Grangemouth Flood Protection Scheme Environmental Impact Assessment Report: Non-Technical Summary

April 2024

GRANGEMOUTH
Flood Protection Scheme
Protecting the heart of our communities

Grangemouth Flood Protection Scheme

Environmental Impact Assessment: Non-Technical Summary

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Preface

This document is the Non-Technical Summary (NTS) of the Environmental Impact Assessment Report for the Grangemouth Flood Protection Scheme (The Scheme). The Scheme is being promoted by Falkirk Council under the Flood Risk Management (Scotland) Act 2009 and is being developed to address flood risk in Grangemouth and surrounding areas including Wholeflats, Glensburgh, Langlees, Carron and Carronshore.

This EIA Report has been published and, along with this Non-Technical Summary and other Scheme documents, can be viewed online at http://www.grangemouthfloodscheme.com/scheme-documents and as printed documents at the following Falkirk Council office:

Falkirk Council
Falkirk Stadium
4 Stadium Way
Falkirk
FK2 9EE

Copies of the EIA Report may be purchased at a cost of £1,320 for a printed set (including VAT) by writing to Falkirk Council, Falkirk Stadium, 4 Stadium Way, Falkirk, FK2 9EE. Alternatively, requests can be made by email to grangemouthfps@falkirk.gov.uk.

Copies of the Non-Technical Summary of the EIA Report are available free of charge on request by writing to the same postal address or email address noted above.

Any person wishing to make any representations about the EIA Report or any of the Scheme documents may do so via email at **objectionsgfps@falkirk.gov.uk** or in writing to the following address before 16 June 2024:

Chief Governance Officer
GFPS Objections
Falkirk Council
The Foundry
4 Central Boulevard
Central Park
Larbert
FK5 4RU

Executive Summary

A Flood Protection Scheme has been proposed by Falkirk Council to address current and future flood risk in the town of Grangemouth and surrounding areas lying along the Rivers Carron and Avon and their tributaries. The Scheme will protect approximately 6,025 people, 2,760 residential and 1,200 non-residential properties as well as 23km of roads from flood risk. The Scheme will comprise some 29 km of riparian and coastal flood walls and embankments and include ancillary features such as flood gates, a new flow control structure on the Grange Burn and relining of the Grange Burn Flood Relief Channel.

During outline design and preliminary environmental assessment, measures were identified that aimed to minimise the extent and height of flood defences required within the urban areas of Grangemouth, while achieving the desired level of flood protection to the 1-in-200-year level (a 0.5% chance that a location will flood in any one year). Other measures were then built into the design to soften impacts on the townscape including aligning the Scheme to avoid amenity trees, using landscaped embankments where possible, or specifying stone clad walls in e.g. Zetland Park.

The Environmental Impact Assessment of the resultant Scheme outline design and likely construction methods identified impacts with potentially significant effects on important assets such as flora and fauna, human health, watercourses, views, historic buildings and archaeology, air quality, climate and the transport network. Mitigation measures were developed to address such effects (e.g. seasonal working near over-wintering bird locations, appropriate planting, a Construction Environment Management Plan to manage impacts during construction, a Carbon Management Plan to reduce greenhouse gas emissions). In addition, a Landscape and Habitat Management Plan will be prepared to mitigate or compensate for adverse landscape and biodiversity effects, while enhancement measures for positive effects for biodiversity have been developed in outline and will be advanced during detailed

design in consultation with relevant stakeholders to ensure the Scheme will have a lasting positive effect on the environment.

Some of the adverse effects identified could not be completely mitigated, including noise and disturbance effects associated with construction, localised townscape and visual disturbance effects associated with vegetation clearance and the presence of construction compounds, materials storage areas and construction vehicles and plant. In addition, adverse visual and landscape effects associated with vegetation loss will prevail but will reduce over time as vegetation becomes established.

While the Scheme will have an overall significant positive effect in terms of flood risk reduction (and associated avoidance of health risks), some localised areas (including residential, commercial and industrial properties and land, as well as on civic and agricultural land) will experience slight increases in flood levels during larger flood events. Discussions with affected residents or landowners during the detailed design stage of the Scheme will be ongoing to determine appropriate mitigation.

Some monitoring will be required to check for any unidentified issues (e.g. below-ground contaminants or archaeology), to ensure mitigation measures are effective and to take further opportunities to reduce adverse effects and achieve more positive effects where feasible. A community liaison manager will also be appointed during the construction phase to understand community concerns as they arise and to make sure they are appropriately responded to.

Overall, it is assessed that the Scheme will have positive effects associated with reduced flood risk and associated positive effects on human health and it will ensure positive effects for biodiversity are realised appropriately. While there will be some unavoidable, significant adverse effects during construction and for a few years once built, in the long-term, such effects will reduce as new vegetation becomes established and the Scheme becomes embedded in the landscape.

Section 1: Introduction

1 Introduction

1.1 Background

Grangemouth and the surrounding areas have an extensive history of flood events. Flood risk assessments and modelling have identified the area as vulnerable to fluvial flood risk (from rivers) and coastal flood risk (from the sea) and a high priority for intervention in the form of a flood protection scheme.

The Grangemouth Flood Protection Scheme (hereafter referred to as 'the Scheme') is the largest flood defence scheme in Scotland. It is being promoted by Falkirk Council under the Flood Risk Management (Scotland) Act 2009 to protect communities from flood risk in Grangemouth, Wholeflats, Glensburgh, Langlees, Carron, Carronshore and Camelon (shown on Figure 1a and 1b).

The Scheme comprises approximately 28km of new flood defences consisting of flood walls, embankments and coastal revetment; the relining of the flood relief channel associated with Grange Burn, a new flow control structure on the Grange Burn and replacement flood gates within the entrance channel to the Port of Grangemouth. In addition, are three replacement bridges (New Carron Road Bridge (B902), Reddoch Road Bridge and Dalratho Road Bridge) and height modifications to various existing footbridges in the Scheme area so they are able to withstand flood events. To accommodate access, the Scheme also includes pedestrian and vehicular flood gates, ramps and access tracks or footpaths. The existing A9 (Beancross) underpass which is subject to flooding will be blocked off.

The Scheme will provide flood risk protection up to the 1 in 200-year level (a 0.5% chance that a location will flood in any one year) against coastal flood risk from the Fifth of Forth, as well as fluvial flood risk, primarily from the River Carron, River Avon, Grange Burn (and associated flood relief channel), as well as short sections of their tributaries.

The overall construction duration of the Scheme is expected to be approximately ten years and will take place in discrete sections.

1.2 Environmental Impact Assessment

An Environmental Impact Assessment (EIA) of the Scheme is required under UK legislation. The EIA for the Scheme was undertaken in line with the Flood Risk Management (Flood Protection Schemes, Potentially Vulnerable Areas and Local Plan Districts) (Scotland) Regulations 2010 (as amended in 2017) based on an outline design for the Scheme. The Marine Works (Environmental Impact Assessment (Scotland) Regulations 2017 (as amended) have also been taken into consideration for those aspects of the Scheme which will require a marine licence.

The purpose of the EIA is to investigate and report the likely significant effects of the Scheme on the biological, physical and historical environment, as well as on members of the public and on current or planned future use of the environment. This Non-Technical Summary (NTS) summarises the EIA Report, including key aspects of the Scheme and the associated beneficial and adverse effects considered to be of particular importance. A Habitats Regulations Appraisal (HRA) of the Scheme has also been undertaken under the requirements of the Conservation (Natural Habitats, & c.) Regulations 1994 (as amended in Scotland) or the "Habitats Regulations". The Habitats Regulations Appraisal is reported in a separate document to the EIA Report, and defines the compensatory measures required to address disturbance impacts on the Firth of Forth Special Protection Area, (a designated area for nature conservation interests), which is located within and in proximity to the Scheme.

Further details about the likely significant effects of the Scheme can be found within the full text of the EIA Report. The EIA Report documents have been subdivided into the following for ease of use:

- Non-Technical Summary (also a stand-alone document)
- Volume 1: Main Report
- Volume 2: Appendices, including Figures

1.3 Need for the Scheme

As required under the Flood Risk Management (Scotland) Act 2009, a National Flood Risk Assessment was conducted across Scotland by the Scottish Environment Protection Agency (SEPA), which provided an evaluation of the risk of flooding and the impacts of flooding on human health, economic activity, the environment and cultural heritage (SEPA, 2018a; SEPA, 2018b) (first published in 2011 and updated in 2018).

To provide support in reducing flood risk and based on the results of the National Flood Risk Assessment, SEPA identified Potentially Vulnerable Areas. Potentially Vulnerable Areas are areas which have been identified as facing significant flood risk or which are likely to be at risk in the future. The Grangemouth area was identified to fall within a Potentially Vulnerable Area (SEPA, 2018a; SEPA, 2018b).

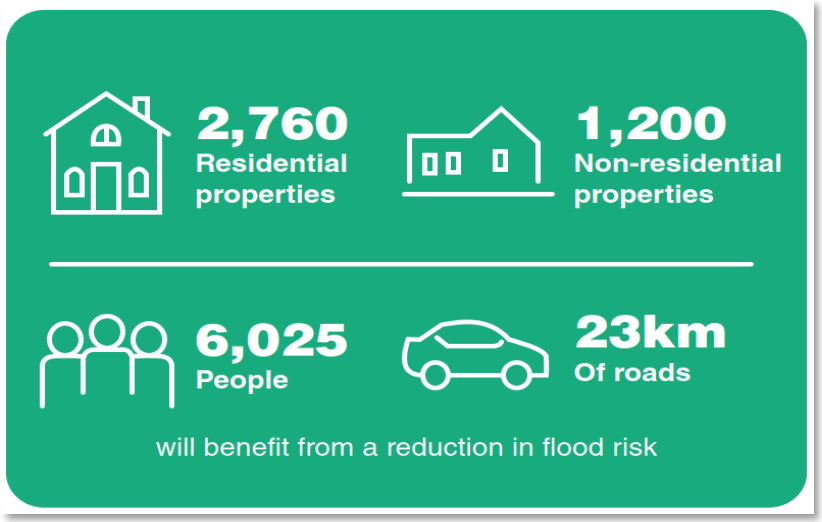

Diagram 1: Receptors benefiting from the Scheme

Image 1: Flooding on the River Carron (February 2022)

Following the National Flood Risk Assessment, SEPA produced a Flood Risk Management Strategy for each flood management district in Scotland. The Flood Risk Management Strategy sets out objectives and actions for flood risk with a focus on Potentially Vulnerable Areas. The Grangemouth area falls within the Forth Estuary Local Plan District Flood Risk Management Strategy, which identifies the requirement for a flood protection scheme for the Grangemouth area. Out of the 42 flood protection schemes proposed across Scotland in the Flood Risk Management Strategies, the flood protection scheme for Grangemouth is ranked as the highest priority scheme (SEPA, 2015a; SEPA, 2015b).

Since 2016, detailed hydrological modelling has been undertaken in the Grangemouth area and areas at current risk of a 1 in 200-year flood risk (combined fluvial and tidal) event have been identified (Figure 1a and 1b). Fluvial flood risk (i.e. from rivers breaching their banks) along the River Avon is predominately located around the Wholeflats Road area, with tidal flood risk dominating the lower reaches of the river. Fluvial flood risk from both the River Carron and Grange Burn is in more intensely populated urban areas. Both these watercourses are also influenced by tides in their lower reaches.

The main receptors at risk of flooding and which will benefit from the Scheme (refer to Diagram 1) are:

- Residential and non-residential properties
- Infrastructure including buildings, roads and open/green spaces
- Utility infrastructure
- Port of Grangemouth
- Refinery and petrochemical plant
- Environmentally sensitive sites.

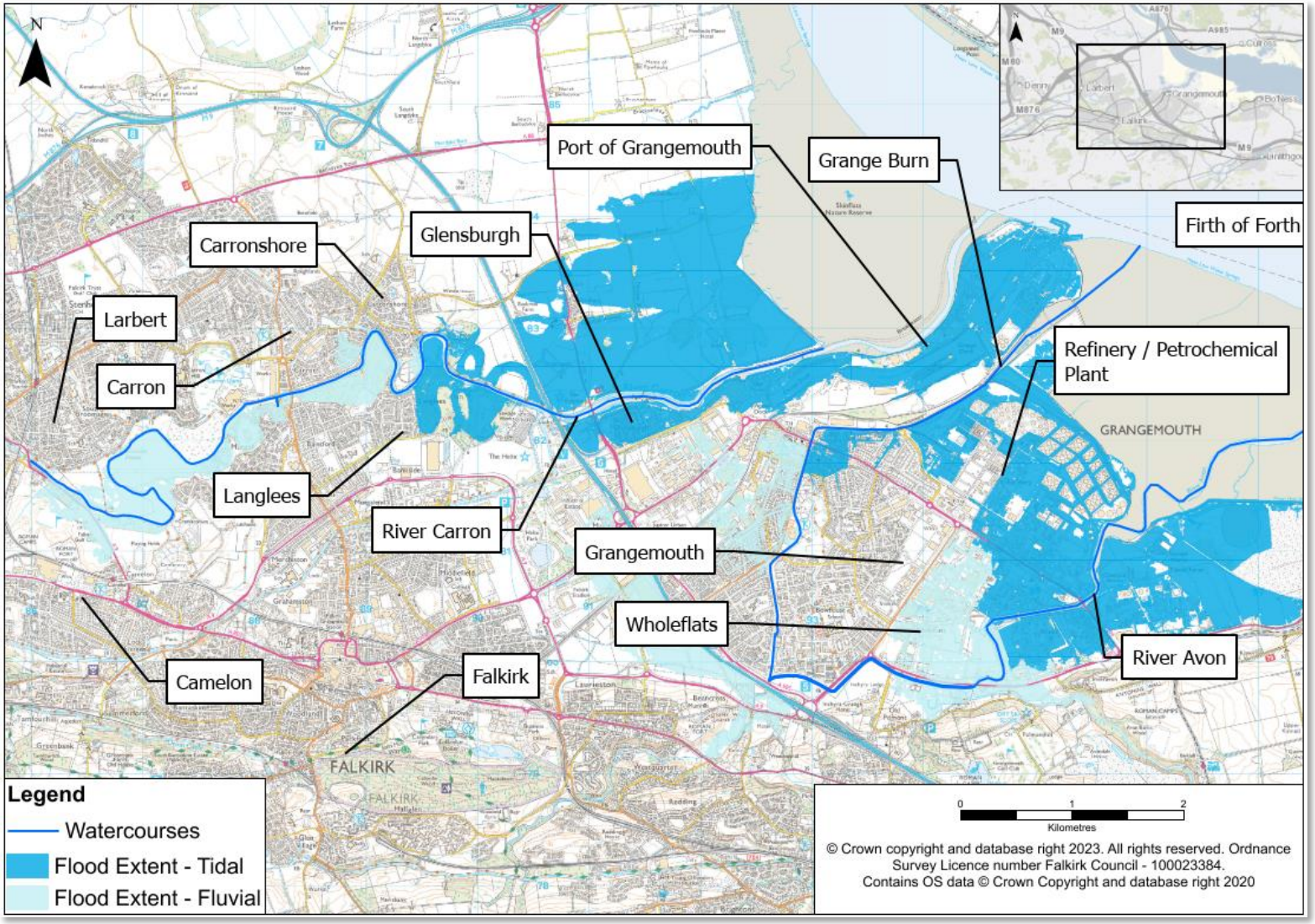

Figure 1a: Grangemouth Baseline Flood Extent

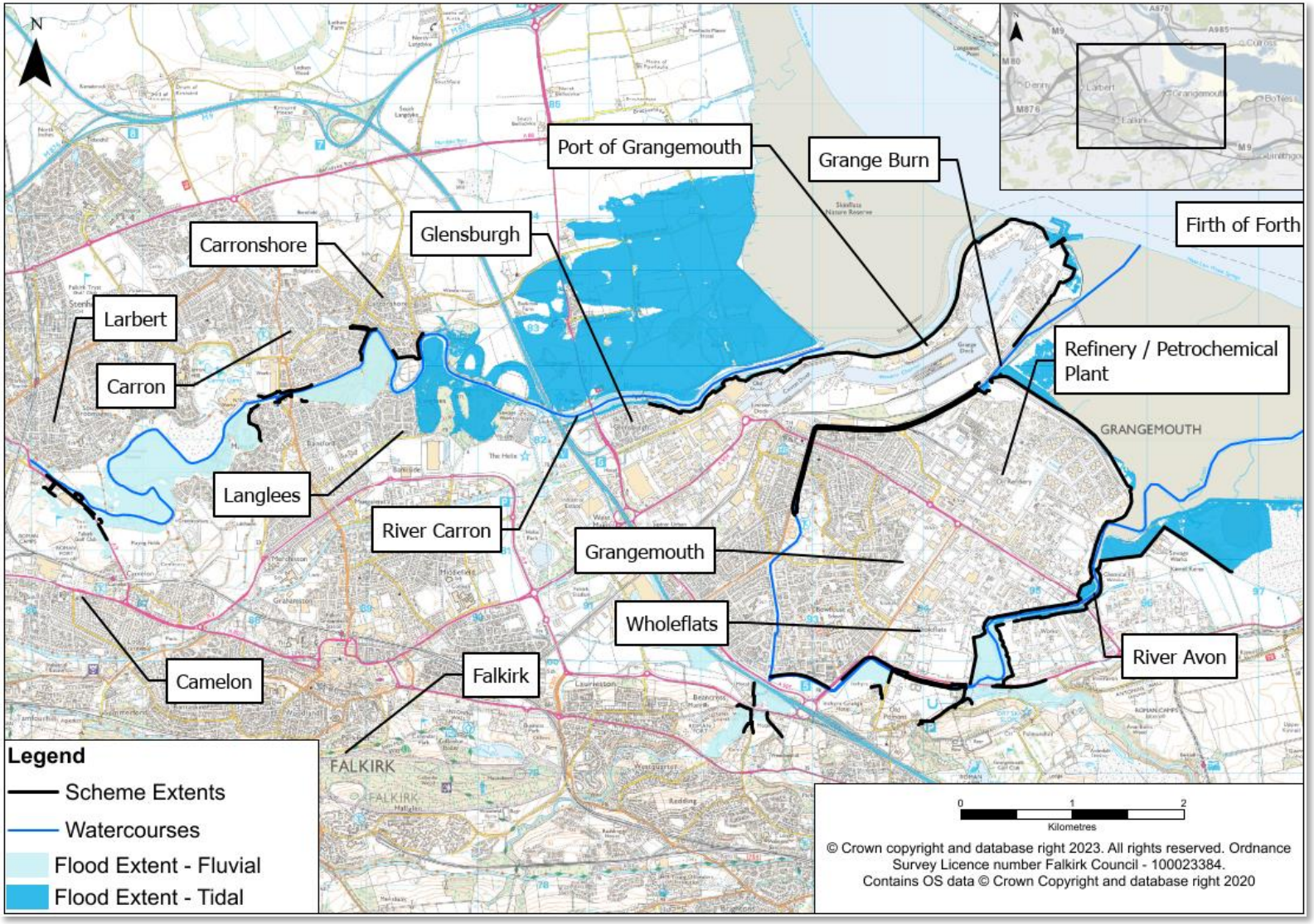

Figure 1b: Grangemouth Flood Extent with Scheme

1.4 The Scheme objectives

The Scheme objectives were set prior to the outline design stage and cover general, social, economic, environmental, technical and hydraulic themes as shown on Diagram 2 (Falkirk Council and Jacobs, 2023).

1.5 Scheme Design Evolution

An initial high-level appraisal of flood risk management options for the Grangemouth area was undertaken by SEPA in 2015 through the Flood Risk Management Strategy process. This appraisal of options was further refined in the Forth Estuary Local Flood Risk Management Plan. Following this, a flood protection study for the Grangemouth Potentially Vulnerable Area was conducted by Jacobs on behalf of Falkirk Council which started with the development and review of a long list of potentially feasible flood protection measures. This long list was reviewed to establish which options could be taken forward to the options appraisal stage. The options were compared in terms of their anticipated outcomes and impact on any major constraints. Examples of reasons for discounting long list options included:

Diagram 2: Scheme Objectives

- lack of any benefit to flood risk;
- very high capital costs;
- significant likely adverse environmental or social impacts;
- impracticalities such as lack of space to place the flood defence measure; and
- significant difficulties in constructing new assets.

A range of potentially feasible options identified from the long list were further explored at the options appraisal stage. The options were assessed and ranked according to how well they performed against Scheme objectives criteria (Diagram 2), with a focus on the economic, environmental, social and technical themes. The iterative process of assessing and discounting or refining options was regularly informed by the review of more detailed flood modelling and other information such as site inspections and stakeholder engagement.

The main options that were considered in various combinations at the option appraisal stage included:

- Direct flood defences (embankments or flood walls)
- The flow control structure on the Grange Burn
- Flood storage area on the Westquarter Burn
- Flood storage area within Zetland Park
- Tidal barrier at the mouth of the Grange Burn.

Constraints and stakeholder feedback from a range of consultees were considered in relation to the options, further detailed hydraulic modelling was undertaken and alternative options were developed as required. An outline of the consultation process for the Scheme is provided in Section 2.3 (Consultation and Scoping).

Through the options appraisal process, the options were refined to identify the most appropriate measures at each location, which together form the preferred Scheme option.

With regard to designing the position and type of direct flood defences, a general preference was given for embankments where possible as they:

- have a lower carbon footprint (as use less concrete than flood walls);
- allow mammals to pass between the aquatic and terrestrial habitats;

- can have relatively lower impact on visual amenity and landscape; and
- can be crossed by pedestrians or be used as raised footpaths to improve access.

Where it was not possible to prioritise the selection of embankments over walls, the reasons generally included:

- space constraints;
- challenging maintenance requirements; and
- economically favourable.

In order to avoid or reduce the environmental impacts of the Scheme, several mitigation measures were integrated into the Scheme design, including the following:

- Repositioning of the flood wall along the Grange Burn in Zetland Park to enable the retention of mature trees.
- Realignment of flood defences along part of the estuary frontage to reduce encroachment into designated nature conservation areas.
- Provision of flood gates and ramps along active travel routes to maintain access through and over the flood protection measures.
- Use of low carbon materials to construct the Scheme to reduce potential greenhouse gas emissions associated with construction.

Section 2: The Scheme

2 The Scheme

The Scheme is located in and around Grangemouth across six different areas which are defined as flood cells (refer to Figures 2 to 9) for ease of reference. Each of these flood cells contains a combination of different flood defence measures.

- Fluvial flood walls: concrete or sheet pile walls with seepage control (approximately 10.3km).
- Coastal flood walls: concrete walls with sheet piles and rock armour revetment to attenuate wave action (approximately 17.6 km).
- Earth embankments: granular filled embankment (approximately 1 km).
- Flood gates: used to control the flow of water.
- Port of Grangemouth (Forth Ports) lock/storm gate: the middle set of gates within the entrance channel at the Port of Grangemouth will be replaced with new flood gates.
- Flood relief channel relining: the existing flood channel associated with Grange Burn will be relined to improve flows and repair damage.
- Flow control structure: a flow structure will be incorporated in the Grange Burn to limit/control the downstream flow.
- Zetland Park Kiosk: the existing kiosk in Zetland Park will be replaced with a new kiosk.
- Culverts: new and/or extensions to existing culverts.
- A9 (Beancross) underpass: the existing A9 (Beancross) underpass which is subject to flooding will be blocked off and infilled with concrete.
- Replacement bridges: three existing bridges will be replaced at their existing locations to withstand flood events: New Carron Road Bridge (B902), Reddoch Road Bridge and Dalratho Road Bridge.
- Work to multiple footbridges on the Grange Burn and the flood relief channel, to incorporate new flood defences (involves reusing the existing footbridges but raising their height).

The height of all proposed flood walls or embankments relative to the surrounding landform varies along their length and depends on the ground level at each location on completion. The defence heights relative to the proposed landform and position of viewers are discussed in detail in Chapter 9: Landscape and Visual Impact Assessment of the full EIA Report.

The Scheme will provide flood risk protection up to the 1 in 200-year level (which means the level where there is a 1:200 or 0.5% chance of a flood event occurring in any one year). To help the Scheme to be adaptable and resilient to the future effects of climate change, including rises in sea level, the foundations for the flood defences have been designed to allow the height to be increased at a later date. Any such works would form part of a future Scheme should the anticipated effects of climate change transpire, and they are not assumed to be constructed as part of the current Scheme.

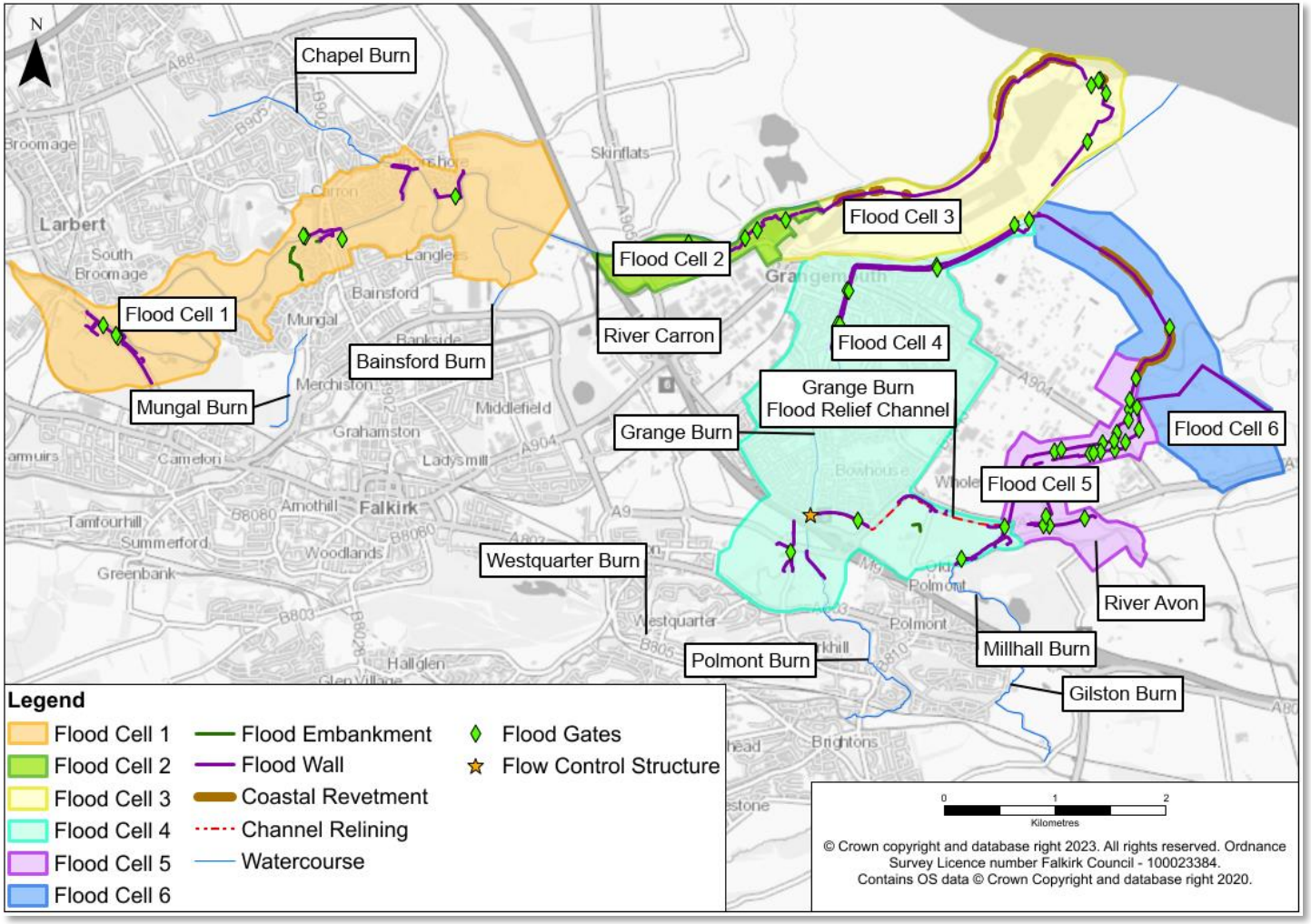

Figure 2: Flood Cell locations and Scheme overview

2.1 Delivering the Scheme

The EIA is based on an outline design of the Scheme. Assuming statutory approval of the Scheme, the outline design will be developed further at a detailed design stage and a contractor will be appointed to construct the Scheme.

For the purpose of the EIA, it has been assumed that the construction works for the Scheme will take around ten years, with discrete sections of the Scheme being completed in phases within that timeframe and with the aim of being operational by 2034.

The Scheme construction works are expected to include establishing site compound and working areas, piling, earthworks, concrete construction, dismantling existing walls, movement of materials, wall cladding, surfacing and landscaping. Construction of the Scheme will involve both in-river working and on adjacent land/riverbanks.

The contractor that delivers the Scheme must adhere to the environmental commitments made in the EIA Report. Should the contractor refine the design which has been assessed by this EIA, then an environmental review will be undertaken to assess whether the scope or scale of residual environmental effects of the refined design would be greater, or significantly different, than those reported in the EIA Report, and if additional mitigation is required. In this situation, additional information would be published for public consultation and comment, and further consideration by Falkirk Council.

2.2 Overview of the EIA Process

The EIA has been undertaken as an integral part of the design process, with environmental constraints and issues identified and incorporated into the decision-making process. The aims of the EIA are to:

- Gather information about the environment, identify environmental constraints and opportunities which may influence, or be affected by the Scheme;
- Identify and assess potential (pre-mitigation) environmental impacts;

- Identify mitigation measures and features (incorporated into the Scheme's design and/or management where possible), to avoid, reduce or offset adverse impacts, and where possible enhance beneficial effects; and
- Assess the Scheme's likely significant residual effects (those remaining after mitigation measures are implemented to avoid or reduce potential impacts).

Impacts were assessed by comparing the existing situation (the baseline conditions) to the conditions that would occur with the Scheme in place.

2.3 Consultation and Scoping

Scoping is a fundamental part of the EIA process, which outlines the approach and scope for the EIA by considering the likelihood of significant effects resulting from the Scheme. A Screening/Scoping Report detailing the outcome of scoping was issued by Jacobs on behalf of the Scheme promoters to Falkirk Council in 2018, in support of a request for a Scoping Opinion under the Flood Risk Management (Flood Protection Schemes, Potentially Vulnerable Areas and Local Plan Districts) (Scotland) Regulations 2010 (as amended in 2017). Responses to the report were provided by Falkirk Council departments and a range of organisations, and a formal Scoping Opinion was provided (under the Marine Works (Environmental Impact Assessment (Scotland) Regulations 2017) by Marine Scotland (now Marine Directorate), which confirmed and directed the approach and focus of the EIA.

During the scoping exercise and throughout the EIA process, the project team worked closely with key stakeholders to reduce the overall environmental impact of the Scheme by avoiding sensitive environmental features and reducing environmental impacts through revised design. Consultees included Falkirk Council, SEPA, NatureScot (formerly Scottish Natural Heritage), Historic Environment Scotland (HES), Scottish Water, the Health and Safety Executive (HSE), Marine Scotland and local landowners and business owners. Key stakeholder feedback was incorporated into the assessment and Scheme design and included:

- aligning the coastal defences to reduce potential effects on estuarine habitats and species, whilst still maintaining the operation of the port and petrochemical site;
- minimising the amount of flood defences within the centre of Grangemouth as much as possible to reduce potential severance and effects on visual amenity and townscape/landscape character (especially at the Grange Burn);
- minimising potential impacts on Zetland Park's open space and the Zetland Park Regeneration Project;

- adjusting the measures proposed at Westquarter Brun to minimise potential effects on the Antonine Wall World Heritage Site;
- minimising disruption to pedestrian and vehicular traffic; and
- reducing the disruption and duration of construction as much as possible.

Public consultation has been undertaken at all stages of design development and public engagement events have taken place since 2018. The first public engagement event was held over two dates in Spring 2018 and the second over two dates in late May 2019. In June 2021, seven online information sessions were held and mobile engagement sessions were held in June 2022 using a Council van, which enabled access to local communities in the Grangemouth and surrounding areas. Six in person and two online events were held between 29 February and 11 March 2024 prior to Scheme publication. These events presented the final outline flood defence alignment (i.e. the location of the flood defences) and the proposed appearance of the flood defences across all six flood cells. All of these served to further promote engagement with local people and the Scheme.

The project team has regularly met with stakeholders throughout the development of the Scheme. This included during the outline design stage, where members of the project team met with individual stakeholders and groups to discuss the Scheme and identify any areas of concern.

Section 3: Environmental Impacts and Mitigation

3 Environmental Impacts and Mitigation

The following subsections summarise the likely significant effects of the Scheme on the environment, including relevant details of mitigation measures. Full details of the EIA, including the detailed methodology, limitations and the findings, are presented in the individual chapters of the EIA Report (Volume 1: Main Report). Chapter 16 (Schedule of Environmental Commitments) of the EIA Report collates the mitigation measures from each chapter and outlines legislative and monitoring requirements, for the following environmental impact topics:

- Population and human health
- Biodiversity
- Noise and vibration
- Landscape and visual
- Water environment
- Soils, geology and land contamination
- Air quality and climate
- Cultural heritage
- Traffic and transport

An overview of the Scheme and key environmental constraints is shown in Figure 3 and by Flood Cell in Figures 4-9.

Image 2: Flooding at Falkirk Golf Course (February 2022)

3.1 Population and Human Health

The population and human health assessment considered the potential impacts and effects of the Scheme on the social, economic and environmental aspects of peoples' lives, their community and their health. Baseline conditions for the population and human health assessment were established through

feedback from stakeholder groups and public consultation events, a desk-based assessment and consultation with council officers.

Regular and/or severe flooding can cause significant adverse effects on local communities by causing damage to residential, commercial and civic property, public spaces and infrastructure. Living within a flood risk area can increase a person's risk of a variety of physical and mental health outcomes, and have an adverse effect on social wellbeing.

While the development of a flood scheme has the potential to positively affect communities through providing improved protection against flooding, the construction and operation of the Scheme can also give rise to other effects (both positive and negative) on people and their communities.

Population and health impacts related to flood risk: During the construction phase of the Scheme, existing flood defences will be removed and replaced at certain locations. Should a flood event occur during construction, there is a temporarily increased risk of flooding in the undefended areas. To mitigate this risk, temporary flood protection measures (e.g. temporary sheet piling / dumpy bags / sandbags / boards) will be implemented during construction. Such measures will be included in all locations where flood risk would be otherwise increased during the dismantling and reconstruction of permanent flood defence measures. The feasibility and sequencing of suitable temporary flood defence measures will be explored during the detailed design stage. With this mitigation in place, the adverse effect during the construction stage from flood risk is significant due to the high sensitivity in terms of health, albeit the flood risk itself is reduced to a small magnitude.

Once the Scheme is constructed and operational, a reduction in flood risk to approximately 2,760 residential (6,025 people) from a major flood event (up to 1 in 200-year event) represents a major positive benefit to the health of the community located within the Scheme area, including those located in more deprived locations. It is expected that the improved protection against flood risk would alleviate adverse health impacts associated with major accidents (such as trauma, stress, reduced access to healthcare services and feeling of loss). On this basis there would be an overall significant beneficial effect on health.

There are some receptors, including two residential properties and a Travelling People's site, who would experience some increases in flood levels during more extreme flood events and who would potentially be adversely affected by the Scheme. It is anticipated that consulting with those potentially affected to explore solutions will help to reduce these potentially significant effects.

Overall, the Scheme will have a residual positive significant effect relating to improved psychological health and reduced disruption to utilities and access associated with flood avoidance.

Safety risks during construction and operation: Construction activity can pose safety risks to people through pedestrian access near construction sites, disabled access restrictions, constrained pedestrian and cyclist access and traffic diversions, as well as to construction workers working in the river environment over prolonged periods. However, with standard mitigation measures in place during construction, these potentially significant adverse effects are expected to be reduced so no longer significant. No significant impacts on safety are anticipated once the Scheme is operational on the basis that appropriate standards, signage and access restrictions will be put in place around the defences.

Population and health impacts related to core paths and active travel: The construction period would result in relatively widespread disruption of the Core Path network due to several temporary closures of some routes. This has potential to discourage people from undertaking active travel journeys due to perceived inconvenience. This may affect groups of high sensitivity such as children who may be reluctant or not permitted (by parents) to use alternative routes via local roads. Disruption to regular active travel in the short-term has the potential to change lifestyle choices and encourage uptake of less active modes such as driving and on this basis the effect on health has been assessed a significant. However, once operational, no likely significant effects are predicted as the active travel network would be restored.

Population and health impacts related to access to green space and outdoor recreation: During construction, access to and the enjoyment of green/open space, including the amenity value of local parks such as Zetland Park and Rannoch Park, would be impacted for people who depend on these spaces for

their health and well-being, particularly children and older people. Given the importance of green space to health and wellbeing, the potential health impacts during construction, as a result of changes to paths, outdoor access and recreation, has been assessed as significant, but will be minor with appropriate mitigation including timing works and ensuring access is maintained during works. No likely residual significant effects during construction or operation are predicted.

Disturbance and local amenity during construction: The overall effect of construction on the disturbance and local amenity caused by traffic congestion; noise and vibration from generators, piling, heavy plant movements; dust, fumes and the visual changes caused by construction would have a significant effect upon peoples' health and wellbeing in the vicinity of the construction sites. The range of measures to mitigate these effects so they are no longer significant include the phasing of works that require the temporary closure or diversion of footpaths, cycle routes and areas available for recreation; the implementation of construction environmental and traffic management plans; ensuring all potentially disruptive works or plant movements are ceased at key locations during the one-week fair leading up to Children's Day celebrations at Zetland Park; the planting of (amenity) trees or shrubs and establishing a community liaison officer for the Scheme.

3.2 Biodiversity

The biodiversity assessment considered the potential impacts and effects of the Scheme on ecological features, including terrestrial, marine and freshwater species, habitats and ecosystems. Baseline conditions for the ecological features were established through desk-based assessment, consultation and site surveys.

Ecological features identified as being potentially impacted by the Scheme include three protected areas designated for particular bird species (the Firth of Forth Special Protection Area (SPA), Ramsar Site, Site of Special Scientific Interest (SSSI)).

Aquatic and terrestrial species and habitats that could also be potentially impacted include Atlantic salmon and other freshwater and estuarine fish species; mammals including bats, otter, badger and hedgehog; bird species including barn owl and kingfisher; great crested newt; ancient woodland habitat and other priority habitats included on the Scottish Biodiversity

List and the Falkirk Council Local Biodiversity Action Plan.

Prior to the incorporation of mitigation, potentially significant effects on ecological features were identified for the construction and operation phases of the Scheme.

Where avoidance of impacts through design has not been possible, mitigation to reduce significant impacts has been identified. Measures include the implementation of pre-construction surveys, a Construction Environmental Management Plan and best working practices during the construction phase of the Scheme. During operation, measures to mitigate potential effects include habitat restoration and new planting (undertaken in line with a Landscape and Ecological Habitat Management Plan), provision of bat boxes, provision of otter sheltering opportunities and installation of earth bunds or ramps for mammal connectivity.

Following the implementation of mitigation measures, three significant effects have been identified.

During construction of the Scheme, a significant residual effect on the Firth of Forth SPA and Ramsar sites is likely due to the disturbance and displacement of roosting birds (including qualifying bird species) at two key areas within these designated sites. Compensatory roosting habitat functionally equivalent to that lost will be provided as part of the Scheme, and this is considered in the Habitats Regulations Assessment for the Scheme, which is reported separately to the EIA.

A significant residual effect during construction and operation is likely due to the permanent loss of broadleaved and mixed woodland. This effect will be temporary in nature as tree planting is proposed as part of the Scheme. In the long term, once the woodland is established, no significant effects are predicted.

No residual effects are predicted for all other ecological features. No significant cumulative effects have been identified.

In addition to mitigating potentially significant effects on the environment associated with construction and operation of the Scheme at the EIA stage, all EIA development is now required to achieve positive effects for biodiversity as required by National Planning Framework 4. The approach to achieving positive effects for biodiversity is provided within

Appendix B7.4 and Chapter 7: Biodiversity of the EIA Report. The requirement to submit the details of enhancement measures for positive effects for biodiversity would be incorporated as suspensive planning conditions that would need to be discharged prior to commencing the construction works. The scope and nature of proposals required to secure positive effects for biodiversity have been developed as part of the EIA and will be developed further at the detailed design stage for the Scheme and in consultation with relevant statutory bodies and other organisations.

3.3 Noise and Vibration

The noise and vibration assessment considered the potential impacts and effects from construction on sensitive receptors located within the vicinity of the Scheme. As the operational activities associated with the Scheme would consist of maintenance works, which are not expected to generate noise and vibration impacts, operational effects were scoped out of the assessment.

Sensitive receptors identified in the noise and vibration assessment include residential buildings, educational facilities, hospitals, hotels, community facilities and places of worship. Baseline noise levels were measured at locations representative of sensitive receptors as part of the noise assessment.

The significance of the potential effects from construction have been determined from consideration of the sensitivity of the receptor, the overall noise level at the receptor, the resultant size of the change in the level of noise or vibration, and the duration of the works required for different elements of the Scheme. The construction assessment has also included the potential noise impact from increased road traffic noise on the local road network during construction.

Appropriate mitigation measures to control and manage the noise and vibration levels during construction have been developed. However, despite provision for mitigation, due to the close proximity of the receptors to some of the proposed works, significant temporary residual effects from construction noise are expected to occur at the following locations (within Flood Cell 1):

- Stirling Road: Residential receptors on Stirling Road.

- Carron Bridges: Residential receptors on Burder Park, Beaumont Drive and Farm Street.
- Chapel Burn: Residential receptors on Waters End, Bryce Avenue, Duncan Avenue, Halket Crescent and Rae Court.
- Dock Street: Residential receptors on Dock Street, Wardlaw Place, Gilfillan Place and The Avenue (including Carron House Lodge).

Due to the transient nature of the works (i.e. construction of a length of flood defence which would be covered in meters per week), it is expected that noise and vibration effects will reduce as construction activities move away from receptors. Residual significant adverse effects are not anticipated at other sensitive receptors. There are predicted to be no significant residual adverse effects from vibration or construction traffic. Similarly, there are not predicted to be any cumulative effects from noise or vibration.

3.4 Landscape and Visual

The landscape/townscape and visual impact assessment considered the potential impacts and effects of the Scheme on the landscape and on specific views and visual amenity that people experience. Baseline conditions were established through a desk-based survey and a site survey.

The Scheme is located within or near two Areas of Townscape Value (AOTV), local landscape designations, which are to the north of Zetland Park and at Old Polmont village, both located in Flood Cell 4. Another local landscape designation, The South Bo'ness Local Landscape Area (LLA), although overlapping the edges of Flood Cells 5 and 6 near Inveravon and Nether Kinneil, does not extend into any of the Scheme working areas. In addition, the southern sections of the Scheme run through two further designated areas, the Frontiers of the Roman Empire (Antonine Wall) World Heritage Site and Green Belt, and there are a number of designated ecological sites within the study area for the Scheme, which contribute to the character and sensitivity of the landscape.

Following a detailed review of the landscape character within the study area, the landscape character was categorised into fifteen Local Landscape Character Zones (LLCZs) to reflect the local character in which the Scheme is located.

The landscape assessment presents the impacts on the landscape character of the spaces within each of the

flood cells, as well as the above designations. The visual assessment reviews effects of the Scheme on the large number of people (receptors), who would experience views of the Scheme from buildings, public areas, local roads and other routes used by pedestrians and cyclists.

Potential impacts of the Scheme on the landscape and on visual receptors will arise from the removal of roadside and riverside vegetation; loss of woodland; loss of screening vegetation and greater visibility of commercial/other properties, as well as from the introduction of new flood defence structures and embankments into the locality.

To mitigate potential impacts and effects, the landscape/townscape and visual impact assessment process has influenced Scheme design through such measures as the positioning of new structures to avoid tree loss and limiting the height of flood walls to reduce visual impact. Other mitigation comprises the commitment to replacement tree planting and requirements for the appearance of flood walls to be made appropriate to their setting. In addition, a Landscape and Ecological Habitat Management Plan (LEHMP) (refer to Appendix B9.10 of the full EIA Report) has been produced in outline to be further developed as the design progresses which will detail the soft landscaping requirements for the Scheme as well as set out associated maintenance and management operations.

Following the implementation of mitigation, there will be significant effects during construction on both the landscape/townscape and views/visual amenity due to the amount of temporary localised landscape and visual disturbance from construction activities such as vegetation clearance and the presence of construction plant.

During the first winter after construction, significant residual landscape and visual effects will remain, largely due to the loss of mature vegetation, because replacement planting will not have grown sufficiently to provide screening or establish a green environment, and because of the size and physical presence of new flood defence structures in some areas.

Image 3: Proposed view south towards Chapel Burn and residential properties adjoining it with the Scheme in place

Fifteen years after construction, it is expected that the Scheme landscaping measures will have settled into the surrounding landscape, resulting in a reduction in the significance of both landscape / townscape and visual effects across many areas. Planting will have substantially developed, and existing tree growth will have helped to embed the Scheme into the area. The landscape character in many areas will change and there are a few places where the size and location of the flood defences will result in permanent changes and where the view of/within these areas cannot be mitigated fully, such as at the embankment in Mungle Community Woodland, flood walls adjacent to the Chapel Burn and alongside the Grange Burn through Zetland Park and on top of embankments at Rannoch Park. An operational maintenance plan will be developed as part of the LEHMP to monitor the development and effectiveness of landscape mitigation measures and remediate these if required.

3.5 Water Environment

The water environment assessment considered the potential impacts and effects of the Scheme on geomorphology (fluvial and estuarine), (which considers the physical features and flow aspects of rivers and estuaries), water quality and supply, flood risk, hydrogeology, groundwater (including terrestrial ecosystems that are groundwater dependent); and private water supplies and abstractions. Baseline conditions were established through desk-based assessments, consultation and site surveys.

The Scheme is located within the River Carron, Grange Burn and River Avon catchments, and the Forth Estuary. The assessment for surface water identified five Water Framework Directive water bodies (water

bodies monitored under the Water Environment and Water Services Act (Scotland) 2003, as amended by the Environment (EU Exit) (Scotland) (Amendment etc.) Regulations 2019 and the European Union (Withdrawal) Act 2018) and seven further water bodies that could potentially be impacted by the Scheme. The Water Framework Directive water bodies are the Middle Forth Estuary, River Carron, Grange Burn/Westquarter Burn, River Avon and Island Farm Lagoon (Bothkennar Pools). The others are Chapel Burn, Mungal Burn, Bainsford Burn, Polmont Burn, Millhall Burn, the Grange Burn Flood Relief Channel and a minor tributary of the River Carron. The assessment for groundwater identified the presence of raised tidal flats and raised marine deposits, intertidal deposits, till, peat, alluvium, coal measures, eighteen areas of potential groundwater dependent terrestrial ecosystems and thirty springs.

In the absence of mitigation, potential significant effects during construction were identified for fluvial geomorphology, surface water quality, surface water supply, groundwater and flood risk. These effects are mainly due to either the potential for the release of polluting materials into the water environment, excavation or sheet piling, or the localised displacement of water caused by construction activities, such as those undertaken when working in rivers.

Significant effects during operation were identified for fluvial geomorphology because of permanent changes to riverbeds under the footprint of new flood defence structures or because of modifications to riverbanks. Significant effects were also predicted in some areas where the works associated with installation of flood defence structures intersect with groundwater and where flood risk levels are predicted to increase.

Where avoidance of impacts through design has not been possible, mitigation to reduce significant effects has been identified, for example, during construction a Construction Environmental Management Plan will be implemented, which will include measures to protect fluvial geomorphology, surface water quality, surface water supply, flood risk, private water supplies and abstractions, and groundwater. There is the likelihood of a significant residual impact to a likely area of high groundwater dependence and associated springs. The detailed design for the Scheme will be progressed with consideration to the local groundwater setting and

mitigation required to limit impacts on groundwater will be embedded within the design as necessary.

Overall, there will be significant positive residual effects in terms of a reduction in flood risk once the Scheme is constructed, benefiting some 2,750 residential and 1,200 non-residential properties currently at risk of flooding, including nationally important infrastructure. There will, however, be localised areas where an increase in peak flood depths is predicted. These are predominantly in areas of floodplain and agricultural land already experiencing flooding, with some more sensitive receptors such as a caravan park, industrial properties and the curtilage of residential properties also affected. For these areas, further consultation is required with affected parties to identify further mitigation during later stages of the Scheme.

3.6 Soils, Geology and Land Contamination

The soils, geology and land contamination assessment considered the potential impacts and effects of the Scheme on existing soils, geology and land contamination. Baseline conditions were established through desk-based assessment, consultation and site surveys.

The Firth of Forth Site of Special Scientific Interest (SSSI) is the only designated site within the study area which is, in part, designated for its geological interests and which is considered important for its geological and geomorphological diversity, including a range of features such as fossil deposits, volcanic rocks, minerals, strata exposures and raised beaches. Most of these features are understood to be located on the Fife coast to the north of the Forth estuary, though, and therefore not in the Grangemouth area.

Superficial deposits (geological sediments) within the study area are primarily composed of glacial and post glacial raised marine deposits and raised tidal flat deposits (distinctive sequences of gravel, sand, silt, and clay layers) and glacial till (unsorted mix of clay, sand, gravel and boulders), with localised areas of more recent intertidal and alluvium deposits (distinctive sequences of gravel, sand, silt, and clay layers). The underlying bedrock is composed of a range of sedimentary rocks (such as sandstones, mudstones and limestones) lain down during the Carboniferous era.

Due to the predominantly urban and built-up nature of the area, artificial ground (made ground) is present

across the study area. Most of the study area is composed of non-soils with no potential for agricultural capability. However, there are localised areas of soils (such as alluvial, mineral gley and brown soils) and land classed as having various degrees of agricultural potential (from land capable of producing a wide range of crops to land capable of use as rough grazing).

There are several potential sources of contamination, associated with the area's extensive industrial legacy including foundries, shipyards, docks, petrochemical plants, coal mining, other mineral extraction activities and a range of other activities. These potential sources of land contamination may have impacted the underlying soils, made ground and/or groundwater in the area.

No direct or indirect Impacts on features of geological interest associated with the Firth of Forth SSSI are envisaged as a result of the Scheme and no significant effects on superficial or bedrock geology or the potential for future extraction of possible mineral resources (such as coal, sand, clay or ironstone) have been identified. There will be some permanent loss and/or covering of soils which may compromise the soil's ability to function, however, as this loss and disturbance is minimal, it will not affect the overall function or value of soils across the study area. Therefore, potential effects on soils are also assessed as not significant.

There will be direct and indirect disturbance of potential sources of land contamination, therefore, appropriate mitigation measures to control and manage the interaction with areas of potential land contamination have been developed in addition to the adoption of standard pollution prevention and control measures. Following the implementation of mitigation, no significant residual effects are envisaged. Likewise, no residual cumulative effects are anticipated on soils, geology or land contamination.

3.7 Air Quality and Climate

The air quality assessment considered the potential impacts and effects of the Scheme on air quality during construction. The main element considered was the dust emissions generated by earthworks and construction activities. Air pollutant emissions from construction traffic on the local road network and off-road machinery were scoped out of detailed assessment due to their likely negligible impact on air quality. Local baseline air quality conditions were established based on Falkirk Council monitoring data.

Falkirk Council has declared two Air Quality Management Areas (AQMAs) within its administrative boundary: the Grangemouth Air Quality Management Area and Falkirk Town Centre Air Quality Management Area. The monitoring data indicated that there were no exceedances of the Air Quality Objectives (Scottish Government, 2021) for the pollutants relevant to the assessment (i.e. nitrogen dioxide and fine particles referred to as 'PM_{10}' and '$PM_{2.5}$'). Other air quality mapping data were also obtained from Scottish Government and designated ecological sites containing features potentially sensitive to air pollution were identified in the vicinity of the Scheme.

An assessment of potential dust emissions from construction activities predicted no significant residual effects at either human exposure locations or sensitive ecological sites. Mitigation measures in the form of a Dust Management Plan for the construction phase will be implemented in relation to dust control and emissions from construction activities and plant.

An assessment of the potential impacts of the Scheme on climate during construction and operation was undertaken, as well as an assessment of the potential vulnerability of the Scheme to climate change impacts during operation.

The greenhouse gas emissions from the Scheme were assessed to result in a very small percentage increase in emissions in relation to existing and likely future emissions and were therefore not anticipated to impact on the UK Government's or Scottish Government's ability to meet the respective carbon reduction budgets and targets set. It was concluded that the greenhouse gas emissions for construction and operation were not considered to be significant.

It is recognised that all developments should seek to reduce greenhouse gas emissions as far as practicable, and mitigation has been proposed to maximise the

potential for carbon reduction on the Scheme. This includes a Scheme-specific Carbon Management Plan being developed for the reduction of greenhouse gas emissions during the construction and operation of the Scheme.

The risk assessment of the vulnerability of the Scheme to climate change identified the key hazards and their potential impacts on Scheme receptors, such as the physical aspects of the Scheme infrastructure; access to Scheme infrastructure for maintenance; and health and safety risks to operational staff and end-users. The purpose of the Scheme is to protect receptors from flood risk, including flood risk brought about by climate change. Given the height of flood defences is to be higher in heavily constrained sections (at the estuary frontage), and provision has been made in the outline design for flood defences to be raised in the future (by over-engineering their foundations), along with proposals for the use of resilient materials in Scheme construction, it was concluded that there will not be any significant effects relating to the vulnerability of the Scheme to climate change.

There are not predicted to be any significant cumulative effects for air quality or climate change.

Monitoring of dust and / or particulates is proposed during construction. As part of the Scheme-specific Carbon Management Plan, relevant data such as fuel use, energy use and materials will be recorded to monitor and track greenhouse gas emissions during the construction phase. Recording and tracking of relevant data during operation may also be required.

3.8 Cultural Heritage

The cultural heritage assessment considered the potential impacts and effects of the Scheme on features of cultural heritage interest, including archaeological remains, built heritage and historic landscapes, some of which have world heritage, scheduled monument or listed building status. Information on these features was established through both desk-based surveys and walkover surveys.

Part of the Frontiers of the Roman Empire (FRS) (Antonine Wall) World Heritage Site crosses Flood Cell 4 at Beancross and Flood Cell 5 at Polmonthill. Sections of the Antonine Wall World Heritage Site are also Scheduled Monuments, including the Antonine Wall and Mumrills fort (also at Beancross, adjacent to Grandsable Road) and the Antonine Wall (Millhall Burn to the River Avon). Other Scheduled Monuments

include an enclosed prehistoric settlement at Mumrills, close to the line of the Antonine Wall, and a circular, prehistoric enclosure at Bowhouse, Polmont. There is one Category A Listed Building within the study area which is within Flood Cell 4, (Dundas Church, Bo'ness Road, Grangemouth), as well as ten Category B Listed Buildings and eight Category C Listed Buildings.

Undesignated features of cultural heritage interest include some prehistoric midden sites, but most are associated with Grangemouth's industrial heritage, such as ferries, churches, bridges, iron works, dry docks, distilleries, ropeworks, limekilns and watermills.

Before mitigation, a significant effect was identified relating to the potential disturbance or removal of any surviving archaeological remains associated with the Antonine Wall and Mumrills Fort Scheduled Monument at the western edge of Grandsable Road at Westquarter Burn. Mumrills Fort Scheduled Monument could be further similarly affected by the groundworks required for construction of a flood defence embankment south of the A9. To mitigate these effects, groundworks and construction traffic are to be avoided, or minimised as much as possible, within the Scheduled Monument boundary at the Antonine Wall and Mumrills fort, while detailed mitigation will be developed in consultation with HES as part of the Scheduled Monument Consent process. A Scheduled Monument Method Statement will also be agreed with Historic Environment Scotland before any work commences within the Scheduled area, with an archaeological watching brief undertaken during groundwork excavations at Westquarter Burn, (near the Antonine Wall World Heritage Site).

The noise and visual aspects associated with constructing the flood defences to the north of the River Avon will temporarily affect the setting of the Antonine Wall World Heritage Site, however these effects are not assessed to be significant.

The Scheme is predicted to have no significant effects on listed buildings of any category.

An archaeological watching brief will be undertaken during excavations within the vicinity of six cultural heritage features, none of which are designated; Grangemouth Public Institute (Town Clock), Grangemouth Police Station, Grangemouth United Presbyterian Church, Bowhouse Mill, Jinkabout Mill, Avon Bridge Toll House, to record any below ground remains.

Photographic surveys will also be undertaken for Ronaldshay Crescent and Park Road Grange Church and Church Hall and Zetland Park War Memorial and Park Gates (both Category B Listed buildings); and Avon Bridge at Grangemouth Road, the Sacred Heart Church and the Zetland Park Fountain (all Category C Listed buildings), in order to record the assets, prior to temporary noise and visual intrusion from construction activities altering their settings .

An archaeological earthworks record will be undertaken of Zetland Park to mitigate impacts on its setting caused by the noise and visual intrusion associated with construction and also by the presence of new permanent flood defence structures in the Park. Monitoring of vibration that could be caused by construction activities will be carried out at Avon Bridge, Grangemouth to ensure vibration levels stay below an appropriate threshold to help avoid any damage to the bridge structure.

Following the implementation of mitigation, no significant residual effects are predicted on the features of cultural heritage interest identified as part of the assessment, either during construction or operation of the Scheme. Other than the recording and monitoring measures during the construction phase, no requirement for long-term monitoring is envisaged.

Image 4: Proposed view south-west towards the B listed gates and stone pillars at the northern entrance of Zetland Park, as well as the war memorial (to the left)

3.9 Traffic and Transportation

The traffic and transportation assessment considered the potential impacts and effects on the road network from construction related traffic during the construction phase, the impacts of construction activities on active travel routes during the construction phase and the impacts of the Scheme on active travel routes once constructed. Active travel routes include national and local recreational and tourist routes and those that form part of a wider network of routes for walking, wheeling and cycling, including the National Cycle Network Route 76 (NCN76) and others on the core path network which include the Helix Around Town Trail and the Helix-Larbert Link.

The assessment considered the likely routes that construction traffic will use to and from the construction site working areas for the Scheme and has utilised baseline traffic data supplied by Falkirk Council and Transport Scotland and the core paths dataset obtained from Falkirk Council.

The Scheme construction related traffic will result in increased traffic flows on roads leading to areas where construction will take place. Overall, the predicted traffic volume increases are not deemed to be considerable and are well within the practical operating capacity of affected roads. On that basis, it was assessed that, with traffic management and other measures in place, such as specifying, where practicable, the use of trunk and A-class roads for construction vehicles, the estimated temporary increases in traffic will not result in significant effects.

During the construction phase, a number of footways and paths, some of which form part of the Helix Around Town Trail (such as Mungal Riverside) and part of the NCN76 (at Inveravon to Wholeflats Roundabout and at Dalratho Road to Bo'ness Road) will be affected by the construction works, and as a result will need to be temporarily diverted, however these effects are not considered to be significant.

The introduction of flood defence walls and embankments in some places will result in the severance of a number of existing active travel routes, including those forming part of the Helix Around Town Trail (Mungal Riverside, the River Carron to the rear of Park Road, Dawson Mission Path and Mumrills Road), paths at Cobblebrae (leading to/from Carronside Street), Stenhouse Road to Mill Lade (part of The Helix-

Larbert Link) and several that link to both Rannoch Park and Zetland Park, as well as part of the NCN76 network (at Inveravon to Wholeflats Roundabout and Jinkaboot Bridge). As mitigation embedded in the design of the Scheme, the use of flood gates and ramps in key locations serves to facilitate continued and safe access for active travellers such that significant effects are avoided.

The A9 (Beancross) underpass will be permanently blocked off and infilled with concrete as it is subject to flooding. This underpass will be replaced by a new, traffic signal-controlled crossing on the A9 to allow connectivity between existing routes either side of the A9 at this location. Although not part of the Scheme design, the new crossing is expected to be installed by Falkirk Council as part of a planned upgrade of the A9/ Grandsable Road junction which will be carried out in advance of Scheme construction in this area. This will be investigated further at the detailed design stage for the Scheme, in consultation with the road's authority.

With the implementation of mitigation measures, residual traffic and transport effects were assessed as not significant.

Image 5: Proposed view west from an informal path along the River Carron, with houses within Carronshore seen beyond the riverbank

3.10 Cumulative Effects

The assessment of cumulative effects considered the potential for synergistic (i.e. the combined effect on receptors of multiple impacts from multiple disciplines, such as the combined effect of noise, visual and access impacts on human receptors), or additive effects (i.e. the combined effect of multiple effects of minor significance across a wider geography, such as the combined effect of multiple minor impacts on water quality with a river). In addition, it assessed the potential combined environmental effects associated with other developments in the Scheme vicinity (planning applications overlapping the area of the Scheme), and major (>1ha) developments across the Falkirk Local Authority Area and within the Firth of Forth (Marine License applications).

Cumulative effects were considered and assessed under each of the environmental impact topics and also together in Chapter 15: Cumulative Effects of the full EIA Report. No significant cumulative effects were identified. With regards to disturbance effects during the construction stage, mitigation to reduce these effects has been included (as part of a Construction Environment Management Plan) and a community liaison strategy will be adopted, to ensure any potentially affected parties are engaged with prior to and during construction.

With regards to other projects identified that may be constructed simultaneously within the vicinity of the Scheme, no significant residual effects are predicted. Pre-construction monitoring of the development and the construction landscape around the proposed Scheme construction areas will be undertaken to determine whether any further appraisal or mitigation may be required.

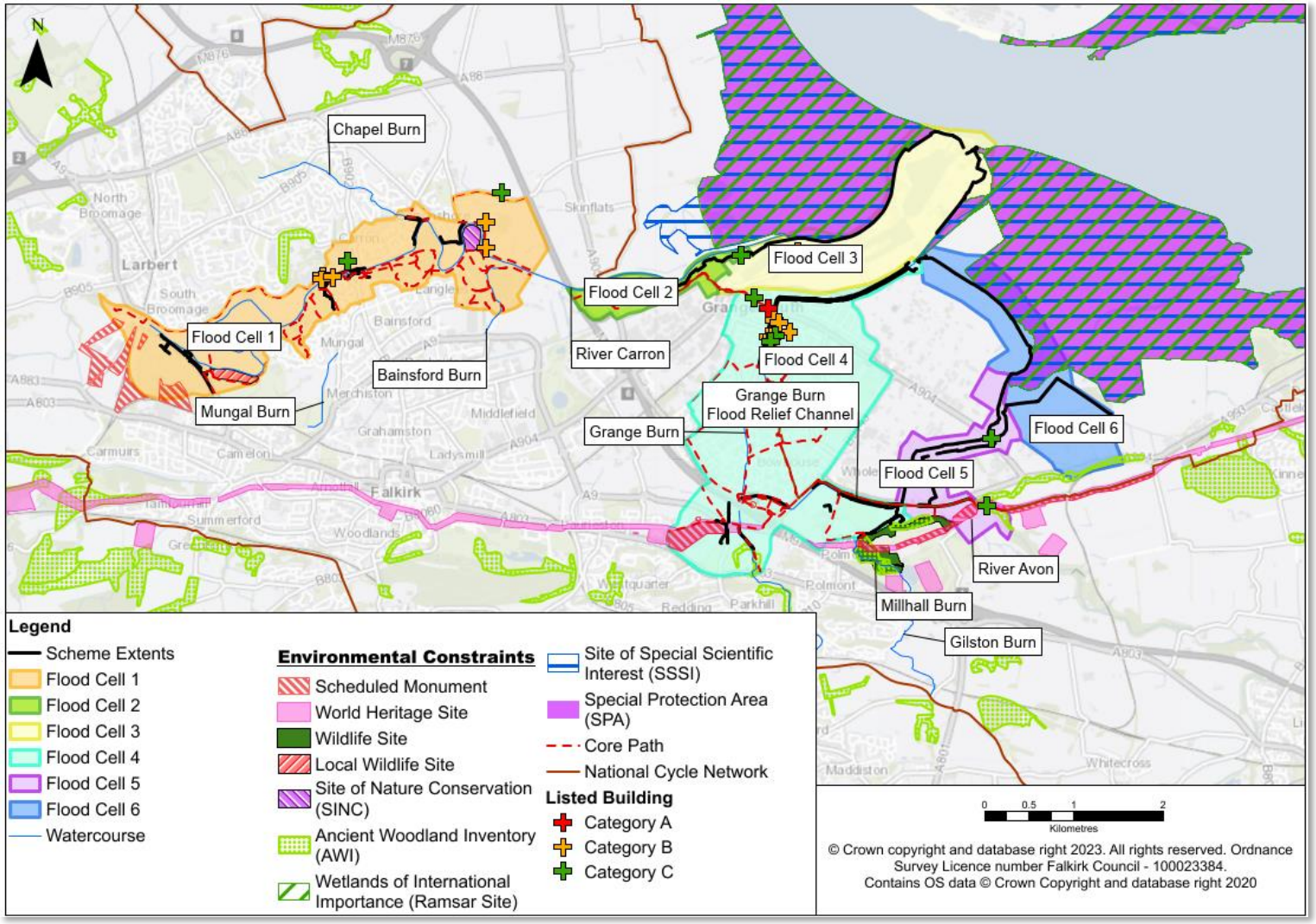

Figure 3: Scheme overview and environmental constraints

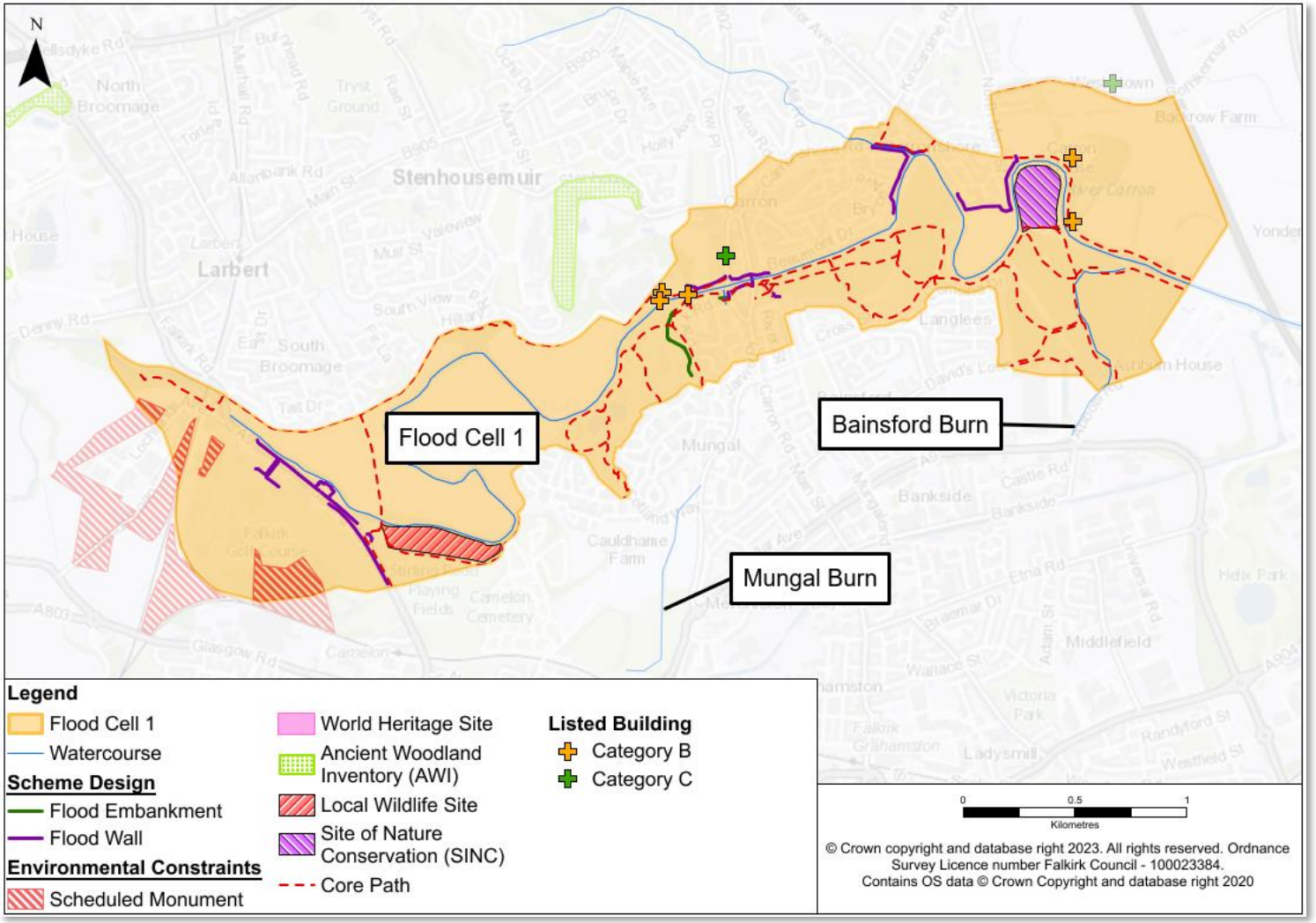

Figure 4: Flood Cell 1 and environmental constraints

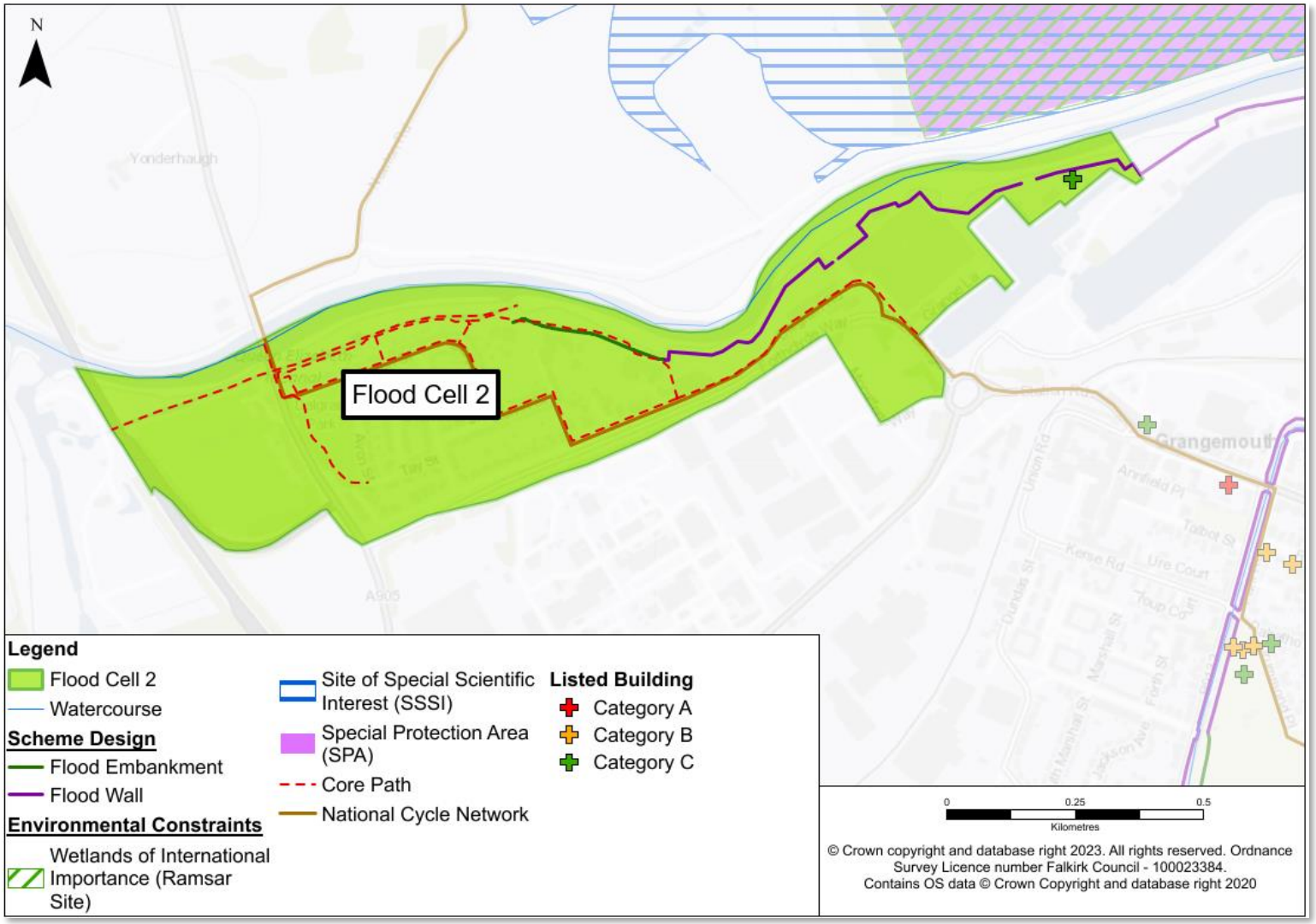

Figure 5: Flood Cell 2 and environmental constraints

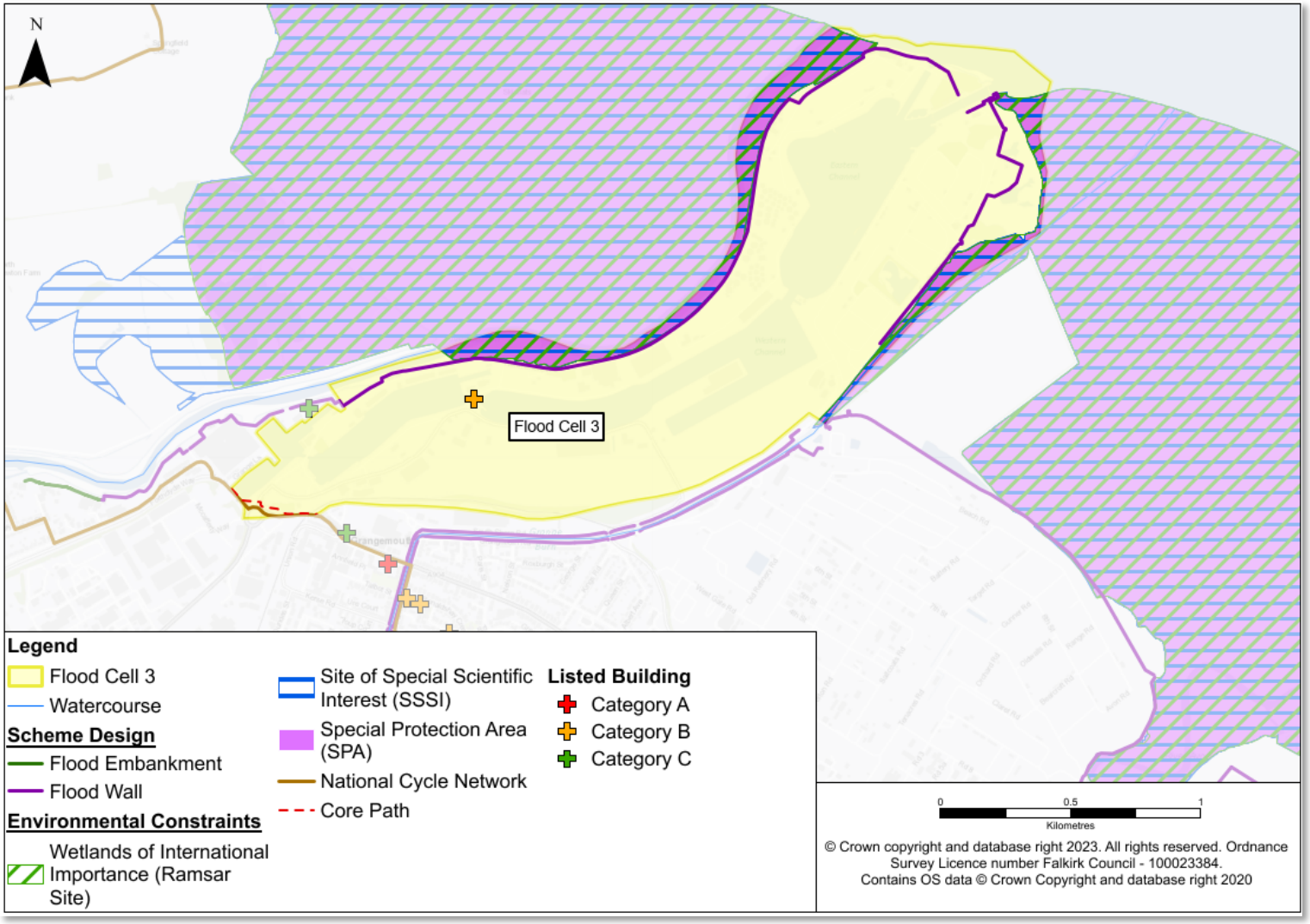

Figure 6: Flood Cell 3 and environmental constraints

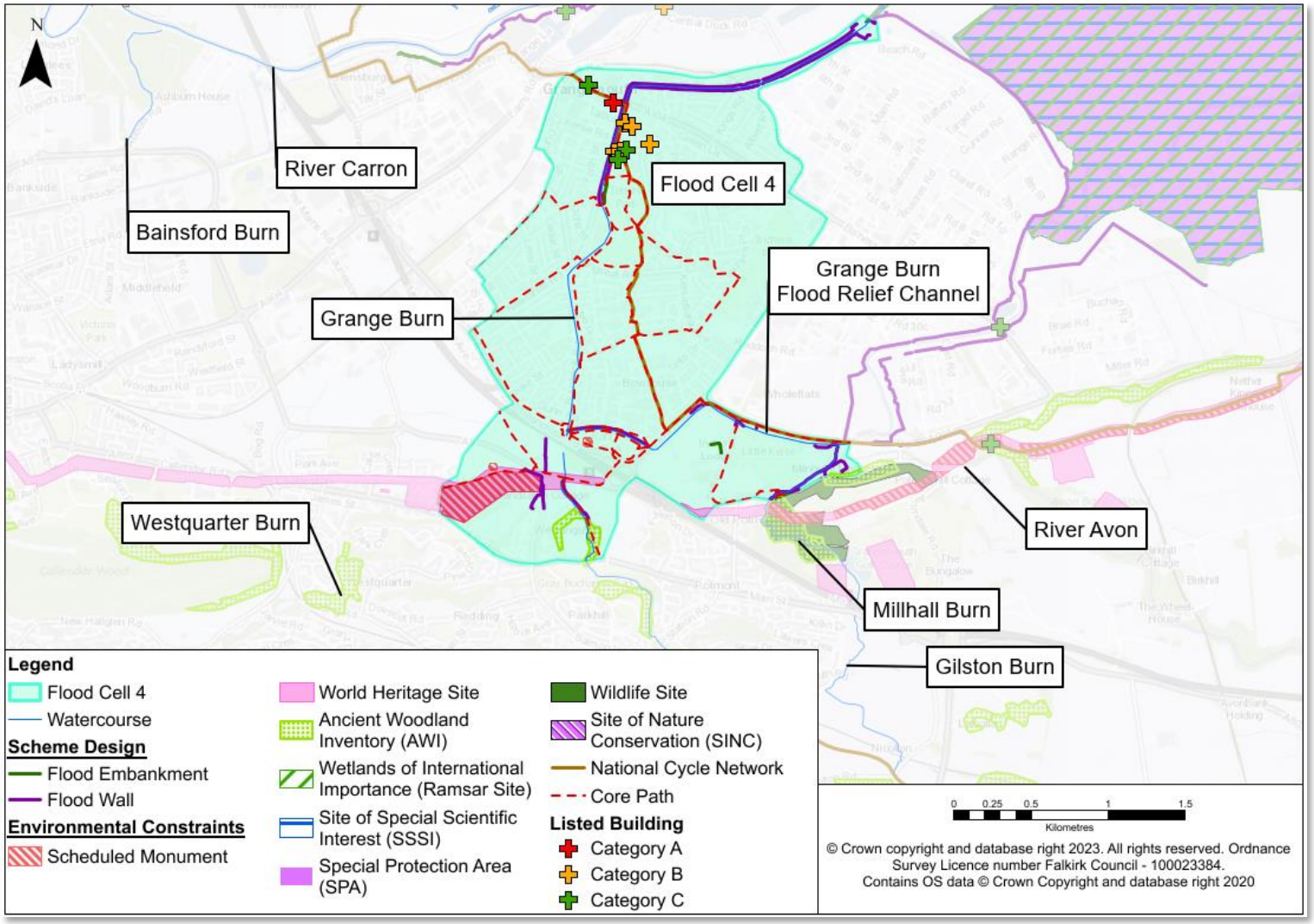

Figure 7: Flood Cell 4 and environmental constraints

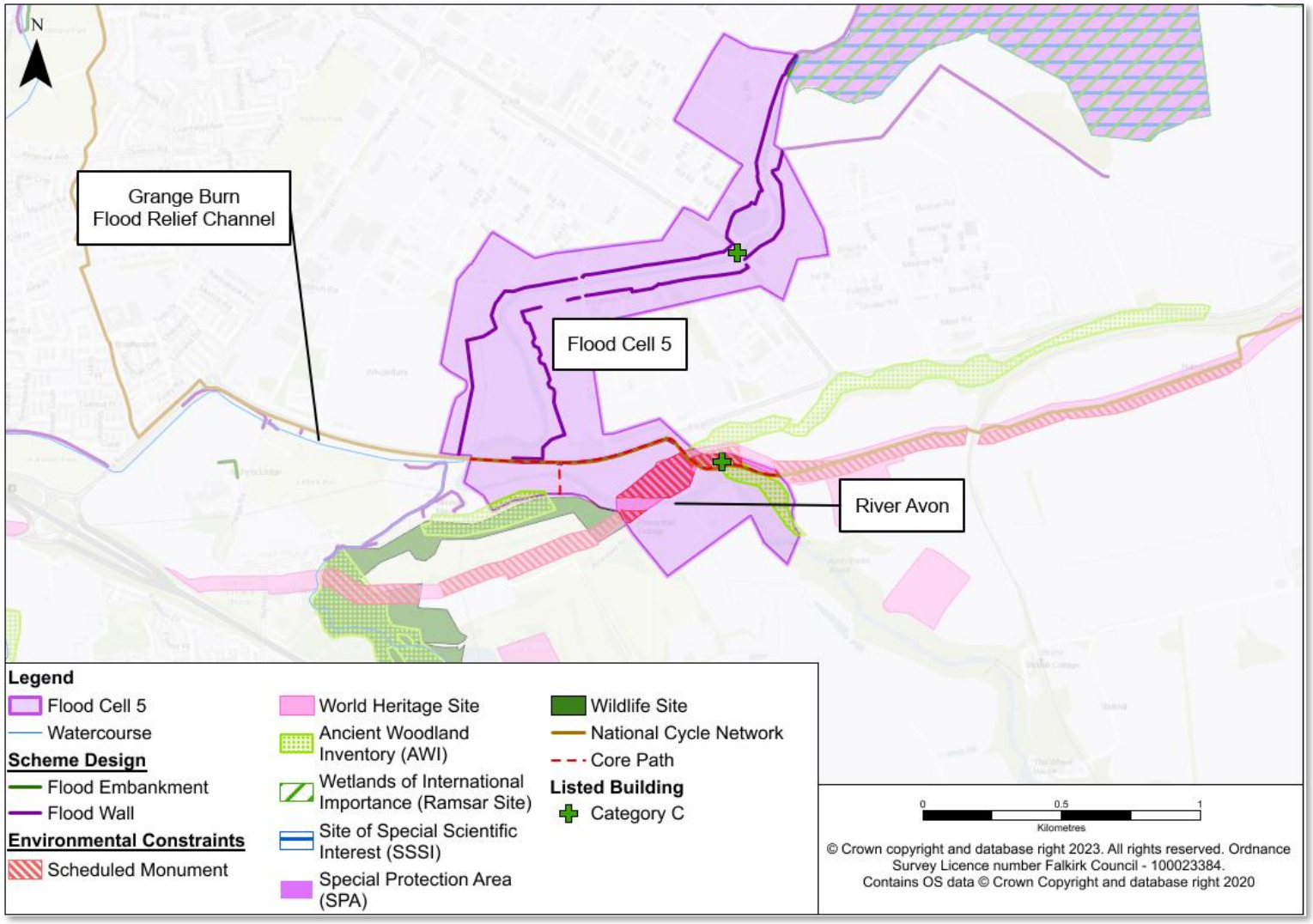

Figure 8: Flood Cell 5 and environmental constraints

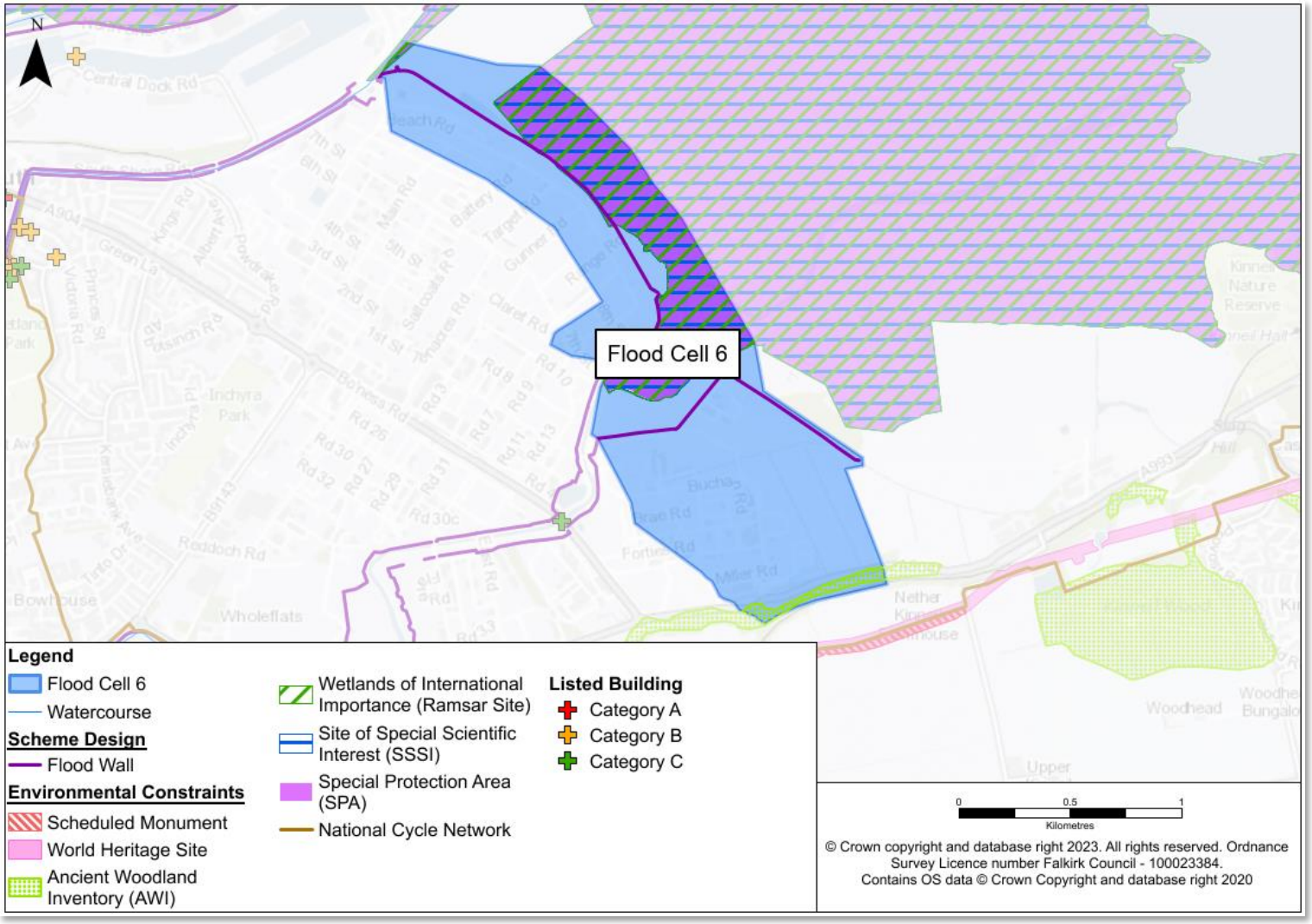

Figure 9: Flood Cell 6 and environmental constraints

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