or flooding.	HMWB On account of physical alterations that cannot be addressed without a significant impact from an increased risk of subsidence or flooding.	-	-
Overall Condition (2014)	Poor	Moderate	Moderate	Moderate	High
Access for Fish Migration (2014)	High	-	High	High	-
Water Flows and Levels (2014)	High	-	High	High	-
Physical Condition (2014)	Moderate	Moderate	Moderate	High	High
Freedom from Invasive Species (2014)	High	Good	High	High	High
Water Quality (2014)	Moderate	Good	Good	Moderate	High
Ecological Condition (2014)	Poor	-	-	-	-

Table 8-2: Baseline Groundwater Bodies within Study Area (SEPA, 2018a)

Waterbody Name	Falkirk	Castle Cary	Grangemouth	Avon Sand and Gravel	Carron Sand and Gravel	Stenhousemuir	Kinneil	Pow Burn and Stenhousemuir Sand and Gravel
ID	150511	150560	150503	150759	150774	150452	150444	150764

Waterbody Name	Falkirk	Castle Cary	Grangemouth	Avon Sand and Gravel	Carron Sand and Gravel	Stenhousemuir	Kinneil	Pow Burn and Stenhousemuir Sand and Gravel
Impacting Flood Cells	1, 2, 4	1, 2	2, 3, 4, 5, 6	4, 5	1, 4	1	5, 6	1
Area	49.4 Km ²	79.7 Km ²	44.3 Km ²	18.1 Km ²	27.5 Km ²	16.7 Km ²	13.1 Km ²	19.6 Km ²
Overall Condition	Poor	Good	Good	Good	Good	Poor	Poor	Good
Water Flows and Levels	Good	Good	Good	Good	Good	Good	Good	Good
Water Quality	Poor	Good	Good	Good	Good	Poor	Poor	Good

8.2 Baseline

8.2.1 Surface Waters

8.2.1.1 Hydrology

The proposed Scheme lies within the catchments of the following baseline water bodies: The Forth Estuary, the River Carron, the Grange Burn (and its tributary the Westquarter Burn) and the River Avon. In addition to these, the following named, non-baseline water bodies overlap the Flood Cells and are visible on the 1:25,000 OS mapping (see Figure 8-3):

- Chapel Burn (Stenhousemuir)
- Gilston Burn (Gilston/Polmont)
- Glen Burn (Falkirk)
- Millhall Burn (Polmont)
- Polmont Burn (Polmont)
- The Grange Burn Flood Relief Channel (Grange Burn)

The 1:25,000 scale OS mapping also shows numerous unnamed ditches and ponds identified throughout the study area, but these will be scoped out of the assessment unless they directly overlap with any of the six Flood Cells as they are not expected to be impacted. Those that will be considered in the assessment are shown in Figure 8-3.

Grangemouth Docks (including Junction Dock, Old Dock and Middle Dry Dock) fall within the extent of the Flood Cells but are scoped out of the assessment as wholly artificial water bodies of very limited environmental value.

The Forth and Clyde Canal (ID: 1) also falls within the surface water (non-tidal) study area but is wholly outwith the extent of the six flood cells.

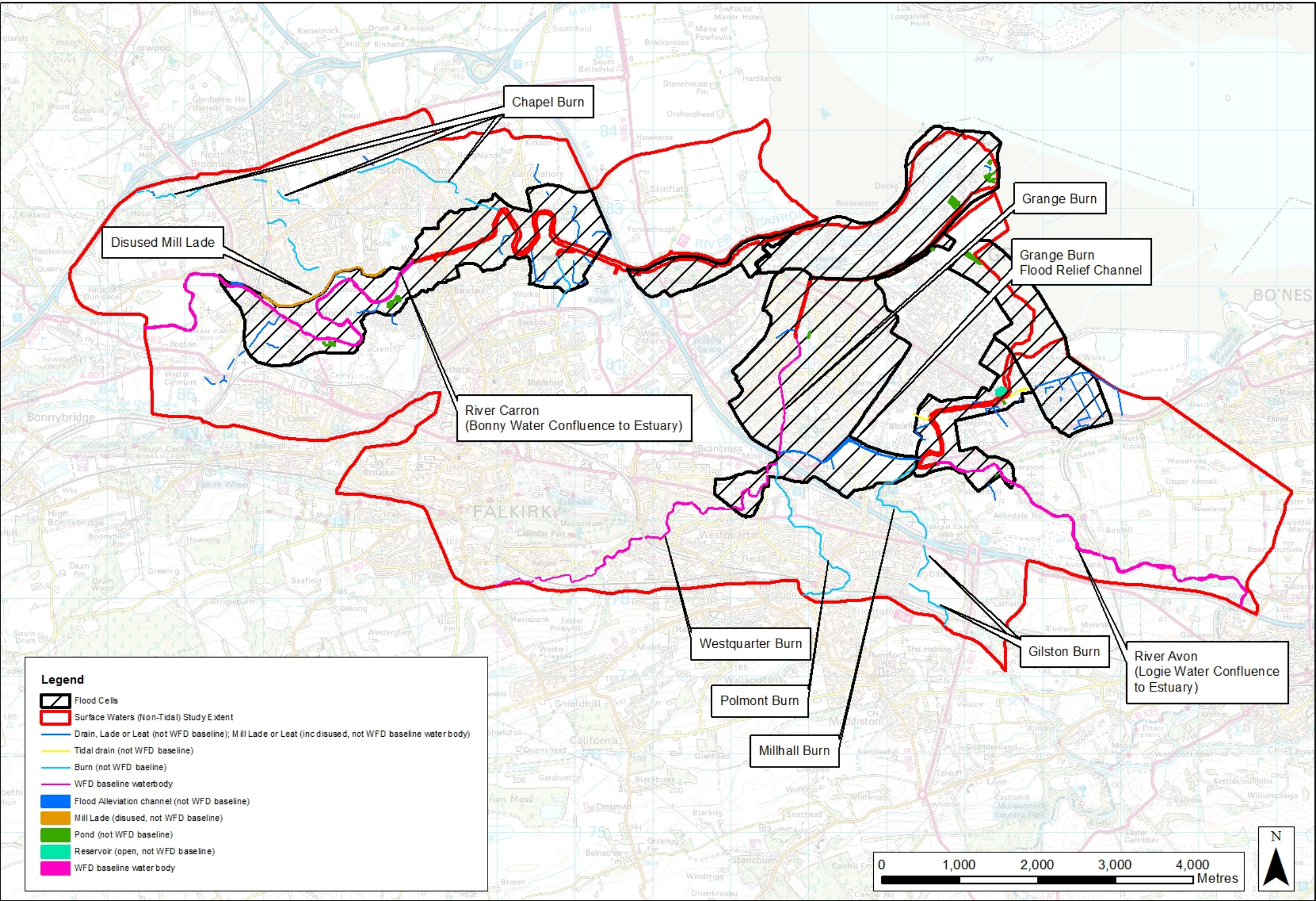


Figure 8-3: Location of ‘scoped in’ Surface Waters (non-tidal)

River Carron

The River Carron drains an area of about 192 km², from its source in the Campsie Fells eastwards into the Firth of Forth via the Carron Estuary (included in the Middle Forth Estuary waterbody) at Grangemouth. The River Carron is approximately 35.6 km in length. It flows through Flood Cells 1, 2 and 3 of this project in its lower reaches.

The bedrock in the headwaters is composed of low permeability igneous rock and Carboniferous sedimentary rocks in the valley. The catchment is mostly overlain by superficial deposits of till, peat and alluvium. In the upper catchment, land use is mainly moorland and plantation forestry, while in its lower reaches (through the area of the Scheme) it is predominately pasture land and urban/industrial development with major road networks and infrastructure. Given the geology, land-use and steepness of the catchment, the river has a flashy response to rainfall events.

Water body condition information is presented in Table 8-1, but pressures on the river throughout the catchment include: flow regulations for abstraction, purification and distribution of water at Carron Valley Reservoir in the upper catchment. In the lower catchment there is flow regulation due to impoundment by weirs and dams for aquaculture. Run-off and flow patterns are significantly affected by the reservoirs and run-off is increased by effluent returns⁴⁵.

There is a gauging station (17001) on the River Carron at Headswood, around 3 km upstream of the proposed Scheme. Data from the National River Flow Archives (NRFA) indicate that at the gauging station, which has an upstream catchment area of 122.3 km², the Q₉₅ flow (i.e. the flow that is exceeded for 95% of the time) is 0.594 m³/s, mean flow is 3.54 m³/s and the Q₁₀ flow (i.e. the flow that is exceeded 10% of the time) is 8.62 m³/s. The NRFA also reports the Base Flow Index (BFI), which is a measure of how much groundwater contributes to river flow, as 0.34⁴⁶.

Grange Burn (and Westquarter Burn)

The Grange Burn is approximately 14 km in length, draining a lowland area of approximately 24 km² into the Firth of Forth. It flows through Flood Cells 4 and 5 of the Scheme and the bedrock of the catchment is composed of moderately permeable Carboniferous sedimentary rocks, mostly overlain by raised tidal flat deposits and alluvium. Land use is pasture land and predominantly urban in its lower catchment. The Grange Burn Flood Alleviation Channel (within Flood Cell 4) moderates discharge downstream by taking flows from the Grangeburn at M9 to the Avon. However run-off is increased by a number of sewage and storm water outfalls into the channel. Water body condition information is presented in Table 8-1.

There are no gauging stations on the Grange Burn.

River Avon

The River Avon drains a lowland catchment of approximately 195 km², from its headwaters near Greengairs, North Lanarkshire, in a north easterly direction to the Firth of Forth near Grangemouth. The River Avon is about 41 km in length. It flows through Flood Cells 5 and 6.

The bedrock comprises moderately permeable Carboniferous sedimentary rocks, predominately overlain by superficial deposits of mostly boulder clay and alluvium. Land-use is dominated by grassland, arable agriculture and forest with a few small former-coal mining towns.

Water body condition information is presented in Table 8-1, however, major pressures include the extensive moorland drainage Schemes in the upper catchment, industrial and agricultural abstractions and point source pollution from sewage disposal (especially downstream of the Logie

⁴⁵ National River Flow Archive for Station: 17001 – Carron at Headswood [Online] Available at: <http://nrfa.ceh.ac.uk/data/station/meanflow/17001> (Accessed June 2016)

⁴⁶ Values of BFI range from 0.1 for a very flashy river to nearly unity for a very stable river with a high base flow proportion (Gustard A., Bullock A., Dixon J.M., 1992. *Low Flow Estimation in the United Kingdom*. Report No. 108. Institute of Hydrology).

Water Confluence). Run-off into the channel is increased by effluent returns⁴⁷. There is some storage of water in the Linlithgow, Lochcota and Forrestburn Reservoirs and Loch Ellrig.

There is a gauging station (17005) on the River Avon at Polmonthill, within the extents of the proposed Scheme. Data from the NRFA indicate that at the gauging station, which has an upstream catchment area of 195.3 km², the Q₉₅ flow is 0.694 m³/s, mean flow is 4.176 m³/s and the Q₁₀ flow is 9.815 m³/s. The NRFA also reports the Base Flow Index (BFI), which is a measure of how much groundwater contributes to river flow, as 0.41.

8.2.1.2 Fluvial Geomorphology

The baseline water bodies expected to be impacted by the Scheme and the Flood Cells with which they overlap are identified in Figure 8-4, with their physical condition outlined in Table 8-1: Surface and transitional water bodies present within the study area (SEPA, 2018a)⁴⁸. A walkover of the reaches of water bodies directly impacted by the Scheme was undertaken in May 2016 and combined with a desk study to produce the baseline report, as part of this project⁴⁹. This has provided the information on the geomorphological baseline conditions presented in this section.

River Carron (Bonny Water confluence to Carron Estuary)

This waterbody lies within the upstream area of Flood Cell 1 where the channel is non-tidal. The channel is approximately 30 m wide, meanders across a floodplain through agricultural land and appears unconstrained. This area of channel was not covered by the 2016 walkover.

Grange Burn/ Westquarter Burn

The Grange Burn is within Flood Cell 4. Upstream of the M9, the channel is relatively sinuous and flows unconstrained across a wide (140 m) floodplain. It is approximately 8 m wide. Downstream of the M9 the channel has been straightened and embanked as part of previous flood defence works, there are, however, signs of some adjustment and increased sinuosity, resulting from localised erosion.

The channel has grassy, tree-lined embankments on both sides, and along much of its length, these disconnect the channel from the floodplain. The banks are fairly steep, uniform and stable with limited morphological diversity along the length of the channel. There is a flood alleviation channel that takes flow from the Grange Burn (just downstream of the M9) to the River Avon.

River Avon (Logie Water Confluence to Estuary)

The River Avon (Logie Water Confluence to Estuary) water body is above the tidal limit and within Flood Cell 5. It flows through a wooded valley, with some disused industrial developments. The channel is approximately 20 m wide confined by steep valley sides; the left bank is steeper and densely vegetated with trees. Bedrock is exposed along the right bank in the downstream section. The right bank is undercut for much of the reach, resulting in localised collapse of the bank and tree fall. Actively eroding banks provide coarse material to the channel contributing to the formation of riffles and bars. The channel is sinuous and has a gravel bed. Channel morphology is pool-riffle dominated with well-defined pools. There are several lateral bars consisting of large gravels and boulders in upstream cascades. Flow conditions are diverse due to the varied channel morphology.

⁴⁷ National River Flow Archive for Station: 17005 – Avon at Polmonthill [Online] Available at: <http://nrfa.ceh.ac.uk/data/station/meanflow/17005> Accessed June 2016.

⁴⁸ SEPA, 2018a. Water Environment Hub [Online] Available at: <https://www.sepa.org.uk/data-visualisation/water-environment-hub/> Accessed January 2018

⁴⁹ Grangemouth Flood Protection Scheme – Geomorphology Baseline Assessment. Prepared for Falkirk Council February 2017

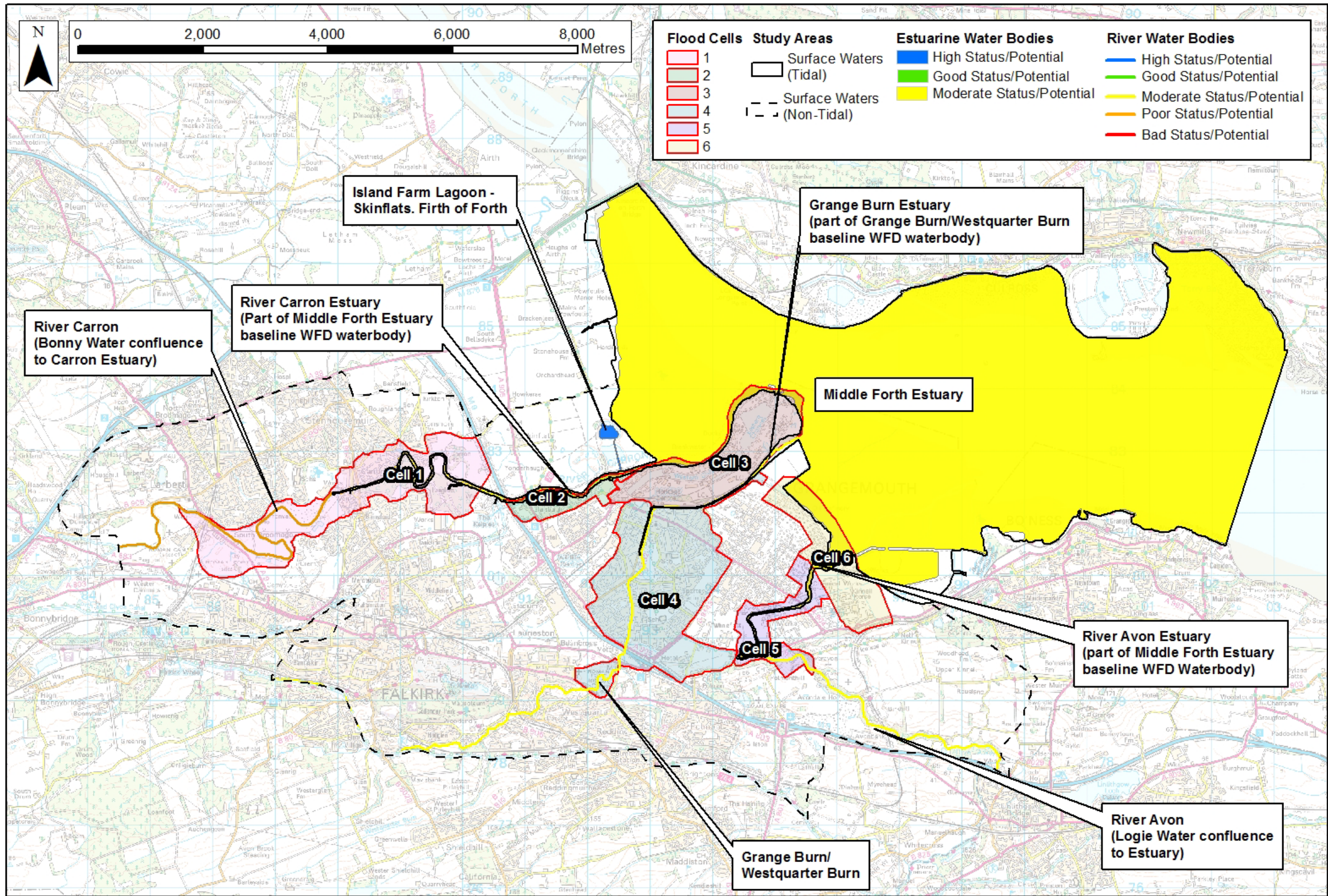


Figure 8-4: Baseline water bodies and project Flood Cells. Note the extent of the surface waters (tidal) study area has been extended slightly beyond the extent Middle Forth Estuary water body to incorporate areas, predominantly saltmarsh, inundated at spring tide

8.2.1.3 Estuarine Geomorphology

Middle Forth Estuary

The main transitional baseline water body potentially affected by the proposed works is the Middle Forth Estuary. This has been designated as a 'heavily modified water body' due to physical alterations of the estuary including reclamation and realignment of shoreline as well as dredging of navigation channels to the Port of Grangemouth. Details on its WFD status are outlined in Figure 8-4. This transitional waterbody includes the tidal reaches of the River Carron and River Avon as well as the Forth Estuary (Figure 8-4). This section describes the physical conditions of this water body in more detail according to the flood cells in which the proposed works occur, namely Flood Cells 1, 2, 3, 5 and 6.

Within Flood Cell 1, the River Carron is tidal, but is likely to be influenced by fluvial rather than estuary processes. The channel is approximately 30 m wide with urban development close to the left bank. Land use along the right bank of the channel is predominately wooded parkland. Both banks in this reach are artificial and formed from coarse material, presumed to have been previously dredged from the channel given the presence of coarse material in the channel. The banks are typically steep and high, with an embankment along the right bank limiting channel-floodplain coupling. The channel appears straightened, and exhibits fairly uniform glide flow conditions with some riffles occurring due to deposition associated with scour at the bridge piers and the partially failed weir. There are also areas downstream of the partially failed weir where defences are failing due to erosion.

Flood Cell 2 comprises of the upper tidal reaches of the Carron Estuary which consists of a single, tidal channel approximately 60 -70 m wide which is backed by flood embankments 5 m high and 10 m wide at the crest. A narrow strip of saltmarsh and mudflat lies seaward of the embankment throughout the length of the channel except on the inside of the Carron channel, where the intertidal habitats extend further offshore. Near the A905 road bridge, the channel is intercepted by a new canal extension built 2012-2014.

The majority of the Carron Estuary is defended except a downstream section on the southern side near the A905 road bridge. In general, the shoreline on the north side shows signs of erosion whilst the south is accreting except near the road bridge where there are signs of erosion. The baseline report also indicates some localised areas of accretion around the inside bend of the channel where saltmarsh has developed.

Flood Cell 3 consists of the lower Carron Estuary and shoreline to the east of Grangemouth Port entrance. The lower Carron Estuary consists of a single, meandering tidal channel approximately 70 - 100 m wide which is flanked by breakwaters to the left and by the Port of Grangemouth to the right. The baseline report indicates that adjacent to the main River Carron tidal channel are mudflats but no other intertidal habitats exist. Southern banks of the Carron are eroding most notably on the outside bends of the channel. Defences in this location are also reported to be in a variable state of repair. This area is likely to be exposed to both locally generated waves and tidal forces.

The shoreline to the east of Grangemouth Port entrance fronting the Forth was not accessible at the time of survey due to construction work. Satellite imagery (Google Earth) of the shoreline suggests it is composed of mudflat, with the Forth Navigation Channel protected by a rock armour breakwater. At the mouth of the Carron, hard defences are set back by 10 – 15 m giving rise to what appears to be a limited foreshore constrained by the Carron channel. To the west of the entrance to Grangemouth Port are mudflats backed by rock armour breakwaters. These relatively exposed locations are likely to be vulnerable to locally generated waves.

Flood Cell 5 consists of the tidal reach of the River Avon. This reach of the Avon, downstream of the A904 bridge to the pipe bridge (350 m away), is a constrained channel with steep muddy banks and narrow mudflats (< 40 m) along the right bank only. Narrow strips of eroding saltmarsh also exist within some of the more sheltered sections. Satellite imagery also reveals bars and sediment deposits throughout this section of the Avon, although it is unclear whether such deposits are tidal

or fluvial in origin. The presence of saltmarsh and sediment deposits within or near the Avon channel indicate a relatively low stream power produced by tidal and fluvial flows and/or high suspended sediment concentrations.

The channel widens upstream of the A904 bridge, characterised by a stable shoreline consisting of a tidal channel fringed by mudflat and an isolated section of saltmarsh present along the inside bend of the left bank. This reach is mainly undefended except for a small section (approximately 200 m in length) along the right bank, which consists of a stonework embankment.

Flood Cell 6 comprises the lower tidal reaches and the mouth of the River Avon, which itself comprises of a channel around 3m deep and 30m wide fringed by mudflats. The shoreline around the mouth of the Avon is currently eroding; there are only short, isolated sections of defences present. Images in the baseline report show erosion to the outside bank in the Avon Estuary (including the promontory). To the West of the Avon Estuary lies the Grangemouth Petrochemical Refinery. Here, the Forth Estuary shoreline is characterised by artificial, vegetated promontories. The promontory was reclaimed between 1984 and 1994 and consists of rubble with some deposits of sands and gravels with pockets of saltmarsh. Much of this reclaimed area is now eroding. An embankment protecting the refinery sits between the promontory and the reclaimed peninsula to the west. In between these features is a stable shoreline consisting of an area of saltmarsh with a tidal channel which crosses the mudflats to the Forth channel. There is a gentle transition from saltmarsh to mudflat (unlike other saltmarshes in this cell which have a cliffed fronting).

Grange Burn/ Westquarter Burn (Estuary)

While technically part of the Grange Burn/ Westquarter Burn waterbody, this part of the estuary is transitional and, as such, is considered in this section. The estuary consists of the main tidal channel which is fringed by mudflats. Saltmarsh is present along the left bank, with other isolated areas of saltmarsh throughout the estuary. The shorelines along the bank of the Grangemouth Port and along the left bank of Grangeburn Estuary are reported to be undefended and currently eroding.

Island Farm Lagoon

Due to the proximity of the Island Farm Lagoon, near Skinflats, to the proposed flood defence Scheme, this water body may also be affected. All conditions within the Island Farm Lagoon water body were classified as 'High' as of 2014 and are not expected to change in 2021, 2027 or the long term.

8.2.1.4 Water Quality

The condition of water quality in each of the potentially affected baseline water bodies is presented in Table 8-1.

The study area does not overlap any part of a Nitrate Vulnerable Zone, the nearest being over 40 km away and in a different catchment and over a different groundwater body. As such no assessment of the impact of the site on Nitrate Vulnerable Zones is required.

There are no surface water Drinking Water Protected Areas within the study area, the nearest being around 11.5 km upstream. As such no assessment of the impact on surface water Drinking Water Protect Areas is required.

The drinking water supply zones within the study area include:

- Turret Zone A (Flood Cell 1)
- Carron Valley B Zone (Flood Cell 1)
- Carron Valley A Zone (Flood Cell 2, 3 and 4)
- Turret/Balmore/Carron Valley Sone (Flood Cell 3, 4, 5 and 6)
- Balmore E Zone (Flood Cell 5 and 6)

No information is publicly available at this stage about the source of drinking water in these zones, or how waste water from the study area is handled. As such consultation with Scottish Water will be undertaken to establish this and facilitate assessment of potential impacts on drinking water and the handling of waste water. The River Carron, the River Avon and the Grange Burn are all designated as Urban Waste Water Treatment Directive (UWWTD) sensitive areas.

8.2.2 Groundwater

8.2.2.1 Hydrogeology

WFD status information for the baseline classified groundwater bodies within the study area can be found in

Table 8-2.

The Hydrogeological Map of Scotland shows that the study area overlies the following aquifer types:

- Concealed aquifers of limited potential, regions without significant groundwater (Quaternary: coastal and river alluvium). Fine grained sands, silts and clays with occasional sand, gravel and cobble deposits occur, but are of limited areal extent. Borehole yields are, for the most part, small, typically 1 and 2 l/s but in rare coarser deposits galleries designed to draw river water have yielded large volumes for little drawdown. Groundwater chemistry is variable, though mineralisation is generally weak with bicarbonate concentrations less than 80 mg/l. These aquifers can be found beneath Flood Cells 1, 2, 3, 4, 5 and 6.
- Aquifers in which intergranular flow is significant; locally important aquifers (quaternary sands and gravels). Sand and gravel of glaciofluvial origin from terraced and gently sloping moundy ground and are of sand and silt grade through to cobble grade. The groundwater potential of these deposits varies according to the thickness of the saturated material, and borehole yields up to 10 l/s and exceptionally 15 l/s have been obtained. Groundwater chemistry is variable but mineralisation is usually weak. The exposed shallow nature of the groundwater places it at risk from diffuse and point-source pollutants. These aquifers can be found beneath Flood Cells 4 and 5 only.

The British Geological Survey 1:625,000 scale Hydrogeological map shows the presence of the following aquifers within the study area. IDs refer to spatially discontinuous bodies of the same nature:

- Scottish Coal Measures Group (ID: 10695). Class 2B. Moderately productive aquifer. Flow is virtually all through fractures and other discontinuities. Regional cyclic multi-layered aquifer with low yields from sandstones. Higher yields where mined but poor quality water, including high iron and fluoride. This aquifer is overlain by Flood Cell 1, 2, 4.
- Scottish Coal Measures Group (ID: 6369). Class 2B. Moderately productive aquifer. Flow is virtually all through fractures and other discontinuities. Regional cyclic multi-layered aquifer with low yields from sandstones. Higher yields where mined but poor quality water, including high iron and fluoride. This aquifer is overlain by Flood Cell 1 only.
- Clackmannan Group (ID: 10675). Class 2B. Moderately productive aquifer. Flow is virtually all through fractures and other discontinuities. Multi-layered aquifer with low yields except where disturbed by mining. Passage group has moderate yields up to 10l/s. This aquifer is overlain by Flood Cell 1 only.
- Clackmannan Group (ID: 10088). Class 2B. Moderately productive aquifer. Flow is virtually all through fractures and other discontinuities. Multi-layered aquifer with low yields except where disturbed by mining. Passage group has moderate yields up to 10l/s. This aquifer is overlain by Flood Cell 2, 3, 4, 5 and 6.

8.2.2.2 Groundwater Quality

The status of baseline groundwater bodies present within the study area can be seen in

Table 8-2. The only existing pressure apparent in the area is the legacy left by mining and quarrying on the Falkirk, Stenhousemuir and Kinneil groundwater bodies, for which SEPA have deemed that no actions are possible to address the pressure and recovery will be natural, albeit not possible within the WFD timescales.

The following Groundwater Drinking Water Protected Areas are Present within the study area:

- Falkirk (ID 150511) – Flood Cells 1 and 4
- Castle Cary (ID 150560) – Flood Cells 1, 2 and 3
- Stenhousemuir (ID 150452) – Flood Cell 1
- Grangemouth (ID 150503) – Flood Cells 2, 3, 4, 5 and 6
- Kinneil (ID 150444) – Flood Cells 5 and 6

8.2.2.3 Groundwater Dependent Terrestrial Ecosystems (GWDTEs)

The impact of potential changes groundwater flows and levels and water quality on GWDTEs will be assessed in conjunction with the ecological assessment of the potential impacts on these areas. The Scottish Wetlands Inventory⁵⁰ identifies several small wetland areas of limited extent to the north of the lower part of the River Carron Estuary and in reclaimed land to the east of the lower part of the River Avon estuary. These areas can be seen in Figure 8-5.

An ecologist will review aerial photography to identify potential GWDTEs within 100m of excavations <1m deep and 250m of excavations >1m deep. Data gathered during ecological surveys such as the Phase 1 Habitat Survey will also be used in support of this. Potential GWDTEs identified from aerial imagery, the Scottish Wetlands Inventory (SEPA, 2018b) and from other ecological survey data will be ground-truthed by an ecologist (if proven to be GWDTE) and likely impacts evaluated.

⁵⁰ SEPA, 2018b. Wetlands Inventory Sites in Scotland in British National Grid [Online] Available at: http://map.sepa.org.uk/atom/SEPA_Scottish_Wetlands_Inventory.atom Accessed March 2018

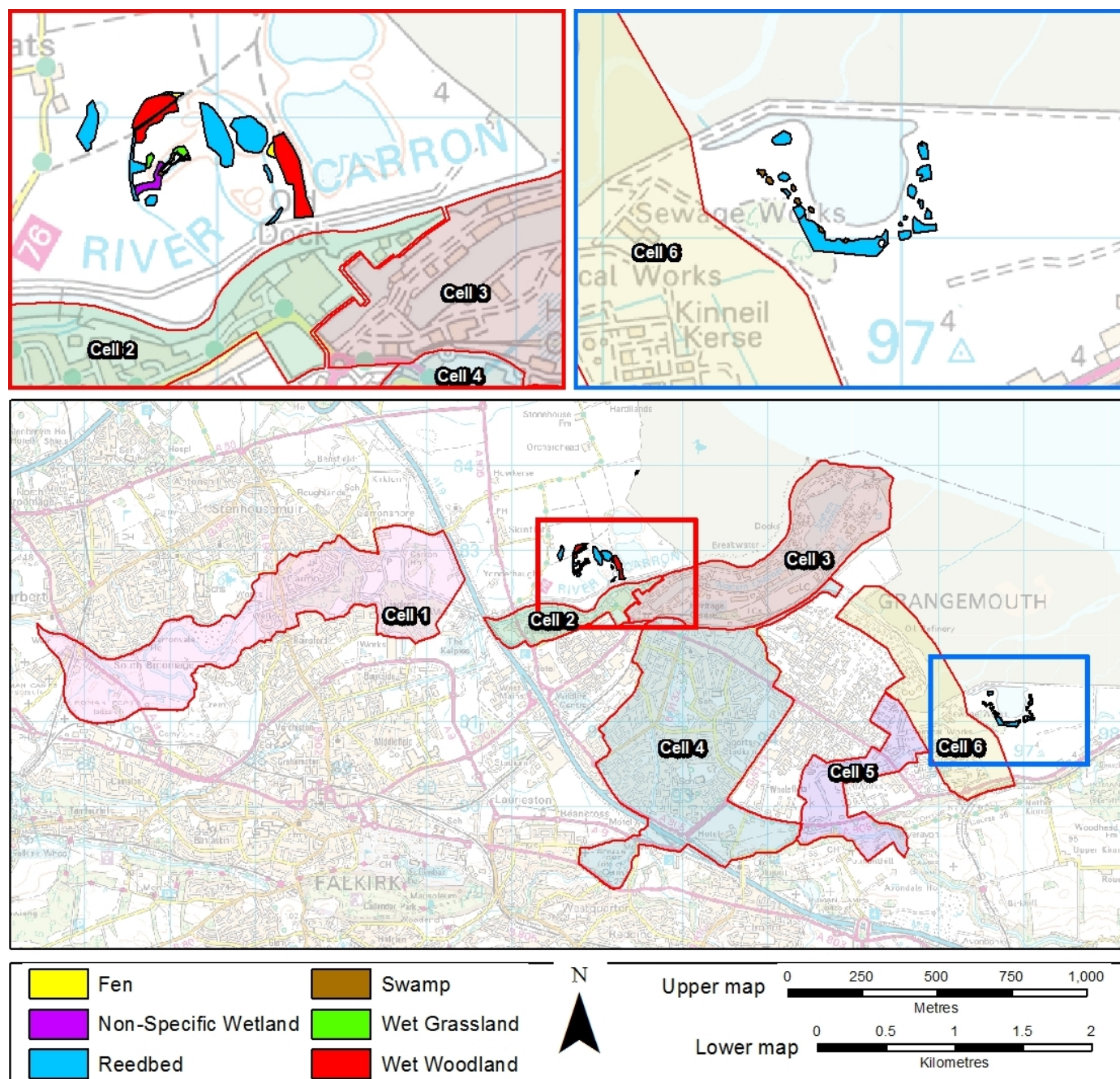


Figure 8-5: Scottish Wetlands Inventory sites around the Proposed Scheme

8.2.3 Flood Risk

SEPA's Flood Risk Management Strategy (FRMS) for Scotland identified that for the Falkirk, Grangemouth, Lauriston, Denny, Redding, Dunipace, Carron and Stenhousemuir area (Potentially Vulnerable Area 10/11) there are approximately 2,000 residential and 330 non-residential properties at risk of flooding. 21% of flood risk originates from surface water (i.e. storms during which the drainage network is under capacity) and 51% from rivers with the remaining 28% from coastal sources.

The highest risk of river flooding is from the River Carron in the Carron / Carronshore area; the Grange Burn in Grangemouth; the Westquarter Burn in Falkirk Westquarter; and the River Carron, Avon Burn and Castlerankine Burn in Denny and Dunipace. The highest risk of coastal flooding is from the Firth of Forth in Grangemouth, and Carron / Carronshore. The highest risk of surface water flooding is in Falkirk, Denny and Cumbernauld.

8.3 Key Issues and Potential Effects

8.3.1 Overview

The key issues for the water environment associated with the proposed Scheme are as follows:

- Minimising the possibility that the proposed option does not lead to a deterioration in WFD status of any surface water or groundwater body, or adversely impact on any water body protected area.
- Minimising the possibility that the proposed option does not significantly impact on available supplies (abstractions) from surface and groundwater bodies, nor on the capacity of surface waters to receive consented wastewater discharges.
- Contributing to improvements in the water bodies wherever possible, as required by the WFD.
- Minimising the risk of water pollution during construction.
- Minimising the possibility that changes in the sediment regime, both during construction and operation, do not significantly impact upon water quality or morphological quality of any of the waterbodies (baseline and non-baseline).
- Identifying all significant physical impacts upon water bodies and mitigating them.
- Minimising the likelihood that changes in the flow regime and flooded areas will impact adversely upon water quality (both surface and groundwater).
- Assessing any changes to flood risk caused by the proposed works.

The Scheme has the potential to have a range of impacts on hydrology of the water bodies related to management of the flow regime to mitigate flooding of areas currently affected. This may result in changes to the flow hydrograph during flood events and affect areas used for temporary flood storage.

The Scheme has the potential to impact the fluvial geomorphology of the waterbodies in a negative way through the hard engineering elements of the Scheme changing flow and sediment transport regime, as they alter the distribution of water on the floodplain, and increase the anthropogenic pressures on the waterbodies. Potential changes to the morphology and water flows and levels of the catchment (positive and negative) caused by the construction and operation of the Scheme will be identified and assessed in the EIA.

The Scheme could also have detrimental impacts upon estuarine geomorphology and processes throughout construction and operational phases. The impacts of the proposed works also need to consider other possible changes to the baselines due to climate change and future anthropogenic behaviour such as land use and drainage.

The possible impacts due to the proposed works include the potential to modify hydrodynamics (fluvial and tidal or combination), water-levels, flow velocities and potentially wave action in the construction and operation phase. This could directly impact upon tidal channel morphology and shoreline stability (erosion of protected habitats) with potential impacts upon flood risk. Modification to estuarine hydrodynamics may also affect sediment transport processes which have the potential to degrade designated areas including estuarine morphology such as mudflat and saltmarsh habitats.

Water quality effects will relate to some extent to changes in flow regime, but also to the exposure, or prevention of exposure to potential pollutants, including sediments (increased turbidity and sediment bound pollutants). A wide range of potential pollutants may be found associated with various land uses within the catchment (e.g. roads, fields, residential and industrial areas). The implementation of the proposed Scheme will reduce the potential for flooding within some of these areas whilst increasing flooding in others, especially where temporary flood storage areas are proposed. There is also the potential to change the dilution capacity during high flow events which

could influence water quality, both locally and downstream of the source. Any impacts upon water quality will be identified and assessed in the EIA.

Works activities during the construction phase have the potential to cause pollution through the spillage or release of potentially polluting material (e.g. silts, organics, metals, concrete, greases, oils and other chemicals/ compounds). This could result in significant adverse impacts to the water environment. The magnitude and significance of such an event will depend upon the scale of the pollution incident and the type of pollutant(s) released and will be considered further in the EIA.

8.3.2 Regulatory Requirements

A Controlled Activities Regulations (CAR) licence will be required from SEPA for engineering works in or near the watercourses associated with the Scheme. A Water Framework Directive MImAS Assessment will be undertaken during the EIA stage and this will also support the CAR licence application.

Some of the proposed works will take place below mean high water spring tidal levels and will require a Marine Licence under Part 4 of the Marine (Scotland) Act 2010. In addition, a works licence will be required by the Forth Ports Authority. The proposed works may also be assessed according to the Flood Risk Management (Scotland) Act 2009.

The proposed works take place within or near several designated sites including Sites of Special Scientific Interest (SSSI), Special Protection Areas (SPA) and Ramsar sites. Impacts on these designated sites will be considered in a separate ecology chapter, but potential changes in the water environment will be highlighted in this chapter.

8.4 Proposed Studies and Consultation for EIA

Table 8-3 shows the proposed studies and consultation required for the EIA.

Table 8-3: Proposed Studies and Consultation for the EIA

Study/Consultation	Justification	Affected Topic	Affected Flood Cells					
			1	2	3	4	5	6
Identification and consultation with recreational and fisheries users of the waterways who may have useful information.	These organisations potentially hold valuable information on water flows and levels, and water quality.	Surface water quality Hydrology	✓	✓	✓	✓	✓	✓
Confirmation from SEPA that no high alkalinity (>50mg/l CaCO ₃) rivers exist in study area	High alkalinity watercourses are considered more sensitive	Hydrology Surface water quality	✓	✓	✓	✓	✓	✓
Establish how SEPA will morphologically classify the different water bodies within the study area for WFD	Estuarine waters do not fit into the morphological classification for rivers (e.g. cascade, step-pool, plane bed etc.). This may affect the magnitude of the assessed impact.	Geomorphology	✓	✓	✓	✓	✓	✓

Study/Consultation	Justification	Affected Topic	Affected Flood Cells					
			1	2	3	4	5	6
Walkover for areas not covered in CH2M HILL, 2017 and areas of interest for other aspects of water environment assessment	Full extent of Scheme not previously known, and therefore not completely covered, by geomorphological baseline walkover. Also, that walkover was specifically from a geomorphological point of view and other water environment issues may require site visits.	All	✓			✓		
MImAS assessment of the Scheme to cover the full extent of the impacted fluvial waterbody	To understand expected change in status before developing CAR licence application.	Geomorphology	✓		✓	✓	✓	
Consultation with Falkirk Council to establish location of Private Water Supplies within a specified radius of the proposed works	Works may affect quantity and quality of water available private from surface and groundwater supplies	Surface Water Quality Groundwater Hydrology Hydrogeology	✓	✓	✓	✓	✓	✓
Consultation with SEPA to establish abstraction and discharge points within the study area.	Works may affect the quantity and quality of water available for abstractions or the ability to continue to discharge. Works may also be affected by these abstractions or discharges.	Surface Water Quality Groundwater Hydrology Hydrogeology	✓	✓	✓	✓	✓	✓
Consultation with Scottish Water to establish sources of drinking water for the area (e.g. reservoir or borehole locations), the location of Water Treatment Works supplying the area and locations of Waste Water Treatment Works.	Depending on the sources of drinking water (and catchments for water treatment works) the works may impact on the quantity or quality of water available, or the paths to or from, or the processes required at Waste Water Treatment Works.	Surface Water Quality Groundwater Hydrology Hydrogeology	✓	✓	✓	✓	✓	✓
Estuarine geomorphological assessment (desk-based)	Improve understanding of estuary behaviour and identify key controls/mechanisms to assess potential impacts caused by proposed works.	Geomorphology	✓	✓	✓		✓	✓

Study/Consultation	Justification	Affected Topic	Affected Flood Cells					
			1	2	3	4	5	6
Numerical Modelling Study** Requirement to be determined at the design stage. Only required if embankments are relocated or subject to significant modification (excl. height).	To identify potential effects on water levels, flow speeds and sediment transport processes due to the proposed works	Geomorphology	✓	✓	✓		✓	✓
Ground Water Terrestrial Ecosystem Survey. Review of aerial photography, Scottish Wetlands Inventory and other ecological survey data to identify potential GWDTEs and the impact of the Scheme on them.	Groundwater flows and levels, and ground water quality, may be affected by the Scheme. In turn this may affect GWDTEs which exist within the boundaries or near to the proposed Scheme.	Groundwater Hydrogeology	✓	✓	✓	✓	✓	✓

8.5 Proposed Methodology

For this scoping stage the baseline environment has been established and from this the water environment receptors have been identified. These are features of the water environment that have the potential to be affected by the proposed Scheme during either construction or operation, or both.

The EIA will describe the existing baseline in further detail in terms of hydrology, geomorphology, groundwater and water quality and identify any further aspects of the water environment (such as abstractions, discharges and smaller water bodies within the Scheme extents). It will also consider the evolution of the baseline without the Scheme, in terms of climate change, change in sea level and change in flood frequency, so we are comparing like with like. Additional online resources will be used to obtain information available. The specific consultation required in order to undertake the EIA for the Water environment have been listed in Table 8-3. Further consultation may be undertaken as part of the general development of the Scheme and this scoping process will be taken into account in the production of the EIA.

Baseline hydraulic modelling data for the Scheme will be reviewed and compared with the proposed “with Scheme” conditions to confirm the extent of changes. As part of the EIA, a MImAS assessment will be undertaken on the baseline water bodies to document any changes in morphological condition that may impact on the WFD classification.

The assessment of the water environment during the EIA will follow the process outlined in Section 2.4: EIA Methodology, with specific development for the water environment following Table 8-4 to Table 8-6 below.

Table 8-4: Criteria used to determine sensitivity

Sensitivity Criteria	Definition
High	<p>Water feature has a high quality and/or rarity on a national and/or international scale, i.e.</p> <p>‘High’ or ‘Good’ overall WFD water quality status, and/or water feature is a valuable water supply;</p> <p>Protected/designated under European Commission (EC) legislation (Special Area of Conservation (SAC), Special Protection Area (SPA), Ramsar site);</p> <p>Water feature appears in complete equilibrium with natural processes occurring;</p> <p>Annual probability of coastal or watercourse flooding is greater than 0.5% (1:200 years); and</p>

Sensitivity Criteria	Definition
	<p>Water feature with direct flood risk to populated areas including residential properties or a very high risk to critical social infrastructure.</p> <p>A groundwater aquifer constituting a valuable resource because of high quality and yield, extensive exploitation for public, private domestic, agricultural and/or industrial supply, or designated sites of nature conservation are dependent on groundwater.</p>
Medium	<p>Water feature has a medium quality and/or rarity on regional/local scale, i.e.</p> <p>‘Moderate’ overall WFD water quality status or considered to exhibit ‘Moderate’ water quality based on professional judgement;</p> <p>‘Moderate’ overall ecology status or potential;</p> <p>Water feature with some natural processes, including varied flow types.</p> <p>Modifications and anthropogenic influences having an obvious impact on natural flow regime, flow pathways and processes;</p> <p>Annual probability of coastal or watercourse flooding is between 0.1% and 0.5% (1:1000 to 1:200 years); and/or</p> <p>A water feature with a possibility of direct flood risk to less populated areas without any critical social infrastructure units.</p> <p>A groundwater aquifer of limited value because its quality does not allow potable or other quality-sensitive uses (but which may be used for agricultural or industrial purposes) and where exploitation is not extensive, or where local areas of nature conservation are known to be sensitive to groundwater quality.</p>
Low	<p>Water feature has a low quality and/or rarity on local scale, i.e.</p> <p>‘Poor’ or ‘Bad’ overall WFD water quality status or potential, or considered to exhibit ‘Poor’ or ‘Bad’ water quality based on professional judgement;</p> <p>‘Poor’ or ‘Bad’ overall ecology status;</p> <p>Water feature which shows no or limited evidence of active natural processes with unnatural flow regime or/and uniform flow types and minimal secondary currents;</p> <p>Annual probability of coastal or watercourse flooding is less than 0.1% (1:1000 years); and/or</p> <p>A water feature passing through uncultivated agricultural land where the socioeconomic impact from flooding is reduced.</p> <p>A groundwater aquifer of low water quality and/or very low permeability that make exploitation of the aquifer unfeasible, or where changes to groundwater are not expected to have an impact on local ecology.</p>

Table 8-5. Criteria used to determine magnitude of change.

Magnitude	Definition
Very high	<p>Proposed Development results in a reduction in the quality and integrity and/or loss of the water feature, i.e.</p> <ul style="list-style-type: none"> Significant changes to the baseline condition of the water feature, hydrology or hydrodynamics, and morphology which may be long-term or permanent; Likely to result in a reduction in the overall WFD chemical/ecological status; Long-term loss or change to designated species/habitats or water supply; and/or A loss of flood storage and/or significant increase in flood risk (i.e. an increase in the 0.5% AEP peak flood level >100 mm). For groundwater, a major permanent or long-term change to groundwater quality or available yield. Existing resource use is irreparably affected. Changes to quality or water table level that have a major impact on local ecology. Or water availability is increased as a result of the development.
High	<p>Proposed Development results in a moderate measurable change in the quality and integrity and/or the loss of the water feature, i.e.</p>

Magnitude	Definition
	<ul style="list-style-type: none"> Moderate changes to the baseline condition of the water feature hydrology or hydrodynamics, and morphology which may be long-term or permanent; Likely to result in a decline in water quality but not sufficient to change the overall WFD chemical/ecological status; May result in temporary impacts on designated species/habitats or water supply; and /or A moderate increase in flood risk (i.e. an increase in the 0.5% AEP peak flood level >50 mm). Changes to the local groundwater regime predicted to have a slight effect on resource use but not rule out any existing supplies. Minor impacts on local ecology may result.
Medium	<p>Proposed Development results in a minor measurable change in the quality or vulnerability of water feature, i.e.</p> <ul style="list-style-type: none"> Observable changes to the water feature hydrology or hydrodynamics, and morphology but temporary in nature; A temporary decline in water quality during construction; and/or a slight decline in water quality during operation but insufficient to change the current WFD chemical/ecological status; and/or A slight increase in flood risk (i.e. an increase in the 0.5% AEP peak flood level >10 mm). Changes to groundwater quality, levels or yields that do not represent a risk to or benefit an existing resource use or ecology.
Negligible	<p>Proposed Development results in an effect on water feature but of insufficient magnitude to affect the use or condition, i.e.</p> <ul style="list-style-type: none"> No observable changes to the water feature, hydrology or hydrodynamics and morphology; No measurable change in water quality at any time during construction and/or operation, thus no change to WFD chemical / ecological status of waterbody; and/or An insignificant increase in flood risk (i.e. an increase in the 0.5% AEP peak flood level <±10 mm). Very slight change from groundwater baseline conditions approximating to a 'no change' situation.

Table 8-6. Matrix for determination of effect of significance. **denotes significant effect in the context of EIA regulations.

	Magnitude			
Sensitivity	Negligible	Low	Medium	High
Low	Negligible	Negligible	Negligible/Slight	Slight
Medium	Negligible	Slight	Moderate**	Moderate**
High	Slight	Moderate**	Substantial**	Substantial**

Land-use, Geology and Contamination

9.1 Introduction

This section appraises the potential for significant effects on land-use, soils, geology and land contamination associated with the construction and operation of the Scheme.

9.2 Baseline

9.2.1 Introduction

The baseline conditions described within this section cover land-use, superficial and solid geology, designated geological receptors, mineral extraction, soils and peat, and potential contamination sources within each cell.

The following subsections consider the potential for significant impacts upon receptors primarily within the six flood cell areas (Figure A3 in Appendix A), as well as impacts that may originate from these areas and affect the wider area.

Where otherwise referenced, data and information for this baseline section have been sourced from the following online resources:

- Land-use: The Centre for Ecology and Hydrology Land Cover Map⁵¹, Main Issues Report (MIR) for the upcoming Falkirk Council Local Development Plan 2 (LDP2)⁵² and the National scale land capacity for agriculture⁵³;
- Geology: British Geological Survey⁵⁴, The Coal Authority⁵⁵ and the National soil map of Scotland⁵⁶; and
- Contamination: A Landmark Envirocheck™ report conducted in 2016.

9.2.2 Flood Cell 1

9.2.2.1 Land-use

Land-use within Cell 1 varies throughout the cell, with land-cover including urban, amenity grassland, mixed riparian woodland and arable uses.

LDP2 MIR shows that the majority of the Cell 1 is allocated as Greenbelt, with the only allocated site for housing lying some 750 m to the east of the proposed defences at Stirling Road.

There is some agricultural land to the west of the proposed works areas at Cell 1 that is identified as having average capacity to produce a range of crops, while other land areas surrounding the river at Carronvale are regarded as having a high-yield capacity.

⁵¹ Centre for Ecology and Hydrology (CEH) Land Cover Map 2007 [online] Available at: <https://www.ceh.ac.uk/services/land-cover-map-2007> (Accessed January 2018)

⁵² Online. Available at: <http://www.falkirk.gov.uk/services/planning-building/planning-policy/local-development-plan/plan-two/docs/Main%20Issues%20Report%20February%202017.pdf?v=201709271049> (Accessed April 2018)

⁵³ National scale land capacity for agriculture (1983) Available at: <http://soils.environment.gov.scot/maps/national-scale-land-capability-for-agriculture> (Accessed 5/2/2018)

⁵⁴ British Geological Survey (2018) Bedrock geology 1:50,000 scale series. Available at: http://www.bgs.ac.uk/products/digitalmaps/digmapgb_50.html (Accessed 22/1/18)

⁵⁵ The Coal Authority (2017) Interactive Map. Available at: <http://mapapps2.bgs.ac.uk/coalauthority/home.html> (accessed 23/01/2018)

⁵⁶ National soil map of Scotland 1: 250,000 (1981) Available at: <http://soils.environment.gov.scot/resources/guide-to-soil-types/> (accessed 5/2/2018)

9.2.2.2 Geology

Designated Geological Sites

There are no designated geological sites within Cell 1.

Bedrock

Bedrock geology at Cell 1 is composed of Scottish Lower Coal Measures strata to the south and Passage Formation (Sedimentary) to the west.

Superficial

The Cell is underlain predominantly by cohesive alluvial deposits described as 'clay and silt', with areas of 'made ground'.

Historic ground investigation data records low strength cohesive alluvium deposits overlying glacial till; with occasional pockets of coarse grained alluvial deposits. Available information suggests bedrock should be encountered at approximately 40 m below ground level (bgl) at the upstream extent of the study area, confirming the published geology⁵⁷.

Mineral Extraction

While some sections of the wider Flood Cell are within the zone of influence of some historical mine workings, there are no visual signs of the land being affected by subsidence or zones of influence of any present underground coal workings⁵⁸. The site does however lie within a coal mining reporting area and there are some coal outcrops noted along the River Carron and six mine entries are concentrated around the Carronshore area.

Soils

The generalised soil types within Flood Protection Scheme (FPS) Cell 1 are alluvial soils and mineral gleys, with an area of brown soils surrounding Cauldhame Farm and Camelon cemetery.

Peat

It is not anticipated that there will be areas of peat located in the areas where soil excavation and/or encroachment is required to accommodate the proposed Scheme within Cell 1.

9.2.2.3 Contamination

The Envirocheck Report shows that within the eastern extent of Cell 1 there are a number of historical land use types that have the potential to be contamination sources. These consist of historical iron works, fire-brick works, a clay pit, a reservoir, historic canal, sewage tanks and a railway line and tramway.

The southern extent of Cell 1 records a historic rifle range south of Carron Dams, and settling tanks southeast of Carron adjacent to the river. In addition, Falkirk Cemetery and crematorium are present to the north of Camelon.

Former and current land uses are recorded within Table 9-1. There are also historic and current waste management sites across the Cell, which will be identified in full as part of the EIA.

Table 9-1: Potential Contamination Sources within Cell 1

Potential Contamination Source/ Land Use	Easting	Northing
Railway lines / tramways present within Cell 1 to the west and centre of study area – 1860s onwards.	Multiple	Multiple

⁵⁷ BAM Ritchies (2014) Ground Investigation Report (GIR) Grangemouth Flood Alleviation Contract 2 – River Carron

⁵⁸ The Coal Authority Property Search Services (2014) Non-residential Coal Authority Mining Report. Reference number (71000502768001)

Potential Contamination Source/ Land Use	Easting	Northing
Sand pit present in or in close proximity to the flood cell – 1860s to 1930s.	287240	682360
Sand pit present in or in close proximity to the flood cell – 1860s to 1930s.	287000	682400
Clay pit present in or in close proximity to the flood cell – 1860s to 1930s.	288250	682645
Iron works, fire-brick works present near the centre of the flood cell (near Carron) – 1860s onwards.	288000	682400
Sewage tanks - 1899	288700	6824500
Sewage purification works 1982	290200	682200
Carmuir Colliery present in the western part of the site	286300	681185
Tram / bus depot in the west of the flood cell (and associated tanks) 1950s	286300	681475
Lochlands Industrial Estate in the west of the flood cell (1980s onwards)	285770	681800
Rifle Range	Undefined	Undefined
Landfill sites	Multiple Locations	Multiple Locations

9.2.3 Flood Cell 2

9.2.3.1 Land-Use

Land-use within Cell 2 at the alignment of the proposed flood defences is urban and industrial, while the (MIR) for LDP2 allocates the land for employment (Site 090).

The urban and industrial area where the Scheme is proposed in this Cell has no current agricultural capacity.

9.2.3.2 Geology

Designated Geological Sites

There are no designated geological sites within Cell 2.

Bedrock

Bedrock geology at Cell 2 is composed of predominantly sedimentary rock cycles of the Clackmannan Group while there is an area of bedrock associated with Scottish Lower Coal Measures Formation to the northwest of the Cell.

Superficial

The superficial geology within Cell 2 is defined as Intertidal Deposits (undifferentiated) consisting of silt and clay.

Mineral Extraction

The Cell is within the coal mining reporting area which highlights the potential risk of abandoned mines. The area is also located in an area containing mineral resources and it is in a secondary opencast coal resource area.

Soils

Soils within Cell 2 are not classified, likely as the area is urban land.

Peat

It is not anticipated that there will be areas of peat located where soil excavation and/ or encroachment is required to accommodate the proposed Scheme within Cell 2.

9.2.3.3 Contamination

A Landmark Envirocheck™ Report conducted in 2015, shows that within Cell 2 there are a number of historical land use types that have the potential to be contamination sources. These consist of historical industrial works (gas works, rope works, smithy) and to the east the timber yard, docks, harbours and timber basins. Potential contamination sources are listed in Table 9-2.

Table 9-2: Potential Contamination Sources within Cell 2

Potential Contamination Source/ Land Use	Easting	Northing
Gas works in the centre of the flood cell – 1864 to 1912	291770	682225
Ship building yard in the centre of the flood cell – 1864 - 1951	292000	682325
Docks / timber basins adjacent to the eastern boundary of the flood cell – 1864 onwards.	Multiple areas	Multiple areas
M9 along the western boundary – 1973 onwards.	Multiple areas	Multiple areas

9.2.4 Flood Cell 3

9.2.4.1 Land- Use

Land use within Cell 3 is primarily dock land and there is a built-up industrial area surrounding both the Eastern and Western channels. There is a small section of land located to the east of the Eastern Channel that is an area of improved grassland.

The Main Issues Report (MIR) for LDP2 shows that there are a number of areas that overlap with the Cell and Scheme alignment that are allocated for employment (090, 128, 162, 163).

The Cell has no current agricultural capacity.

9.2.4.2 Geology

Designated Geological Sites

The Forth of Firth, Site of Special Scientific Interest (SSSI)⁵⁹ borders Cell 3 to the north and south, is not only designated for biological interest but is important for the wide range of geology that can be found there. The qualifying geological features are shown in Table 9-3. The geological and geomorphological diversity found here include a range of features that have aided in the understanding of the Earth's history and, as such, are extremely important. The features include fossil deposits, volcanic rocks, minerals, strata exposures and raised beaches.

Table 9-3: Firth of Forth SSSI Qualifying Geological Features

Qualifying Geological Features
Arthropoda (excluding insects and trilobites)
Carboniferous - Permian Igneous rocks
Coastal Geomorphology of Scotland
Lower Carboniferous [Dinantian - Namurian (part)] rocks

⁵⁹ Forth of Firth Site of Special Scientific Interest. Citation, Scottish Natural Heritage. Available at: http://gateway.snh.gov.uk/sitelink/siteinfo.jsp?pa_code=8499#features (accessed 19/02/2018)

Mineralogy of Scotland
Palaeozoic Palaeobotany
Permian - Carboniferous Fish/Amphibia
Quaternary of Scotland
Upper Carboniferous [Namurian (part) - Westphalian]

Bedrock

Bedrock geology at Cell 3 is composed of Scottish Lower Coal Measures Formation. Passage Formation (Sedimentary) associated with the Clackmannan Group Type are shown to the south of the cell.

Superficial

The Cell is underlain predominantly by Intertidal Deposits consisting of silt and clay, with large areas of made ground.

Mineral Extraction

The Cell is within an area known for coal mining activity. However, although there are no mine entries within the cell, there is one entry out with the cell located to the north of the River Carron, at the northern end of North Shore Road.

There is evidence of a coal seam that outcrops and trends to the south of the River Carron at the top end of North Shore Road, which is also identified by the Coal Authority as a development 'high risk' area.

BGS mapping indicates that within Cell 3, the area is located in an area containing mineral resource silica sand, coinciding with fireclay. In addition, Cell 3 contains an area of limestone associated with carboniferous lower and upper limestone formations, and the site is associated with secondary opencast resource areas.

Soils

There are no classified soils within Cell 3 due to the urban/ industrial nature of the area.

Peat

It is not anticipated that there will be any areas of peat located where soil excavation and/or encroachment is required to accommodate the proposed Scheme within the Cell.

9.2.4.3 Contamination

Within Cell 3 there are a number of historical land use types that have the potential to be contamination sources. These consist of several docks and a timber basin that occupied the western end of the flood cell. In addition, there were also other associated industrial land uses, including smithies, cranes and timber yards, along with Grangemouth train station and railway lines serving the harbour.

Within the section of reclaimed land to the north-west of the Eastern Channel, there are historic creosoting works, a bulk oil depot, a petroleum installation and oil and naphtha storage areas.

These former and current land uses are summarised in Table 9-4.

Table 9-4: Potential Contamination Sources within Cell 3

Potential Contamination Source/ Land Use	Easting	Northing
Extensive railway lines and sidings in the south of the cell 1899 onwards	Multiple	Multiple

Potential Contamination Source/ Land Use	Easting	Northing
Timber yard, creosoting works and saw mill 1921 - 1958	294600	6683400
Tank and oil depot (oil and naphthalene storage) 1921 - 1938	294400	683200
Tallow Works 1943-1966	294400	683200
Dockland (infilled ground), from 1921	294600	628600
Tanks and pump house 1968 onwards	294700	682900
Oil storage depot – 1951 onwards	294300	682500

There may be contamination present in the area associated with these historical industrial activities e.g. buried petroleum tanks and pipes. Additionally, there might also be contamination present associated with current activities including, goods sheds, railway land, docks, depots and works along the route of the Scheme.

9.2.5 Flood Cell 4

9.2.5.1 Land-use

Land-use within Cell 4 is predominantly residential with areas of arable land, market gardens and small areas of forestry. The (MIR) for LDP2 allocates one small area for housing at Abbots Road (site 170) and an employment opportunity area at Little Kerse (Site 206).

The urban and industrial area where the Scheme is proposed in this Cell has no current agricultural capacity. Fields at Wholeflats and Beancross area are identified as 'land capable of average production'.

9.2.5.2 Geology

Designated Geological Sites

There are no designated geological sites within Cell 4.

Bedrock

Bedrock geology at Cell 4 is composed of predominantly Passage Formation sedimentary rock, with areas to the south-west of the cell comprising sedimentary rock of the Scottish Lower Coal Measures Formation (LCMS).

Superficial

The superficial deposits along the course of the Grange Burn consist of predominantly 'Raised Tidal Flat Deposits from the 'Holocene Age' and 'Raised Marine Deposits of the Devensian period'.

In the northeast of the cell, intertidal areas consist of silt and clay, while further south and west, they represent former intertidal areas (raised marine deposits) consisting of soft to firm compressible silt clay with occasional layers of silt, sand and gravel. These deposits are anticipated to provide long-term sediment supply of a range of sizes to the channel as it erodes its bed and banks.

Mineral Extraction

There is no record of any underground mining within Cell 4; however, the south-west of the cell by Polmont burn is located within an area of development high risk area. Similarly, this area falls within an area of surface coal resource area and probable shallow coal extraction.

BGS mapping indicates that within Cell 4 the area is located in an area containing mineral resource silica sand coinciding with fireclay. The area also Glaciofluvial deposits and both Sub-alluvial and river terrace deposits. It is also noted as a secondary opencast resource area.

Soils

The majority of soils within Cell 4 are unclassified due to the urban/ residential nature of the area. To the south-east of the cell, soils are classified as mineral gleys associated with raised beach terraces, while gentle slopes and brown soils surround the Grange Burn to the southwest of the cell.

Peat

It is not anticipated that there will be areas of peat located where soil excavation and/ or encroachment is required to accommodate the proposed Scheme within Cell 4.

9.2.5.3 Contamination

A Landmark Envirocheck™ Report conducted in 2015 shows that within Cell 4 there are a number of historical land use types that have the potential to be contamination sources. These consist of the Docks and associated infrastructure (timber basins, railway and smithys), Grandsables Cemetery lies to the south of the site, while soap works and saw mills were located adjacent to the western site boundary. These former and current land uses are summarised in Table 9-4.

Table 9-5: Potential Contamination Sources within Cell 4

Potential Contamination Source/ Land Use	Easting	Northing
Sawmills and iron foundry 1899-1915	293300	682400
Railway lines adjacent to western and northern boundaries – 1860s onwards.	Multiple	Multiple
Good shed 1921 to 1958	294000	682600
Dockland (infilled ground), from 1921	294600	628600
Tanks and pump house 1968 onwards	294700	682900
Oil storage depot 1951 onwards	294300	682500
Dock yard and associated processes 200 m to the north of the flood cell. Present 1860s onwards	Multiple	Multiple
Sand pit present in the south of the flood cell and 50 m to the north – 1890s to 1930s and 1890s respectively.	292280	679070
Grandsables Cemetery in the south since 1920s	292330	679180
Airfield in the east – 1950s	293560	680750
Oil refinery adjacent to the eastern cell boundary – 1960s onwards	Multiple areas	Multiple areas

Additionally, there might be contamination present associated with current day activities including, railway land, docks, depots and works areas.

9.2.6 Flood Cell 5

9.2.6.1 Land-use

Land-use within flood Cell 5 is predominantly built-up areas and gardens to the north, while the southern area includes a mix of improved grassland, broad leaved, mixed and yew woodland with areas of arable farming and horticulture.

The Main Issues Report (MIR) for LDP2 shows that there is an employment opportunity area at Wholeflats Road (200 m north-west of the alignment; site 202).

Some areas surrounding Beancross and Wholeflats are classified as 'land capable of average production'. Towards Polmonthill, the land is classed as 'land capable of producing consistently high yields' and considered to be prime agricultural land.

9.2.6.2 Geology

Designated Geological Sites

There are no designated geological sites within Cell 5.

Bedrock

The bedrock within Cell 5 is Passage Formation (Sedimentary) to the west, while the north-east of the cell is defined as upper Limestone Formation. Both bedrock geologies are of the Clackmannan group type, and associated with sedimentary rocks of fluvial, palustrine and shallow-marine origins. They are detrital, forming deposits reflecting the channels, floodplains and deltas of a river in a coastal setting (with periodic inundation from the sea).

Superficial

The superficial deposits within this cell are described as raised tidal flat deposits of the Holocene age consisting of silt and clay.

Mineral Extraction

Cell 5 is located within a coal mining reporting area, but there is no evidence to suggest that there are any mining works having taken place. Consequently, historical mine workings or mine entries are unlikely to represent a potential contamination constraint in relation to the cell.

BGS mapping indicates that the area contains mineral resource silica sand coinciding with fireclay. In addition, Cell 5 is also associated with primary opencast resource areas.

Soils

Soils in the area consist mainly of mineral gleys associated with the land forms of raised beach terraces with gentle slopes.

Peat

It is not anticipated that there will be areas of peat located where soil excavation and/ or encroachment is required to accommodate the proposed Scheme within Cell 5.

9.2.6.3 Contamination

A Landmark Envirocheck™ Report conducted in 2013 shows that within Cell 5 there are a number of historical land use types that have the potential to be contamination sources. These consist of areas of sewage treatment works, oil storage depots relating to the adjacent oil refinery and associated infrastructure.

These former and current land uses are summarised in Table 9-6.

Table 9-6: Potential Contamination Sources within Cell 5

Potential Contamination Source/ Land Use	Easting	Northing
Avonside Hospital for infectious diseases 1951	294300	6797100
Jinkabout Mill - 1951	294600	679800
Oil storage depot 1951 onwards	294300	682500
Tank farm (oil refinery and chemical works) from along northern bank and estuary area from 1958 onwards	Undefined	Undefined
Piggery 1958	294400	679600
Sewage Works	294600	679900
Sewage works and Tanks 1973	295800	679600
Goods Shed 1921 - 1958	294000	682600
Tanks and pump house 1968 onwards	294700	682900

9.2.7 Flood Cell 6

9.2.7.1 Land-use

Land use within flood Cell 6 is predominated by built-up areas within the oil refinery, chemical works and sewage works areas. The eastern areas of the cell located around Kinneil Kerse are predominantly improved grassland, arable and horticultural land.

The Main Issues Report (MIR) for LDP2 does not show any allocations for this area.

Land around Cell 6 is mainly classified as urban industrial with no agricultural capacity, other than a section surrounding the Kinneil Kerse, which is classed as 'land capable of average production'.

9.2.7.2 Geology

Designated Geological Sites

There are no designated geological sites within Cell 5.

Bedrock

The bedrock geology within Cell 6 is defined as upper Limestone formation, which is a sedimentary bedrock formed approximately 324 to 329 million years ago in the Carboniferous Period. The local environment was previously dominated by swamps, estuaries and deltas.

Superficial

The superficial deposits within this cell are described as raised tidal flat deposits of the Holocene age consisting of silt and clay.

Mineral Extraction

Part of the north-west of the site is associated with abandoned mines, within an area of probable shallow coal mine workings (located over Grangemouth Road (A904), and within this area, there are sections of coal outcrops.

BGS mapping indicates that the area is located in an area containing mineral resource silica sand coinciding with fireclay. In addition, Cell 6 is also associated with secondary opencast resource areas.

Soils

Much of the soils across the Cell are unclassified with some areas to the east being classified as mineral gleys associated with the raised beach terraces with gentle slopes.

Peat

It is not anticipated that there will be areas of peat located where soil excavation and/ or encroachment is required to accommodate the proposed Scheme within Cell 6.

9.2.7.3 Contamination

The Envirocheck report shows that within Cell 6 there are a number of historical land use types that have the potential to be contamination sources. These consist of Avonbank Knackery, Rifle Ranges and targets, oil refinery, sewage works, plastic works and chemical works which after 1968 is incorporated within the oil refinery.

These former and current land uses are summarised in Table 9-7

Table 9-7: Potential Contamination Sources within Cell 6

Potential Contamination Source/ Land Use	Easting	Northing
Avonbank Knackery 1921-1958	295400	680850
Rifle Range and Targets - 1921	295400	681850
Rifle Range and Targets - 1921	296600	680800
Oil Refinery Works - 1958	295400	682200
Chemical Works - 1968	295000	681200
Sewage Works - 1984	296200	681100
Gas Separator Plant and pumping station - 1984	296000	680600
Plastic works - 1984	294400	681000

9.3 Key Issues and Potential Effects

9.3.1 Land-use

While there is some potential overlap between the Scheme and development areas as identified within the emerging LDP2, no significant effects are predicted as any issue will be addressed accordingly through the appropriate planning process. It is noted that while the emerging LDP2 contains reference to the proposed Scheme, the alignment will have to be confirmed and updated within the Plan to ensure any future development conflict is avoided.

Cells 1, 3, 5 and the north-west of Cell 4, surrounding Beancross, contain agricultural grassland areas. While the Scheme has the potential to slightly reduce the extent of agricultural land in these cells, none of these areas is regarded as prime agricultural land. Locally affected land-owners and tenants will also be consulted with a view to addressing any issues during Scheme design.

The impacts of any such losses may be assessed with reference to the threshold set-out in Schedule 1 of the Environmental Impact Assessment (Agriculture) (Scotland) Regulations 2006⁶⁰, which set a significance threshold of 200 ha for projects “*involving restructuring of rural land holdings on agricultural land wholly outwith a sensitive area*”. As such, potential impacts upon material assets are not considered to be significant with respect to the requirement for further assessment under statutory EIA, as agricultural land take is not anticipated to exceed a few hectares.

9.3.2 Geology

Potential impacts with regards to designated geological sites, the general geology in the area or mineral extraction locations are expected to be limited or absent. Mineral stability is a low risk in the ports and Grange Burn areas. There is an expected presence of old shafts, with various historical maps showing sand pits near the Grange Burn, which may, where appropriate, require engineering solutions to reduce stability risk. However, further ground investigation prior to works and development of a sensitive design throughout the pre-works process should reduce any risk and identify significant issues that require resolution.

Cells 3, 4 and 5 have very soft/ soft superficial geological clays with varying thicknesses and a variable distribution of sands and clays, including boulders within the glacial till. This geological sequence may have potential for risks for the project including the bearing capacity that can be achieved, and hence the overall structural stability of the proposed defences. It is however anticipated that the development will be sensitively designed to ensure that pile construction, where required, is undertaken in areas where the founding strata or bedrock is more competent.

⁶⁰ The Environmental Impact Assessment (Agriculture) (Scotland) Regulations (2006). Available at: <http://www.legislation.gov.uk/ssi/2006/582/schedule/1/made> (Accessed 25/10/2017)

Such construction techniques may also have interactions with hydrogeological and the hydrological aspects of the Scheme area and will require consideration during the design development and appraisal, together with factors such as water quality.

9.3.3 Soils and Contamination

The Scheme has the potential to impact upon soils in the area and interact with potential contamination sources, both in the short-term during construction/ earthworks, and/ or the long-term through operation and maintenance.

Each cell has specific potential contamination sources as described in the baseline above. Cell 3 has the potential for historical buried petroleum tanks/ pipes, associated with the dockland area to be present, which may be a risk when piles or exploratory holes are drilled into the underlying ground. Such constraints may result in potential obstruction and alteration to the development, or potential contaminant migration risk. Likewise, in Cells 4-6, there is the potential for contamination to be present in the form of historic spills and/or made ground material associated with the industrial legacy of the site. Investigation and construction works may include encountering areas of hazardous waste material, which will have to be treated separately from the standard soil arising from the works.

9.4 Proposed Studies and Consultation for EIA

For this scoping stage, the baseline conditions have been established from desk-based assessments. Ongoing site and Scheme specific ground investigations will confirm the nature of the soils, geology, groundwater and potential contamination conditions within the Scheme area. These will be specifically where no historical information is available. A condition survey of the existing flood defences, where present, will also be undertaken where necessary.

This additional information will be taken into account within the initial options assessment for the various flood prevention measures being considered and inform the outline and detailed design processes.

It is anticipated that the additional studies and consultation shall be undertaken to further inform the baseline conditions and EIA and shall include the following:

- A continuation of the desk-based study to update and develop a conceptual site model to inform the ground investigation plan, to further assess the potential contamination, geology and soil conditions within the Scheme extents. The ground investigation plan will be submitted to Falkirk council for comment.
- Impacts on soil resources, groundwater and surface water, disturbance of potentially contaminated soils, or surcharging of the ground may lead to accelerated erosion, subsidence or contaminant mobilisation or leaching. All of these items will therefore need to be considered in the EIA Report.
- It is acknowledged that the Scheme crosses within the vicinity of a number of Tier One COMAH sites and pipelines, and consultation is ongoing with site and pipeline operators as well as with contaminated land and Health and Safety officers at Falkirk Council and HSE.

9.5 Proposed Methodology

The EIA Report will describe the existing baseline conditions in further detail and will be assisted by the ongoing consultations with, and feedback from, locally affected land-owners and tenants in relation to the land-use and potential land-take associated with the proposed FPS.

The assessment for EIA will be informed by the results of the emerging Ground Investigation Report (GIR), which will reveal the site-specific geology, soil and potential contamination conditions across the site. The GIR will specifically include an assessment of potential pollutant linkages, provide commentary on the nature and extent of contamination encountered and include an assessment of

the risk that these may present. Should any contaminants be found, a remedial strategy will be prepared.

In the absence of specific guidance in relation to Schemes of this nature, where required, the assessment of potential impact significance in relation to land-use, soils and geology as part of the EIA will follow guidance provided in the Design Manual for Roads and Bridges (DMRB; Volume 11 Section 3 Part 6 Land Use⁶¹ and Part 11 Geology and Soils⁶²) and the Scottish Natural Heritage (SNH) Handbook on Environmental Impact Assessment⁶³, transposed to fit with the criteria set out in Section 2.4.

Professional judgement will be used to determine receptor sensitivities in accordance with this guidance where possible and will be based on consideration of their size, distribution, importance and quality, as well as the policy and legal significance associated with them. This will also be used to assess the magnitude of potential impacts based on their extent, duration and reversibility.

Consideration of potential contamination in the EIA will be undertaken in accordance with guidance provided in CIRIA C552⁶⁴, Environment Agency guidance⁶⁵ and professional judgement. As a result, the assessment cannot be reported in terms of sensitivity, magnitude and significance. Instead, it will be reported in terms of the likelihood of potential contamination risks being present with respect to the consequence of effects on likely receptors, from which an overall level of risk shall be established.

Within the GIR, any potential contamination risks shall be assessed in the context of a conceptual site model, with potential mitigation measures being identified where appropriate. Potential contamination risks will also be considered in the context of the Water Environment and Air Quality chapters, which will also be informed by the GIR.

⁶¹ DMRB Volume 11 Section 3 Part 6 Land Use. Available at: <http://www.standardsforhighways.co.uk/ha/standards/dmr/vol11/section3/11s3p06.pdf> (accessed 5/2/2018)

⁶² DMRB Volume 11 Section 3 Part 11 Geology and Soils. Available at: <http://www.standardsforhighways.co.uk/ha/standards/dmr/vol11/section3/11s3p11.pdf> (accessed 5/2/2018)

⁶³ SNH (2013) A handbook on environmental impact assessment. Available at: <http://www.snh.org.uk/pdfs/publications/heritagemanagement/EIA.pdf> (accessed 5/2/2018)

⁶⁴ CIRIA (2001) CIRIA C552 'Contaminated Land Risk Assessment: A Guide to Good Practice'

⁶⁵ Environment Agency (2004) The Model Procedures for the Management of Land Contamination

Air Quality and Climate

10.1 Introduction

10.1.1 Overview

This chapter includes a review of the potential air quality and climate concerns arising from the construction phase of the project, including the generation of dust and potential release of emissions. Although, at this stage, no air quality or climate change assessment has been undertaken, the flood protection scheme is itself being put in place, partly to address future flood risk associated with climate change projects. This section highlights the methodology to be followed and a brief evaluation of the potential project constraints in relation to Air Quality and Climate Change impacts.

10.1.2 Study Area

The proposed FPS falls within the Falkirk Council area and is divided into six key areas / cells (as shown in Figure 10-1). Air quality within the vicinity of the FPS is currently influenced by emissions from road traffic and various industrial operations. Sensitive receptors within the project area include residential areas, schools, hospitals and designated ecological sites within and adjacent to the project footprint areas.

The construction phase of the Scheme has the potential to result in temporary air quality impacts resulting from the emission of dust and emissions from construction vehicles. Due to the nature of the Scheme, operational air quality impacts have been scoped out of the EIA, as it is not anticipated to result in any notable changes to the traffic or transport regime within the area such that air quality may be affected.

It is anticipated that climate considerations will be undertaken at a regional level, highlighting key local level impacts as applicable.

10.1.3 Legislation

10.1.3.1 Air Quality (Scotland) Amendment Regulations 2002

The air quality objectives (AQO) applicable to Local Air Quality Management (LAQM) in Scotland are set out in the Air Quality (Scotland) Regulations 2000, the Air Quality (Scotland) Amendment Regulations 2002 and the Air Quality (Scotland) Amendment Regulations 2016. Limit Values are set for individual pollutants and are made up of a concentration value, an averaging time over which it is to be measured, the number of exceedances allowed per year, if any, and a date by which it must be achieved.

There is a parallel set of legislation which relies on European Union legislation, specifically EU Ambient Air Quality Directive 2008/50/EC is implemented in the UK through the Air Quality Standards Regulations 2010 (amended in 2016). It imposes duties upon Secretary of State for Environment to achieve compliance with the EU limit values for the UK as a member state of the EU. The LAQM process, as set out in Part IV of the Environment Act (1995) places an obligation on all local authorities to regularly review and assess air quality in their areas, and to determine whether air quality objectives are being achieved.

The main pollutants of concern most relevant to the construction phase of the proposed Scheme include Nitrogen Dioxide (NO₂) and Particulate Matter (PM). These pollutants are known to have detrimental cardiopulmonary (heart and lung) effects on the human body, and can trigger increased hospital admissions and contribute to premature mortality. They can also have adverse impacts on sensitive ecological receptors through dry deposition, which can alter photosynthetic processes, affecting ecosystem health.

The AQO for NO₂ and PM values are presented in Table 10-1, as these have the potential to be exceeded within the study area during the construction phase of the project.

Table 10-1: Scottish Air Quality Objectives for NO₂ and PM

Pollutant	Concentration	Averaging Period
Nitrogen Dioxide (NO ₂)	200 µg/m ³ <i>not to be exceeded more than 18 times a year</i>	1-Hour Mean
	40 µg/m ³	Annual Mean
Particles (PM ₁₀)	50 µg/m ³ <i>not to be exceeded more than 35 times a year</i>	24-Hour Mean
	18 µg/m ³	Annual Mean
Particles (PM _{2.5})	10 µg/m ³	Annual Mean

Where it is anticipated that an AQO will not be met, it is a requirement of the Act that an Air Quality Management Area (AQMA) is declared. Where an AQMA is declared, the local authority is obliged to produce an Action Plan in pursuit of the achievement of the AQOs. There is an AQMA declared in the district for sulphur dioxide (SO₂), due to emissions from the industrial complex at Grangemouth. However, the proposed Scheme will not be a source of SO₂ emissions, and therefore SO₂ has not be considered in this assessment.

10.1.3.2 Climate Change (Scotland) Act 2009

The Climate Change (Scotland) Act 2009 established a framework for Scotland to achieve its long-term goals of reducing greenhouse gas emissions by carbon emissions by at least 80% by 2050. An interim target of a 42% reduction by 2020 was also set. To ensure that regular progress is made, the Act established a system of Annual Targets, covering the period 2010-2022, 2023-2027, and further batches set every five years thereafter. Therefore, it is important that impacts from future Schemes on greenhouse gas emissions are carefully considered.

10.2 Baseline

10.2.1 Air Quality Management Areas

The baseline conditions for all the FPS Cells within the proposed FPS have been consolidated and are described below. The 2017 Air Quality Progress Report for Falkirk Council (June 2017) reported that automatic and non-automatic monitoring data for 2016 showed no exceedances of the Scottish AQO, outside existing AQMAs (as shown in Figure 10-1), which include:

- Grangemouth AQMA, declared for exceedance of the SO₂ 15-minute mean AQO, within which Cells 2,3,4,5 and 6 are located;
- Falkirk Town Centre AQMA, declared for exceedances of the NO₂ and PM₁₀ AQO, located approximately 1.5 km south-east of Cell 1;
- Banknock and Haggs AQMA, declared for exceedances of the NO₂ AQO, located approximately 7 km south-west of Cell 1; and
- Falkirk Council AQMA no 5 Order 2011, declared for exceedances of the PM₁₀ AQO, approximately 8 km south-west of Cell 1.

As noted above, the FPS is partially located within the Grangemouth AQMA and within 1.5 km of the Falkirk Town AQMA. Due to the distance from the FPS, Banknock and Haggs AQMA and Falkirk Council AQMA no 5 Order 2011 are unlikely to be impacted on by the construction of the project, and hence have not been considered further in this assessment.

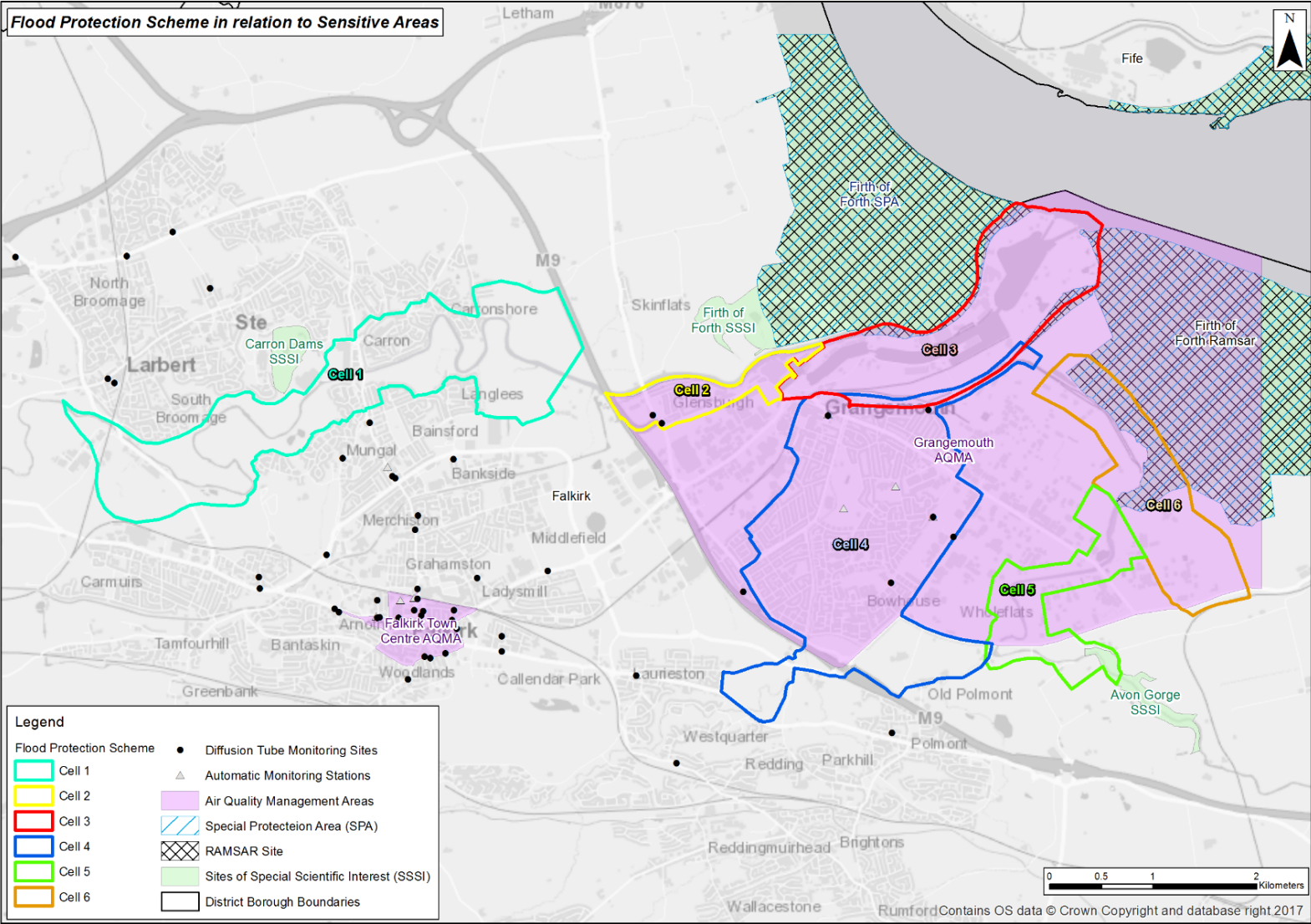


Figure 10-1: Sensitive Areas

10.2.2 Air Quality Monitoring Data

Falkirk Council monitor NO₂, SO₂ and PM concentrations by an automatic monitor, as well as NO₂ concentrations from a network of diffusion tubes positioned at various locations throughout the administrative district (as shown in Figure 10-1).

10.2.2.1 Nitrogen Dioxide

Falkirk Council undertakes ambient monitoring of NO₂ across its administrative area using a network of seven automatic monitors and 61 passive diffusion tubes. Six of the automatic analysers and fifty-one of the diffusion tube monitoring sites are located in Grangemouth AQMA, Falkirk Town Centre AQMA or within proximity to the FPS Cells. Results of NO₂ monitoring undertaken at these sites between 2012 and 2016 are presented in Table 10-2.

Table 10-2: Annual Mean NO₂ Monitoring Results 2012 - 2016

Monitoring ID	Site Type	Annual Mean NO ₂ Concentration (µg/m ³)				
		2012	2013	2014	2015	2016
A5	Automatic	25	23	23	21	23
A7	Automatic	43	39	41	37	37
A8	Automatic	16	14	16	14	16
A9	Automatic	19	16	15	15	18
A10	Automatic	24	20	19	18	21
A15	Automatic	n/m	n/m	n/m	15	24
NA3	Diffusion Tube	21	21	19	20	19
NA5	Diffusion Tube	31	28	27	27	25
NA7	Diffusion Tube	19	19	18	17	16
NA9	Diffusion Tube	25	26	29	26	25
NA21	Diffusion Tube	30	28	28	28	28
NA24	Diffusion Tube	37	42	37	38	35
NA26	Diffusion Tube	22	21	18	17	18
NA27	Diffusion Tube	61	53	45	47	48
NA29	Diffusion Tube	20	18	17	15	17
NA38	Diffusion Tube	20	19	18	16	17
NA42	Diffusion Tube	21	20	19	20	20
NA44	Diffusion Tube	17	16	16	12	12
NA48	Diffusion Tube	21	21	20	19	19
NA50	Diffusion Tube	30	30	27	22	24
NA51	Diffusion Tube	27	24	25	19	25
NA52	Diffusion Tube	28	26	21	24	24
NA57	Diffusion Tube	27	26	26	20	23
NA58	Diffusion Tube	23	22	21	21	20
NA59	Diffusion Tube	31	28	26	29	26
NA60	Diffusion Tube	29	29	27	24	26
NA61	Diffusion Tube	25	26	25	24	24
NA62	Diffusion Tube	39	36	38	39	39
NA63	Diffusion Tube	41	38	36	36	36
NA64	Diffusion Tube	20	20	18	18	18
NA65	Diffusion Tube	25	24	18	27	26
NA67	Diffusion Tube	31	31	28	25	29
NA68	Diffusion Tube	35	31	29	35	31
NA69	Diffusion Tube	38	33	35	30	34
NA70	Diffusion Tube	30	28	28	n/m	34
NA71	Diffusion Tube	38	35	33	35	29
NA72	Diffusion Tube	33	33	32	30	32
NA73	Diffusion Tube	34	35	33	31	22
NA76	Diffusion Tube	24	20	23	23	22
NA77	Diffusion Tube	25	24	22	23	33
NA78	Diffusion Tube	31	30	30	32	31
NA80	Diffusion Tube	31	29	30	32	27
NA81	Diffusion Tube	32	32	29	26	19
NA82	Diffusion Tube	22	20	18	20	38
NA83	Diffusion Tube	41	37	34	35	21
NA86	Diffusion Tube	19	19	15	18	32
NA89	Diffusion Tube	34	34	30	31	32
NA94	Diffusion Tube	38	36	31	24	21
NA98	Diffusion Tube	26	25	22	15	26
NA99	Diffusion Tube	29	26	25	22	21

Monitoring ID	Site Type	Annual Mean NO ₂ Concentration (µg/m ³)				
		2012	2013	2014	2015	2016
NA100	Diffusion Tube	22	21	20	16	23
NA101	Diffusion Tube	26	24	24	17	n/m
NA107	Diffusion Tube	n/m	31	30	28	30
* Results exceeding the AQO are indicated in Bold.						

Air quality monitoring results show continual improvements between 2012 and 2016, with the only exceedance of AQO in 2016 was recorded at NA27 (48 µg/m³), which is located within the Falkirk Town Centre AQMA, approximately 1.7 km south-east of Cell 1.

10.2.2.2 Particulate Matter

Falkirk Council undertakes ambient monitoring of PM₁₀ and PM_{2.5} across its administrative area using a network of eight automatic monitors. Five of the automatic analysers measuring PM₁₀, one of which also measures PM_{2.5}, are located within proximity to the FPS Cells. Results of PM monitoring undertaken at these sites between 2012 and 2016 are presented in Table 10-3.

Table 10-3: Annual Mean PM Monitoring Results 2012 - 2016

Monitoring ID	Site Type	Annual Mean NO ₂ Concentration (µg/m ³)				
		2012	2013	2014	2015	2016
A7	PM ₁₀ Monitor	17.8	19.5	17.7	15	15
A8	PM ₁₀ Monitor	14.1	14	12.4	12.2	11
A10	PM ₁₀ Monitor	14.7	15	14.6	13	13
A12	PM ₁₀ Monitor	16	16.3	13.2	11.8	13
A15	PM ₁₀ Monitor	n/m	n/m	n/m	12.8	10
A8	PM _{2.5} Monitor	10.5	9.2		8	9.2
* Results exceeding the AQO are indicated in Bold.						

As indicated in Table 10-3, no exceedances of the Annual mean AQO for PM₁₀ and PM_{2.5} have been recorded since 2014.

10.2.3 Background Concentrations

The baseline air quality can be conceptualised as the '*background concentration + the local contribution*'. Background concentrations for the whole of the UK are modelled and published for each year up to 2030, based on the National Atmospheric Emissions Inventory. Using background concentrations means that in an air quality assessment for a specific project, only the dispersed concentrations of the emissions sources associated with the project need to be calculated explicitly for the assessment, and then added to the background concentrations. The background concentration of a pollutant is contributed to by regional, national and international sources of emissions and often represents a significant proportion of the total pollutant concentration. The local component is determined by local pollutant sources such as road traffic and chimney stacks.

Data from the 1 km² grid squares, within 2 km of the FPS Cells for 2017 were downloaded from the Scottish Air Quality website (<http://www.scottishairquality.co.uk/data/mapping?view=data>) and are summarised in Table 10-4. As indicated, average background concentrations for 2017, are below the relevant AQOs. Background concentrations representative of future years have not been used.

Instead, following a conservative approach, the 2017 concentrations have been adopted to represent the background conditions at the time of the construction activities.

Table 10-4: Defra Background Pollutant Concentrations

Pollutant	2017 Maximum Concentration (µg/m ³)	2017 Average Concentration (µg/m ³)
NO _x	21.4	14.2
NO ₂	15.5	10.6
PM ₁₀	18.0	10.2
PM _{2.5}	10.9	6.4
* Results exceeding the AQO are indicated in Bold.		

10.2.4 Ecological Designated Sites

Construction activities relating to the flood defences within the vicinity of the designated sites could potentially have detrimental effects on ecosystem performance as a result of the deposition of particulates as well as increased NO₂ concentrations resulting from the movement of construction vehicles within the area.

The pollutant of most concern in relation to vegetation and ecosystems is NO_x. Excessive exposure to NO_x can cause death in plants and roots and damage the leaves of many agricultural crops as a result of the lowering of pH of soil and surface and groundwater.

The sensitive ecological receptors (e.g. designated sites) identified within the project area, as shown in Figure 10-1, include international conservation sites (Firth of Forth Ramsar site) and national conservation sites (Firth of Forth SPA and SSSI, Carron Dams SSSI and Howierig Muir SSSI). These ecological receptors may potentially be impacted by the construction of the FPS as they contain ecological features that could be sensitive to changes in nitrogen levels, which could have direct and indirect effects on vegetation affecting species composition and ecosystem health.

Table 10-5 presents the critical load ranges and baseline nitrogen deposition rates for all identified designated sites within the project area, according to APIS. It is important to note that there is uncertainty attached to these APIS values, as they are based on empirical data from field experiments and observations.

Table 10-5: Designated site critical loads for nitrogen deposition and baseline nitrogen deposition (kg N h 1 y 1)

Designated Site	Critical Load Class	Critical Load (kg N/ha/yr)
Firth of Forth (Ramsar site, SPA and SSSI)	Permanent oligotrophic waters: Softwater lakes	3 - 10
	Raised and blanket bogs	5 - 10
	Northern wet heath: Calluna-dominated wet heath (upland moorland)	10 - 20
	Pioneer, low-mid, mid-upper saltmarshes	20 - 30
	Moss and lichen dominated mountain summits	5 - 10
	Low and medium altitude hay meadows	20 - 30
	Shifting coastal dunes	10 - 20
	Coastal stable dune grasslands - acid type	8 - 10
	Coastal stable dune grasslands - calcareous type	10 - 15
	Moist and wet oligotrophic grasslands: Heath (Juncus) meadows and humid (Nardus stricta) swards	10 - 20
	Broadleaved deciduous woodland	10 - 20
Carron Dams (SSSI)	Valley mires, poor fens and transition mires	10 - 15
	Rich fens	15 - 30
	Mountain rich fens	15 - 25
Howierig Muir (SSSI)	Raised and blanket bogs	5 - 10

10.2.5 Climate

The Intergovernmental Panel on Climate Change⁶⁶ states that “Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions”.

Greenhouse gas (GHG) emissions have a combined environmental effect that is approaching a scientifically defined environmental limit. As such, any GHG emissions or reductions from a project should be considered. All new embodied carbon emissions⁶⁷, arising from the use and consumption

⁶⁶ (IPCC, 2013) Summary for Policymakers (p.19) [Online]: http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_SPM_FINAL.pdf
Accessed April 2018

⁶⁷ The embodied carbon dioxide emissions of a material is the total carbon dioxide equivalent emissions released prior to it leaving the factory gate. This would normally include extraction or harvesting, the manufacturing process and any pre-distribution transportation. However, it does not include the carbon dioxide emissions associated with transport

of material resources, are therefore likely to contribute to a significant negative environmental effect.

According to the Köppen Climate Classification the climate in the Grangemouth area is classified as subtype "Cfb". (Marine West Coast Climate), characterised by equitable climates with few extremes in temperature and constant precipitation through all months in the year.

The UK Climate Projection (UKCP09) was produced in 2009, funded by a number of agencies led by Defra and managed by the Environment Agency working with the Met office to presents the future climate projections within the UK. The aim of the platform is to provide information across the UK to possible climate changes that can be expected in the future. UKCP18, planned to be released in November 2018, is currently underway to update the UKCP09 projections.

The Met Office gridded baseline data for average conditions and UK Climate Projection (UKCP09) Weather Generator simulated baseline data for extreme weather events within the study area were considered in this assessment.

According to the UK Climate Projection (UKCP09) Weather Generator, the current climate and extreme weather events experienced in the region are summarised at Falkirk station (closest to the FPS) as follows:

- Annual average temperature is 12.9 °C and ranges from an average minimum and maximum temperature of 0.8 to 19.5 °C.
- An average annual precipitation received for the area is 949.2 mm, with approximately 147.2 days in the year receiving precipitation.

Future Climate projections in the area indicate an increase in temperatures of between 1.1 and 5.6 °C and changes in precipitation patterns. Precipitation trends indicate an increase of up to 19% in winter months, while a decrease during summer months by up to 21% by 2080.

10.2.6 Greenhouse Gas Emissions

The National Atmospheric Emissions Inventory (NAEI) provides an inventory of all emissions across the UK. As presented on the NAEI system, Table 10-6 represents the total sector contributions to the carbon dioxide equivalent (CO₂e) emissions within the jurisdiction of the Falkirk Council. As indicated in Table 10-6, the biggest contributor to CO₂ emissions (56% in 2015) in the area are attributed to Large Industrial Installations.

Table 10-6: Sector Contributions to 2015 Carbon Dioxide levels (kt)

Sector Name	CO ₂ (kt)
Industry & Commercial Electricity	125
Industry & Commercial Gas	129
Large Industrial Installations	1,276
Industrial & Commercial Other Fuels	35
Agricultural Combustion	7
Domestic Electricity	101
Domestic Gas	168
Domestic Other Fuels	18
Road Transport (A roads)	98
Road Transport (Motorways)	150
Road Transport (Minor roads)	125
Diesel Railways	13
Transport Other	2
Land Use, Land Use Change and Forestry (LULUCF) Net Emissions	36

10.3 Key Issues and Potential Effects

The construction of the Scheme will include various activities, their potential effects on air quality and climate are discussed in this section, as well as other key issues.

Activities including excavation and earthworks; handling, storage and transport of materials to construction compounds and works areas; backfilling and landscaping activities; the removal of any waste materials from site; and vehicle movements on un-surfaced ground are anticipated during the construction phase of the FPS.

The impacts on air quality resulting from the construction phase of the FPS are through the generation and subsequent deposition of dust, and elevated local PM₁₀ concentrations. Most construction dust consists of large particles (diameter > 30 µm) that have a very short lifetime in the atmosphere (EP UK, 2017) and tend to be deposited close to the source. However, dust deposition onto properties can lead to complaints and may constitute a statutory nuisance, as well as permanent ecological damage and adverse human health effects.

There are a number of COMAH sites throughout the FPS area. There is therefore the potential for the occurrence of accidents occurring during construction phase of the scheme as a result of HGV movements, including damaging of pipes, releasing contaminants into soils, flood events during construction period, and some of which could result in the emission of pollutants into the atmosphere. Consultations with HSE on the associated risks and procedures to be followed are currently being undertaken.

Heavy Duty Vehicles (HDVs) involved in the construction works will add to local traffic on the road network surrounding the Scheme, and therefore there is the potential for roadside local air quality to be affected, although this is not anticipated to be significant as the HGV movements is expected to be below 200 / day. Construction vehicles will be operated on the roads during the construction phase of the Scheme, through the movement of plant and materials to the site, as well as worker transportation. Greenhouse gases released through direct fuel consumption and/or consumption of supplied electricity in the supply chain of materials during the construction and operational phase of the FPS have the potential to increase overall greenhouse gas emissions and therefore potentially impact on the climate and the Government's ability to meet its legally binding greenhouse gas reduction targets.

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

10.4 Proposed Studies and Consultation for EIA

The impact of climate on flood risk will be considered in the Water and Geomorphology chapters of the EIA Report, and the suitability and resilience of the FPS design will be assessed by the design team in relation to future flooding scenarios resulting from projected climate changes.

Based on a preliminary assessment undertaken in relation to the information available at the time of drafting this chapter, no significant air quality and climate impacts are anticipated as a result of the FPS. However, it is proposed that these assessments be re-considered once more information on construction activities, schedule and traffic loads are further defined.

Consultation with the relevant Local Authorities may be necessary for data gathering should the latest data not be published and in the public domain. There is no further consultation anticipated at this stage.

10.5 Proposed Methodology

10.5.1 Construction Dust

The air quality assessment will primarily focus on the potential impacts associated with the construction phase of the FPS.

The assessment of the air quality impacts associated with the construction phase of the proposed FPS will follow the IAQM *'Guidance on the assessment of dust from demolition and construction activities'* (2014). The guidance is concerned with the risks of dust impacts from four construction

activities (i.e. demolition, earthworks, construction and trackout) to determine the level of required mitigation measures. Sensitive human receptors will be identified up to 350 m from the construction boundary, while ecological receptors will be considered up to 50 m from the construction site. Both human and ecological receptors will be chosen based on their sensitivity to dust soiling or deposition, and PM₁₀ exposure.

The estimated magnitudes of each construction activity (small, medium, large or negligible) will be determined and will be combined with the area sensitivity, which is determined by the number and proximity of receptors to the construction boundary and the background PM₁₀ concentration. This qualitative analysis will provide the overall level of risk of impacts for dust soiling, human health and ecology. The level of risk of each impact will be used to identify appropriate mitigation measures.

10.5.2 Construction Vehicle Emissions

As set-out in Section 3.17, Transport Assessment Guidance (TAG)⁶⁸, a Transport Assessment may be required where 100 or more vehicle movements per day or 10 freight movements per day may be expected. Where the number of movements is less than this, significant impacts on air quality are not expected. The Local Air Quality Management guidance for air quality assessment (TG16) suggests that significant air quality impacts are unlikely where the change in Heavy Duty Vehicle movements is less than 200/day. As the construction period for the Scheme is anticipated to extend across a two-year period, with construction traffic movements being phased according the stage being developed, it is considered unlikely that the thresholds that trigger requirement for detailed Transport Assessment will be passed, and therefore an assessment of air quality impacts from highway emissions will not be necessary, since significant impact on roadside air quality is very unlikely.

At this stage, the need for the assessment of construction vehicle emissions is not anticipated, however, it will be confirmed when traffic loads are further defined. Should the need for an assessment of construction vehicle emissions arise, a local air quality assessment of the construction traffic should be undertaken, whereby the study area should cover receptors (residential and ecological) within 200 m of the affected road network (ARN), determined based on the movement of construction vehicles. The assessment should be based on recent traffic data and considered for the area with and without the addition of construction vehicles.

10.5.3 Climate

The climate assessment associated with the FPS should be undertaken at a regional level, highlighting key local level impacts where applicable.

As noted in the Institute of Environmental Management and Assessment (IEMA) *Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation* (2015) the consideration of Climate Change into an EIA should consider the future projected climate, an assessment of the impacts of the Scheme on climate change and the vulnerability of the Scheme and environmental receptors to climate factors, and the impacts relevant to adaptation.

In considering the elements of climate, professional judgements should be used to provide a qualitative description of the nature of the impacts and, where appropriate, to describe the predicted change that the Scheme will introduce in comparison to the baseline conditions.

Due to the uncertainties that exist around the subject of Climate Change, there are limitations associated with predicting the impacts of Climate Change into the future, including:

- Uncertainty around climate change projections;
- Limited methodological guidance on how a climate change assessment should be carried out; and

⁶⁸ TAG guidelines [Online] Available from: https://www.transport.gov.scot/media/4589/planning_reform_-_dpmtag_-_development_management_dpmtag_ref_17_-_transport_assessment_guidance_final_-_june_2012.pdf [Accessed: September, 2017]

- Limited literature describing climate change impacts on infrastructure and assets.

10.5.3.1 Effects of the Scheme on Climate

In line with TAG Unit A3 Environmental Impact Appraisal (DfT, 2015), Chapter 4 Greenhouse Gases; and PAS 2080: 2016 Carbon management in infrastructure, the assessment of the effects of the Scheme on climate will include:

- Identification and assessment of greenhouse gases, and any other significant carbon emission which will occur throughout the lifecycle of the project, their relative scale, in relation to the baseline and in comparison, to the UK emission predictions; and
- Identification of opportunities for mitigation.

10.5.3.2 Vulnerability of the Scheme to Climate Change

As presented in the IEMA 2015 guideline, the assessment of the vulnerability of the Scheme to climate change will identify and assess the rate of climate change, highlighting the potential extent of disruption which may occur throughout the lifecycle of the project.

Noting that the development of the scheme is itself being put in place, partly to address future flood risk associated with climate change projects, therefore the design will carefully consider suitable defence levels are maintained when considering future climate change projections.

10.5.4 Summary

In summary, provided best practice mitigation measures relating to the management of dust are implemented throughout the construction phase of the project, no significant impacts are anticipated. Furthermore, it is not expected that more than 50 outbound HDVs will operate per day, therefore no impact on the local air quality resulting from the movement of HDVs during the construction phase is anticipated.

Based on the information available at the time of this assessment, no significant air quality impacts are foreseen as a result of the construction phase of the FPS, and therefore assessment of HDV emissions is recommended to be scoped out of the EIA. However, construction dust impacts should be re-evaluated once more information on the Scheme construction strategy is available.

During the options appraisal phase of the project the CO₂e emissions were calculated for each Cell of the FPS in accordance with the Carbon Planning Tool published by the Environment Agency. The tool is aimed at providing a mechanism to assess carbon over the whole life of constructed assets, in line with the Project Cost Tool, and allows for the establishment of project options that facilitate the reduction of carbon emissions. The calculated CO₂e emissions for each Cell have been considered in the Scheme design as a form of primary mitigation.

The FPS is potentially vulnerable to the effects of a changing climate. However, based on the incorporation of climate adaptive measures being embedded into the design of the Scheme, the impacts are not expected to be significant. The impact of climate on flood risk will be further considered in the Water and Geomorphology chapters of the EIA Report, and the suitability and resilience of the FPS design will be assessed by the design team in relation to future flooding scenarios resulting from projected climate changes.

Cultural Heritage

11.1 Introduction

11.1.1 Overview

This chapter considers cultural heritage assets (archaeology, built heritage and historic landscapes) and has been prepared in accordance with guidance provided by the Design Manual for Roads and Bridges (DMRB)⁶⁹, and the International Council on Monuments and Sites (ICOMOS 2011)⁷⁰.

Historic Environment Scotland (HES) are responsible for designated cultural heritage assets including: world heritage sites; scheduled monuments and their settings; category A-listed buildings and their settings; inventory gardens and designed landscapes; inventory battlefields; and Historic Marine Protected Areas (HMPAs).

Falkirk Council archaeological are responsible for: designated category B and C listed buildings; non-designated cultural heritage assets (both archaeological and built heritage); previously unknown archaeological assets (archaeological potential); and historic landscapes.

11.1.2 Study Area

The study area comprised the footprint of the proposed flood defences plus a surrounding 300m radius area. In the baseline discussion below, the study area is further subdivided into the six proposed flood cells.

The study area was determined following DMRB and was considered appropriate given the nature of the FPS and anticipated sensitivity of the receiving environment.

11.1.3 Data Sources

Data were obtained from the following sources:

- Historic Environment Scotland for information on designated assets (world heritage sites, scheduled monuments and listed buildings);
- Falkirk Community Trust for information on non-designated cultural heritage assets recorded within the Falkirk Sites and Monuments Record (SMR);
- Falkirk Council for information on Conservation Areas; and
- HLAmaph for historic landscape characterisation data.

Positions of Listed Buildings, Scheduled Monuments and the UNESCO World Heritage Site are provided in Figures A11 and A12 in Appendix A, while a gazetteer has been prepared that lists all cultural heritage assets within the study area and is provided as Table A4 in Appendix A. Where discussed in the baseline below, assets are referred to by the unique asset number provided in the gazetteer.

11.1.4 Assessment of Cultural Heritage Value

The assessment of cultural heritage value was undertaken on a six-point scale of Very High, High, Medium, Low, Negligible and Unknown based on the criteria defined by ICOMOS, which was consulted throughout to provide the appropriate value for each asset identified in Table 11-1 below.

⁶⁹ Online. Available at: <http://www.standardsforhighways.co.uk/ha/standards/dmr/b/vol11/section3.htm> (Accessed February 2018)

⁷⁰ Online. Available at: https://www.icomos.org/world_heritage/HIA_20110201.pdf (Accessed February 2018)

Table 11-1: Assessment of Cultural Heritage Value Table

Resource value	Criteria
Very High	<ul style="list-style-type: none"> – World Heritage Sites (including buildings and those inscribed for their historic landscape qualities). – Individual attributes that convey OUV of the WHS. – Assets of acknowledged international importance. – Assets that can contribute significantly to acknowledged international research objectives. – Extremely well-preserved historic landscapes with exceptional coherence, time-depth or other critical factors. – Areas associated with ICH activities as evidenced by the national register. – Areas with associations with particular innovations or individuals, technical or scientific developments or movements of international importance.
High	<ul style="list-style-type: none"> – Scheduled Monuments (including standing remains). – Designated historic landscapes of outstanding interest. – Undesignated assets of schedulable quality and importance. – Assets that can contribute significantly to national research objectives. – Grade A Listed Buildings. – Other Listed Buildings that can be shown to have exceptional qualities in their fabric or historical associations. – Conservation Areas containing very important buildings. – Undesignated structures of clear national importance. – Undesignated landscapes of outstanding interest, high quality or importance and of demonstrable national value. – Well-preserved historic landscapes, exhibiting considerable coherence, time-depth or other critical factors.
Medium	<ul style="list-style-type: none"> – Designated or undesignated assets that contribute to regional research objectives. – Undesignated historic landscapes that would justify special historic landscape designations, or landscapes of regional value. – Averagely well-preserved historic landscapes with reasonable coherence, time-depth or other critical factor. – Grade B and C Listed Buildings. – Conservation Areas containing buildings that contribute significantly to its historic character. – Historic Townscape or built-up areas with important historic integrity in their buildings, settings or built settings.
Low	<ul style="list-style-type: none"> – Designated and undesignated assets of local importance. – Robust undesignated historic landscapes and historic landscapes with importance to local interest groups. – Historic landscapes whose value is limited by poor preservation and / or poor survival of contextual associations. – Assets compromised by poor preservation and/or poor survival of contextual associations. – Assets of limited value, but with potential to contribute to local research objectives – ‘Locally Listed’ buildings. – Historic (unlisted) buildings of modest quality in their fabric or historical association. – Historic Townscape or built-up areas of limited historic integrity in their buildings, or built settings.
Negligible	<ul style="list-style-type: none"> – Assets with very little or no surviving archaeological interest. – Buildings of no archaeological or historical note, or buildings of an intrusive character. – Landscapes with little or no significant historical interest.

11.2 Baseline

A total of 202 cultural heritage assets have been identified within the study area including: The Frontiers of the Roman Empire (Antonine Wall) world heritage site (Asset 1) and associated buffer zone (Asset 2); nine scheduled monuments (Assets 3-11); 22 listed buildings (Assets 11-32) including the Grade A Dundas Church (Asset 22), 13 Grade B buildings and 8 Grade C buildings; 100 non-designated assets (Assets 33-132); and 70 historic landscape areas (Assets 133 – 202).

These assets are discussed by each flood cells below.

11.2.1 Flood Cell 1

Designated Assets

There are three scheduled monuments recorded within this area comprising: the Lochlands Roman camps (Asset 4) and Camelon Roman forts (Asset 9) located at the western limit of the flood cell; and the Carron House dovecot (Asset 11), also Grade B listed, located at the eastern limit of the flood cell on the eastern bank of the River Carron. These assets are of high cultural heritage value.

There are seven listed buildings recorded within this area comprising: the Grade C Old Bridge at Larbert (Asset 17) at the western limit of the flood cell; the Grade C Carron Company Clock Tower (Asset 16), the Grade B Weir at the Carron Iron Works (Asset 18), the Grade B Former Railway Bridge across the River Carron (Asset 19), and the Grade B Grahamston Ironworks Gate (Asset 20) within the central part of the flood cell; and the Grade B Carron House (Asset 15) and associated dovecot (Asset 11). These assets are of medium cultural heritage value.

Non-designated Assets

There are 21 non-designated assets recorded within this area (Assets 33-40, 42-48 and 127-132). The majority of these relate to former industrial sites (dry docks, harbours, distilleries, and iron works) along the River Carron and extant post-medieval features (bridges and buildings). However, also of note is the findspot of a post-medieval log boat (Asset 40) from the foreshore of the River Carron within the central part of the flood cell. These assets are of low cultural heritage value.

Historic Landscape

Twenty-five historic landscape areas intersect with this flood cell (Assets 139-143, 146, 150, 153-155, 157, 158, 161-163, 165, 170, 173, 180, 185, 188-190, 201 and 202). All date to the post-medieval period and are of low resource value.

Archaeological Potential

There is a potential for previously unknown archaeological assets within this flood cell, particularly in the west in the vicinity of the scheduled Roman forts and along the fringe of the River Carron.

11.2.2 Flood Cell 2

Designated Assets

There is one listed building within this area comprising: the Grade C Former Workshop Building (Asset 27) on the southern bank of the River Carron. This asset is of medium cultural heritage value.

Non-designated Assets

Seventeen non-designated assets are recorded within this area (Assets 55-58, 69-73, 80, 84, 86-88, 91, 99 and 106). The majority of these assets relate to former industrial sites along the River Carron shown on historic mapping. Such assets are of low cultural heritage value.

Historic Landscape

Six historic landscape areas intersect with this flood cell (Assets 151, 156, 170, 187, 192 and 200). All date to the post-medieval period and are of negligible resource value.

Archaeological Potential

While the proximity of this flood cell to the River Carron may indicate a potential for previously unknown archaeological assets, taking into account the level of past development within this area, the potential for such remains is considered to be negligible.

11.2.3 Flood Cell 3

Designated Assets

There is one listed building within this area comprising: the Grade B Carron Dock and Western Channel Swing Bridge (Asset 26). This asset is of medium cultural heritage value.

Non-designated Assets

Two non-designated assets are identified within this area comprising: the battered stump of a 19th century lighthouse (Asset 64); and the site of the Forth Sawmills (Asset 75). These assets are of low cultural heritage value.

Historic Landscape

Five historic landscape areas intersect with this flood cell (Assets 151, 156, 175, 192 and 199). All date to the post-medieval period, relate to modern industry and infrastructure, and are of negligible resource value.

Archaeological Potential

While the proximity of this flood cell to the River Carron may indicate a potential for previously unknown archaeological assets, taking into account the level of past development within this area, the potential for such remains is considered to be negligible.

11.2.4 Flood Cell 4

Designated Assets

The southern part of this flood cell, in the vicinity of the proposed Westquarter Burn Flood Storage Area (FSA), contains part of The Antonine Wall (Asset 1) and its associated buffer zone (Asset 2). This asset is of very high cultural heritage value.

There are two scheduled monuments within this area comprising: the Bowhouse circular enclosure (Asset 5) at Polmont; and the Antonine Wall and Mumrills fort (Asset 6), located coincident with the world heritage site. Both assets are within the vicinity of the proposed Westquarter Burn FSA in the southern part of the flood cell. These assets are of high cultural heritage value.

There are 10 listed buildings recorded within this area comprising: the Grade C Sacred Heart Roman Catholic Church (Asset 21); the Grade A Dundas Church (Asset 22); the Grade B Abbotsgrange Middle School (Asset 23); the Grade B Grange Church and Hall (Asset 24); the Grade B Zetland Parish Church (Asset 25); the Grade C former La Scala Cinema (Asset 28); and four assets (29-32), all Grade B and C, forming part of the Zetland War Memorial Park. All of these assets are clustered in the north-west corner of the flood cell. The Grade A Dundas Church (Asset 22) is of high cultural heritage value. The remainder of the listed buildings are of medium cultural heritage value.

Non-designated Assets

There are 36 non-designated assets recorded within this area (Assets 50, 51, 59, 62, 63, 65-68, 76-79, 81-83, 85, 89, 90, 93, 94, 96-98, 100, 102, 104, 105, 107-110, 115, 120, 122 and 126). The

majority of these relate to extant and former buildings dating to the post-medieval period. Such assets are of low cultural heritage value.

Historic Landscape

Twenty-three historic landscape areas intersect with this flood cell (Assets 133-136, 141, 147, 151, 152, 166, 170, 174, 176, 177, 179, 183, 184, 186, 192 and 195-199). All date to the post-medieval period, with the majority of the flood cell characterised as a 19th century built-up area. The historic landscape is of low cultural heritage value.

Archaeological Potential

Given the presence of The Antonine Wall (Asset 1), and adjacent scheduled monuments (Assets 5 and 6), in the southern part of this flood cell, there is a potential for previously unknown archaeological assets, particularly those of Roman date.

The northern part of the flood cell has been heavily redeveloped and the potential for previously unknown assets within this area is considered to be low.

11.2.5 Flood Cell 5

Designated Assets

The southern part of this flood cell contains part of The Antonine Wall (Asset 1) and its associated buffer zone (Asset 2). This asset is of very high cultural heritage value.

There are three scheduled monuments within this area comprising parts of the Antonine Wall: Millhall Burn to River Avon (Asset 7); Nether Kinneil to Ineravon (Asset 8); and a fort and shell midden, 240m wsw of The Tower, Ineravon (Asset 10). These assets are coincident with the world heritage site in the southern part of the flood cell. These assets are of high cultural heritage value.

There are two listed buildings within this area comprising: the Grade C Grangemouth Road Bridge (Asset 12); and the Grade C Ineravon Tower (Asset 13). These assets are of medium cultural heritage value.

Non-designated Assets

Three non-designated assets are identified within this area comprising: part of the uncompleted Bo'ness Canal (Asset 54); the Jinkabout Ford and Bridge (Asset 60); and the site of Jinkabout Corn Mill (Asset 61). These assets are of low cultural heritage value.

Historic Landscape

Nine historic landscape areas intersect with this flood cell (Assets 135, 138, 145, 148, 152, 160, 166, 167 and 182). All date to the post-medieval period and are of low resource value.

Archaeological Potential

Given the presence of the Antonine Wall (Asset 1), and coincident scheduled monuments (Assets 7, 8 and 10), in the southern part of this flood cell, there is a potential for previously unknown archaeological assets, particularly those of Roman date.

In addition, there is a potential for previously unknown archaeological assets within the vicinity of the River Avon.

11.2.6 Flood Cell 6

Designated Assets

The southern limit of this flood cell overlaps with The Antonine Wall buffer zone (Asset 2). This asset is of very high cultural heritage value.

No other designated assets are recorded within this area.

Non-designated Assets

Three non-designated assets are identified within this area comprising: three shell middens (Assets 49, 52 and 53) identified at Kinneil Kerse and East Kerse. These assets are of low cultural heritage value.

Historic Landscape

Nine historic landscape areas intersect with this flood cell (Assets 133, 138, 149, 152, 167, 168, 171, 172 and 174). All date to the post-medieval period and are of low resource value.

Archaeological Potential

There is a potential for previously unknown archaeological assets within this flood cell, particularly in the south in the vicinity of the Antonine Wall and associated buffer zone (Assets 1 and 2) along the River Avon and coastal foreshore.

11.3 Key Issues and Potential Effects

11.3.1 Flood Cell 1

Designated Assets

Potential effects to the settings of the two scheduled Roman forts (Assets 4 and 9) in the west of this flood cell due to the proposed defences along Stirling Road.

The proposed flood defences along the River Carron could directly affect the Grade B Former Railway Bridge across the River Carron (Asset 19).

Potential effects to the settings of the Grade B Carron House (Asset 15), the Grade B Weir at the Carron Iron Works (Asset 18) and the Grade B Grahamston Ironworks Gate (Asset 20) due to the proposed flood defences along the River Carron.

Further assessment of these designated assets would be scoped in.

Non-designated Assets

The proposed flood defences along the River Carron could directly affect the following non-designated assets, either physically or through changes to their settings: Graving Dock (Asset 35); Carronshore Harbour (Asset 42); and the site of Carronshore Limekiln (Asset 46).

The proposed flood defences along Stirling Road could directly affect the following non-designated assets, either physically or through changes to their settings: Falkirk Tram Depot (Asset 127); Stirling Road Bus Depot (Asset 128); and Lightwater Burn Bridge (Asset 132).

Further assessment of these non-designated assets would be scoped in.

Historic Landscape

The historic landscape of this cell is of low cultural heritage value.

Further assessment of the historic landscape would be scoped out due to the low resource value and unlikelihood of significant effects.

Archaeological Potential

Groundworks for the flood defences within this cell could affect previously unknown archaeological assets.

Further assessment of the archaeological potential of this cell would be scoped in.

11.3.2 Flood Cell 2

Designated Assets

Potential effects to the setting of the Grade C Former Workshop Building (Asset 27) due to the proposed flood defences along the River Carron.

Further assessment of this designated asset would be scoped in.

Non-designated Assets

The proposed flood defences along the River Carron could directly affect the following non-designated assets, either physically or through changes to their settings: Graving Dock (Asset 55); Grangemouth Dockyard (56); and Grangemouth Gas Works (Asset 70).

Further assessment of these non-designated assets would be scoped in.

Historic Landscape

The historic landscape of this cell is of negligible cultural heritage value.

Further assessment of the historic landscape would be scoped out due to the negligible resource value and unlikelihood of significant effects..

Archaeological Potential

Further assessment of the archaeological potential of this cell would be scoped in to determine past development impacts.

11.3.3 Flood Cell 3

Designated Assets

Potential effects to the setting of the Grade B Carron Dock and Western Channel Swing Bridge (Asset 26) due to the proposed flood defences along the River Carron.

Further assessment of this designated asset would be scoped in.

Non-designated Assets

The proposed flood defences along the River Carron could directly affect the following non-designated asset, either physically or through changes to its setting: the battered stump of a 19th century lighthouse (Asset 64).

Further assessment of this non-designated asset would be scoped in.

Historic Landscape

The historic landscape of this cell is of negligible cultural heritage value.

Further assessment of the historic landscape would be scoped out.

Archaeological Potential

Further assessment of the archaeological potential of this cell would be scoped in to determine past development impacts.

11.3.4 Flood Cell 4

Designated Assets

The proposed Westquarter Burn FSA lies adjacent to The Frontiers of the Roman Empire world heritage site (Asset 1) and coincident Antonine Wall and Mumrills fort scheduled monument (Asset 6). The proposed FSA also sits within the buffer zone of the world heritage site (Asset 2).

Further assessment of potential effects to the settings and Outstanding Universal Value (OUV) of these high value designated assets would be scoped in.

Potential effect to the setting of the Bowhouse circular enclosure (Asset 5) due to the proposed flood defences on Rannoch Road and Inchyra Road.

Further assessment of this designated asset would be scoped in.

The cluster of listed buildings within this cell (Assets 21-25 and 28-32) could be affected by the proposed flood defences along Abbots Road and Park Road due to changes to their settings. In addition, the proposed flood defences along the western boundary of Zetland Park run parallel to Grade B listed park wall and gate (Asset 30) and could physically impact this.

Further assessment of these designated assets would be scoped in.

Non-designated Assets

The proposed flood defences within this cell could directly affect the following non-designated assets, either physically or through changes to their settings: Avonside House (Asset 63); Oswald Saltcoats (Asset 82); Madison Place (89); Grangemouth Custom House (Asset 93); Abbots Road Nursery (100); Charing Cross Church (Asset 107); Victoria Library (Asset 108); and Grangemouth Town Hall (Asset 109).

Further assessment of these non-designated assets would be scoped in.

Historic Landscape

The historic landscape of the majority of this cell is of low cultural heritage value. However, as the southern part of the cell includes part of the Antonine Wall (Asset 1) and associated buffer zone (Asset 2), and given the landscape scale of this asset, further consideration of the historic landscape would be scoped in.

Archaeological Potential

Groundworks for the flood defences within this cell could affect previously unknown archaeological assets.

Further assessment of the archaeological potential of this cell would be scoped in.

11.3.5 Flood Cell 5

Designated Assets

The proposed flood defences at the southern limit of this cell cross the line of The Antonine Wall (Asset 1), the coincident Antonine Wall, fort and shell middens, 240m wsw of The Tower, Ineravon (Asset 10), and the world heritage site buffer zone (Asset 2). Groundworks within this area could directly affect the fabric of these high value designated assets and also could alter their settings.

Further assessment of these designated assets would be scoped in.

Potential effects to the Grade C listed Grangemouth Road Bride due to the proposed flood defences along the River Avon.

Further assessment of this designated asset would be scoped in.

Non-designated Assets

The proposed flood defences within this cell could directly affect the following non-designated assets, either physically or through changes to their settings: part of the uncompleted Bo'ness Canal (Asset 54); the Jinkabout Ford and Bridge (Asset 60); and the site of Jinkabout Corn Mill (Asset 61).

Further assessment of these non-designated assets would be scoped in.

Historic Landscape

The historic landscape of the majority of this cell is of low cultural heritage value. However, as the southern part of the cell includes part of The Antonine Wall (Asset 1) and associated buffer zone (Asset 2), and given the landscape scale of this asset, further consideration of the historic landscape would be scoped in.

Archaeological Potential

Groundworks for the flood defences within this cell could affect previously unknown archaeological assets.

Further assessment of the archaeological potential of this cell would be scoped in.

11.3.6 Flood Cell 6

Designated Assets

The proposed flood defences at the southern limit of this cell lie outside of, but in close proximity to, the world heritage site buffer zone (Asset 2) and could affect its wider setting.

Further assessment of this designated asset would be scoped in.

Non-designated Assets

No non-designated assets would be directly affected by the proposed defences within this cell.

Historic Landscape

The historic landscape of this cell is of low cultural heritage value.

Further assessment of the historic landscape would be scoped out.

Archaeological Potential

Groundworks for the flood defences within this cell could affect previously unknown archaeological assets.

Further assessment of the archaeological potential of this cell would be scoped in.

11.4 Proposed Studies and Consultation for EIA

Early engagement with key stakeholders (Historic Environment Scotland, Falkirk Council Archaeological and Heritage Conservation advisors) would be undertaken to allow for an appropriate scope to be developed for detailed assessment.

A cultural heritage desk-based assessment (DBA) would be undertaken to quantify the cultural heritage baseline and assess the impact of the proposed FPS on this resource including direct physical impacts and changes to the settings of assets.

The DBA would seek to:

- Introduce the factor;
- State the methodology;
- Provide a legislative and planning background;
- Present the baseline (including the sources listed below);
- Make an preliminary impact assessment based on the preferred option and the known baseline including any impacts to the settings of assets;
- Provide conclusions on the preferred option and recommendations for further investigation or mitigation where appropriate; and

- Present the data available with figures.

The DBA would adhere to the Chartered Institute for Archaeologists (CIfA) standard and guidance for historic environment desk-based assessment (CIfA 2014) and the guidance provided by ICOMOS (2011) for Heritage Impact Assessments (HIA) in respect of world heritage sites⁷¹.

The assessment of settings impacts would be undertaken following the three-staged approach recommended by Historic Environment Scotland in Managing Change in the Historic Environment – Setting (2016).

Further guidance provided by Historic Environment Scotland in respect of Managing Change in the Historic Environment – World Heritage (2016) would be followed.

The following sources would be utilised for the DBA:

- The Frontiers of the Roman Empire (Antonine Wall) world heritage site management plan and nomination document;
- Historic Environment Scotland for Information on designated assets (world heritage sites, scheduled monuments and listed buildings);
- Falkirk Community Trust for information on non-designated cultural heritage assets recorded within the Falkirk Sites and Monuments Record (SMR);
- HLAmaph for historic landscape characterisation data;
- Aerial photographs held by the National Collection of Aerial Photography;
- Historic maps held at the Falkirk Archives;
- Unpublished archaeological reports;
- Published archaeological journals;
- Local history publications;
- A site walkover and assessment of setting/asset intervisibility.

The consultation will also inform the FPS design. Potentially the design could incorporate heritage enhancements, such as signage or interpretative boards possibly in combination with amenity/recreation enhancements. There may also be opportunities to improve the setting of some of the listed buildings through improved landscape/visual amenity in the river corridor.

The assessment will inform the need for, and scope of archaeological investigation. Known and unknown buried archaeology can pose a risk to the FPS construction programme. Archaeological investigation (evaluation) could be required to establish the presence, extent and significance of the resource. This would inform the need for a mitigation strategy as demanded by national and local planning policies. In this way, the risk of archaeological discovery would be managed in line with stakeholder expectations and the threat of costly delay to the project minimised.

11.5 Proposed Methodology

The methodology for assessing the significance of effect would be based upon the criteria described in the International Council on Monuments and Sites ((ICOMOS) 2011) which is widely accepted as the standard for developing potentially affecting World Heritage Sites.

The EIA Report chapter would be based on the cultural heritage DBA, and any other necessary archaeological works (evaluations), described above.

⁷¹ Online. Available at: https://www.icomos.org/world_heritage/HIA_20110201.pdf (Accessed February 2018)

Traffic and Transportation

12.1 Introduction

This chapter of the report considers the potential significance of any traffic and transportation impacts that may be associated with the operation and construction of the Grangemouth Flood Protection Scheme (FPS).

On completion of construction, the only anticipated traffic movements associated with the Scheme will be for routine inspection and maintenance of the flood defence structures. These movements will be infrequent and almost certainly made by light vehicles, and will not therefore generate traffic impacts beyond anticipated day-to-day variations in traffic i.e. the Institute of Environmental Management and Assessment (IEMA) publication *Guidelines on the Environmental Assessment of Road Traffic (Guidance Note 1)*, 1993 (IEA guidelines) state that “it should therefore be assumed that projected changes in traffic of less than 10% create no discernible environmental impact”. The FPS will provide beneficial traffic impacts by providing increased flood protection along routes currently affected by flooding. As such, operational impacts are proposed to be scoped out of the EIA.

12.2 Baseline

The study area for construction related impacts includes the local and strategic road network within and around Grangemouth that will be used by construction traffic. This will be further defined in the EIA as the construction details i.e. location of construction compounds, sources of materials and construction routes etc., are established. Nevertheless, the identification of appropriate baseline conditions for the traffic, transport and access assessment are proposed to comprise the following aspects:

- Identification of suitable construction traffic routing and any access restrictions to construction vehicles.
- The establishment of the existing traffic flows on the local and strategic road network.
- Determining the existing provision of sustainable travel i.e. walking, cycling and public transport.
- Establishing potential sensitive receptors.

The identification of baseline conditions will include a desk-based review of available information, and of any information that will need to be obtained e.g. additional traffic to supplement counts supplied by Falkirk Council and Transport Scotland. The prospective counts will be undertaken using temporary Automatic Traffic Counts to record vehicle movements and classification, likely to be over a two-week period, to be agreed. Projected baseline traffic flows for the predicted year of construction of the Scheme will be considered, and likely be calculated using National Road Traffic Flows (NRTF) growth factors to be agreed with the roads authorities. However, not applying a growth factor would present a worst-case scenario.

12.3 Key Issues and Potential Effects

The key traffic and transportation issues, anticipated only to be relevant during the construction phase of the Scheme, are likely to comprise:

- The identification of suitable construction traffic routing and access restrictions to construction vehicles.
- An increase in the overall volume of traffic on the road network.

- An increase in the proportion of heavy goods vehicles on the road network.
- Public access restrictions.
- Geometric constraints to construction vehicles on the local road network.
- Any improvements or modifications to existing road bridges to accommodate flood defence works, and associated traffic management to accommodate these works.
- Disruption and potential delay to local road users because of construction traffic and any temporary traffic management measures that may be required.

It is unlikely the Scheme construction will have any impacts of significance upon public transport network, as it is assumed temporary bus stances and/or traffic diversions will be put in place to address potential temporary disruption to the transport network, although this will be examined further in the EIA.

12.4 Proposed Studies and Consultation for EIA

It is proposed that traffic and transportation impacts during the construction phase will be solely explored as part of the EIA, ensuring that any potential adverse significant impacts are avoided or minimised. As part of the EIA input it will be necessary to consider a Traffic Management Plan, or similar, as part of the mitigation proposals. However, this will only be outlined in the EIA, as this will likely form part of any post-planning conditions, and will be developed in consultation with Falkirk Council and Transport Scotland.

To inform the EIA, consultation and negotiation will be required with parties concerned with the traffic and transport impacts associated with the proposed development. This could include, but is not limited to: local roads authorities; Transport Scotland; the Trunk Road Operating Company; Police Scotland; and Network Rail (Scotland). These discussions will help define the study area and determine the scope of the access, traffic and transport related assessment.

12.5 Proposed Methodology

Construction vehicle access routes will be identified to each site access. Access routes will aim to provide a direct route for construction traffic to minimise the potential for disruption to other road users and to residents and businesses. Impacts on footpaths, cycle routes and other non-motorised means of transport shall also be considered.

Access arrangements to each of the flood cell sites associated with the FPS will be established and will be informed by site visits and construction vehicle requirements. Any impacts associated with these accesses, in terms of inadequate vehicle routing or turning facilities, public access restrictions or severance, will be identified at this stage and suitable mitigation measures proposed.

The methods adopted to assess the likely traffic and transportation impacts on traffic flows and transportation infrastructure will comprise:

- Determination of the baseline traffic and transportation conditions, and the sensitivity of any receptors likely to be affected in proximity of the road network e.g. carriageway, structures, other road users; and adjacent communities.
- A review of the development proposals to determine the predicted construction and operational requirements, by identifying the type and number of vehicles using the identified road network during the construction period including: numbers of light and heavy vehicles; numbers and dimensions of any abnormal loads; and the duration of construction works.

- An assessment of the significance of predicted impacts from these transport requirements considering impact magnitude (before and after mitigation) and baseline environmental sensitivity.

The assessment of environment effects of road traffic will be undertaken in accordance with the guidance set out within the IEA guidelines, which generally advise that further assessment should be undertaken on:

- Highway links where traffic flows will increase by more than 30% (or the number of HGV's will increase by more than 30%).
- Any specifically sensitive areas where the traffic flows have increased by 10% or more.

Therefore, potential road related environmental impacts such as: driver delay; severance; pedestrian amenity; safety; etc., will be considered and assessed where appropriate i.e. where the thresholds identified above are exceeded. From the collated information, to be provided and collected, the magnitude of the potential traffic and transport effects will be determined in terms of percentage increases. From these calculations, and using the IEA guidelines and guidance obtained from scoping responses, the severity of impact on the affected receptors will be classified based on the sensitivity of each identified receptor and the magnitude of the traffic and transport effect.

Although assessing some the significance of effects can often be subjective, it is proposed to apply a percentage impact assessment that considers existing guidance. For example, Section 3.17 of the IEA guidelines, refers to a range of indicators for determining the significance of the relief from severance i.e. that changes in traffic flows of 30%, 60% and 90% are regarded as producing 'slight', 'moderate' and 'substantial' changes in severance respectively. It is on this basis that the magnitude of the potential traffic and transport effects will be determined.

The final output of the assessment will be a Traffic and Transportation Chapter and supporting graphics and appendices, for inclusion in the EIA.