Aberdeen City Council

BERRYDEN CORRIDOR IMPROVEMENT PROJECT

Flood Risk and Drainage Impact Assessment

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MARCH 2020

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Flood Risk and Drainage Impact Assessment

WSP

110 Queen Street
Glasgow
G1 3BX

Phone: +44 141 429 3555

Fax: +44 141 429 3666

WSP.com

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Checked by	N Earley M. Dickinson	N. Earley M. Dickinson	N. Earley M. Dickinson	
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Authorised by	T. Jolley	T. Jolley	T. Jolley	
Signature	Jolley, Tim Digitally signed by Jolley, Tim DN: cn=Jolley, Tim, ou=Perth (Broxden Business Park), email=Tim.Jolley@wsp.com Reason: Authorised Date: 2020.03.16 14:01:19 Z	Jolley, Tim Digitally signed by Jolley, Tim DN: cn=Jolley, Tim, ou=Perth (Broxden Business Park), email=Tim.Jolley@wsp.com Reason: Authorised Date: 2020.03.16 14:02:17 Z	Jolley, Tim Digitally signed by Jolley, Tim DN: cn=Jolley, Tim, ou=Perth (Broxden Business Park), email=Tim.Jolley@wsp.com Reason: Authorised Date: 2020.03.16 14:03:31 Z	
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EXECUTIVE SUMMARY

WSP were commissioned by Aberdeen City Council (ACC) to prepare a Flood Risk Assessment and Drainage Impact Assessment of the proposed Berryden Corridor Improvement Project (hereon in referred to as 'the Project'). The study assesses the flood risk to the existing road alignment and surrounding area ('baseline') from all sources of flooding and assesses the impacts of flooding from the Project with associated mitigation works to alleviate the potential impacts of flooding.

The improvement works involve widening the existing road, junction improvements and the construction of a new section of road. The works extends for approximately 1.9km from Skene Square in the south to Kittybrewster roundabout in the north.

An Integrated Catchment Model of Aberdeen was previously commissioned by Aberdeen City Council in partnership with Scottish Water to develop an understanding of surface water flood risk and interactions across the city of Aberdeen. This model has been used as a basis for assessing the baseline flood risk within the area surrounding the project and to further assess the potential impacts of the Project.

The assessment investigates the risk of flooding to key receptors based on the significance of potential effects based on the allocation of the sensitivity of a receptor and the magnitude of impact. Where a receptor is shown to be negatively impacted, an assessment is made of mitigation measures to reduce and/or eliminate the increased risk.

Hydraulic modelling has been undertaken for a range of circumstances:

- The 'Baseline' scenario which assesses flooding from all sources based on the existing conditions;
- The 'With Project' scenario which assesses flooding from all sources with the proposed scheme and drainage proposals included within the hydraulic model. This modelling scenario replicates the proposed works to assess the potential impacts on flow pathways, flood depths and associated flooding from the Project.
- The 'With Mitigation' scenario which incorporates mitigation into the model to alleviate the risk of flooding associated with the Project.

Receptors were identified based on proximity to the improvement works – a 200m buffer was assumed to the east of the site based on direction of flow and from west to east. In addition, an initial assessment was undertaken to determine change in depths between the baseline and with project scenario to identify additional receptors where an increase in depth was identified and attributed to the Project.

The initial model runs for the 'With Project' scenario indicate that there are a total of 23 receptors which are impacted (either negatively or positively) which require further assessment. The significance of potential effects was applied to each receptor shown to be impacted to determine whether additional mitigation measures would be required to manage the flood risk. The receptors

range from commercial units to residential properties. It should be noted that the receptors have been identified even where there has been a decrease to risk of flooding as a result of the project.

Some receptors identified are not a result of the project but rather a result of the way in which the hydraulic model has been developed. In some isolated locations water is unable to escape a depression in the underlying ground model due to surrounding buildings or structures (which in reality do allow flowing water), such as receptor B7 at Laurelwood Avenue. This results in a false accumulation of water resulting in high water levels. In reality, flows would permeate these structures and be allowed to enter the surrounding drainage network.

The results of the hydraulic modelling indicate that a total of 7 receptors will require additional mitigation measures to mitigate the impacts of the Project. Mitigation measures incorporated local increases in pipe sizes within the proposed drainage network and reinstating boundary walls and upstands along the road alignment to maintain flows within the road network as occurs in the baseline scenario. This largely addresses localised increases in flood risk, however, it was identified that some key locations still showed some increase in flood risk.

Upon further investigation, it was identified that the residual impacts were either as a result of anomalies within the hydraulic model or small features, such as low walls, gates and small openings, missing from the ground model. An explanation of these limitations is described below:

- Receptor A6 Aberdeen City Council depot and storage building – total storage capacity within the upstream detention basin will accommodate the increase in volume at the model peak flow. This has not been identified as the detention basin is not modelled within the underlying Digital Terrain Model (DTM).
- Receptor C5 Railway line – limitation in the ground triangulation process (i.e. the way in which the hydraulic model processes the underlying ground level data) resulting in the baseline model creating different ground mesh than is created within the proposed model. A false blockage is within the 'With Project' model which does not reflect reality. There is a total volume reduction at higher return periods in this location.
- Receptor C8 Speedy Depot – flooding identified to the building due to the mesh not picking up small wall surrounding the building threshold. These would intercept the small depths at the property and divert them south away from the building threshold. In addition, gulley's are not represented within the hydraulic model which would manage small depths and volumes within the local drainage network. Local drainage improvement will manage the changes and will be assessed at detailed design stage.

The model shows that there is an overall reduction in flood volumes of 9% at the 1 in 200 year flood and 6% at the 1 in 200 year plus climate change flood event. There is therefore an overall reduction in flood risk as a result of the Project.

Some isolated manholes experience an impact caused by the Project however, these isolated increases are due to model limitations and the way in which the manholes gullies are represented. There are also localised increases in volumes of less than 1% which are considered negligible and can be attributed to slight instabilities of the model. Surrounding manholes experience a reduction in volume and therefore there is an overall improvement in the network.

In addition, there are localised increases in volumes of water spilled at a number of Combined Sewer Overflows (CSO's). However, these increases are compensated by an overall reduction in

volume spilled by all the CSO's and therefore there is an overall improvement to the downstream receptors and the Special Area of Conservation at the River Dee.

Contact name Nicola Earley

Contact details 0141 429 3555 | nicola.earley@wsp.com

1

INTRODUCTION

1 INTRODUCTION

1.1 PURPOSE

1.1.1. WSP was commissioned by Aberdeen City Council (ACC) to prepare a Flood Risk Assessment (FRA) and a Drainage Impact Assessment (DIA) to support the Berryden Corridor Improvement Project (hereon in referred to as 'the Project').

1.1.2. The objectives of the study are to support the planning submission for the proposals by undertaking the following:

- Assessing the baseline flood risk from all sources of flooding within the area surrounding the Project;
- Assessing the impacts of the Project on existing flood risk;
- Where applicable, proposing suitable mitigation to reduce flood risk;
- Assessing the impacts of the Project on the existing drainage network;
- Assessing the impacts on the wider drainage network to reflect the Project along with the proposed mitigation measures.

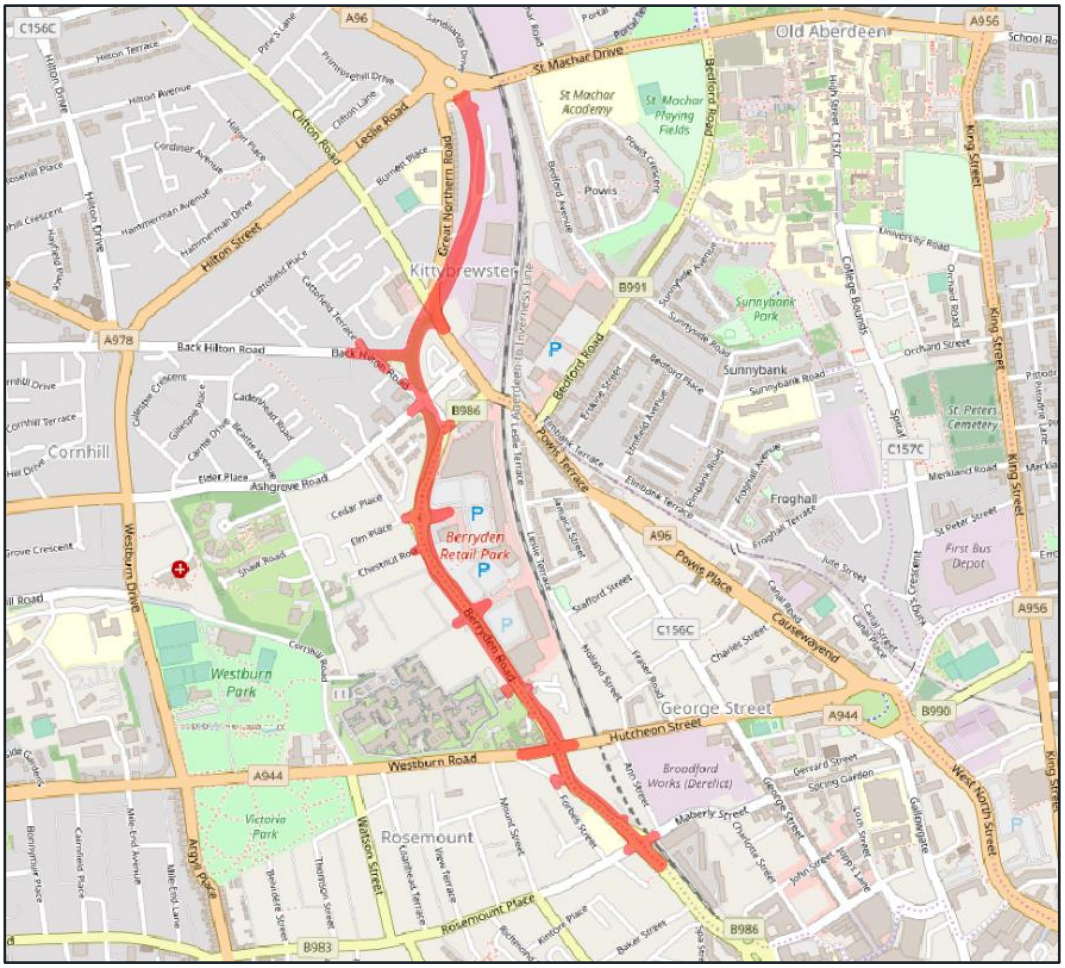
1.2 CONTEXT

1.2.1. The existing Berryden corridor facilitates journeys between the city centre, the north of Aberdeen and beyond. The corridor represents a pinch point in the city road network and has been identified as a route operating beyond its capacity leading to significant congestion and journey time delays, particularly at peak times.

1.2.2. The Project involves widening the existing road and junction improvements between Skene Square and Ashgrove Road, and constructing a new section of road between Ashgrove Road and Kittybrewster roundabout.

1.2.3. Figure 1-1 shows the extent of the proposed improvement works.

Figure 1-1 - Project Extents



1.3 LEGISLATION, POLICY AND GUIDANCE

1.3.1. The report has been prepared in accordance with the relevant national, regional and local guidance included in the following publications, where applicable:

- LA 113 – Road Drainage and the Water Environment
- National Planning Framework 3, Scottish Government, 2014
- Scottish Planning Policy (SPP), Scottish Government, 2014
- Flood Risk Management (Scotland) Act. 2009, Scottish Government, 2009.
- Technical Flood Risk Guidance for Stakeholders, SEPA, 2018
- Sewers for Scotland v4.0, Scottish Water, 2019
- Regulatory Method (WAT-RM-08), Sustainable Urban Drainage Systems, SEPA, 2019
- The SuDS Manual, CIRIA, 2015
- Climate change allowances for flood risk assessment in land use planning, 2019
- National Flood Hazard Mapping for Scotland, SEPA, 2014

LA 113 – Road Drainage and the Water Environment

1.3.2. This document contains the requirements associated with the assessment and management of potential environmental impacts on the water environment from road construction, operation, improvement and maintenance.

1.3.3. This guidance details levels and methods to assess flood risk as well as measures that may be applied to mitigate flood risk and methods to assess their performance.

National Planning Framework (NPF), Scottish Government

1.3.4. This document is the spatial expression of the Government Economic Strategy, and of plans for development and investment in infrastructure. The NPF identifies national developments and other strategically important development opportunities in Scotland. It is accompanied by an Action Programme which identifies how it is expected to be implemented, by whom and when.

1.3.5. It's key outcomes include:

- A successful sustainable place - supporting economic growth, regeneration and the creation of well-designed places.
- A low carbon place - reducing carbon emissions and adapting to climate change.
- A natural resilient place - helping to protect and enhance the natural cultural assets and facilitating their sustainable use.
- A connected place - supporting better transport and digital connectivity.

Scottish Planning Policy (SPP), Scottish Government

1.3.6. The SPP, supported by the NPF3, sets out a precautionary framework approach when determining the suitability of land for development in flood risk areas, with the intention of steering development away from areas of high risk of flooding to the areas of lower flood risk and not increasing the risk of flooding elsewhere.

Flood Risk Management (Scotland) Act, Scottish Government

1.3.7. The Flood Risk Management (Scotland) Act (FRMA) was passed by Parliament in May 2009 and received Royal Assent in June 2009.

1.3.8. Specific measures within the Flood Risk Management (Scotland) Act 2009 include:

- A framework for coordination and cooperation between all organisations involved in flood risk management
- Assessment of flood risk and preparation of flood risk management plans
- New responsibilities for SEPA, Scottish Water and local authorities in relation to flood risk management
- A revised, streamlined process for flood protection schemes
- New methods to enable stakeholders and the public to contribute to managing flood risk, and;
- A single enforcement authority for the safe operation of Scotland's reservoirs.

Technical Flood Risk Guidance for Stakeholders, SEPA

1.3.9. This guidance sets out the methodologies that must be applied for hydrological and hydraulic modelling as well as the information that needs to be submitted to SEPA as part of a flood risk assessment.

Sewers for Scotland, Scottish Water

1.3.10. This document states Scottish Water's technical specification for the design and construction of sewers for developments.

1.3.11. The section specific to surface water drainage design sets out that flooding must not occur in any part of the site in a 1 in 30 years return period and with the requirement of a 1 in 200 year minimum flood resilience assessment check.

1.3.12. Sewers for Scotland contemplates attenuation storages as feasible solution to prevent flooding at the development site and to reduce the site peak runoff rate and the total volume discharged into the network.

Regulatory Method (WAT-RM-08), SEPA

1.3.13. This document provides guidance on the regulation of surface water discharges from built developments including roads. It covers the planning consultation procedure for new developments and the appropriate types of Sustainable Drainage Systems (SuDS or SUD systems) for the developments. It also establishes that SuDS are a legal requirement for all developments draining to the water environment other than a single dwelling or discharges to coastal waters.

The SuDS Manual, CIRIA

1.3.14. This guidance covers the planning, design, construction and maintenance of SuDS to assist with their effective implementation within new developments. Its purpose is to maximise amenity and biodiversity benefits and deliver the key objectives of managing flood risk and water quality.

National Flood Hazard Maps, SEPA

1.3.15. As part of the requirements of the Flood Risk Management (Scotland) Act 2009, SEPA were required to develop national flood maps for Scotland to represent flooding from all sources. SEPA published flood hazard maps in January 2014 which represent flooding from fluvial, pluvial and coastal sources at a strategic level to show where flooding may happen which can enable better planning decisions and identify where more detailed flood modelling may be required.

Climate Change Allowances for Flood Risk Assessment in Land Use Planning, SEPA

1.3.16. This guidance sets out recommended allowances for climate change that can be applied to Flood Risk Assessments submitted in support of planning applications and Strategic Flood Risk Assessments to inform the spatial strategy of development plans. It supersedes previously documented advice on climate change allowances for flood risk assessment in land use planning.

1.3.17. The guidance sets out climate change allowances that should be used for uplifts in peak river flow, peak rainfall intensity and sea level rise.

1.4 LIMITATIONS

1.4.1. The findings and opinions conveyed via this report are based on information obtained from a variety of sources, as detailed, which WSP believes are reliable. Nevertheless, WSP cannot and does not guarantee the authenticity or reliability of the information it has relied upon from these sources.

1.4.2. This report has been written on behalf of the Client and no responsibility is accepted to any Third Party for all or any part. This report should not be relied upon or transferred to any or other parties without the express written authorisation of WSP. If any unauthorised third party comes into possession of this report, they rely on it at their own risk and the authors owe them no duty of care

or skill. WSP disclaims any responsibility to the Client and others in respect of any matters outside the scope of the above contract.

1.4.3. This report has been prepared by WSP with all reasonable skill and care within the terms of the Contract with the Client and considering the information made available by the Client, with the manpower and resources devoted to it by agreement with the Client.

1.4.4. It should be noted that the insurance market applies different tests to properties in relation to both determining premiums and, more fundamentally, determining the insurability of properties for flood risk. Those undertaking development in areas which may be at risk of flooding are advised to contact their insurers or the Association of British Insurance (ABI) to seek further guidance prior to commencing development.

1.4.5. The findings of this assessment have been based on data available at the time of the study and on the review of available information that has been undertaken to date.

2

SITE DESCRIPTION

2 SITE DESCRIPTION

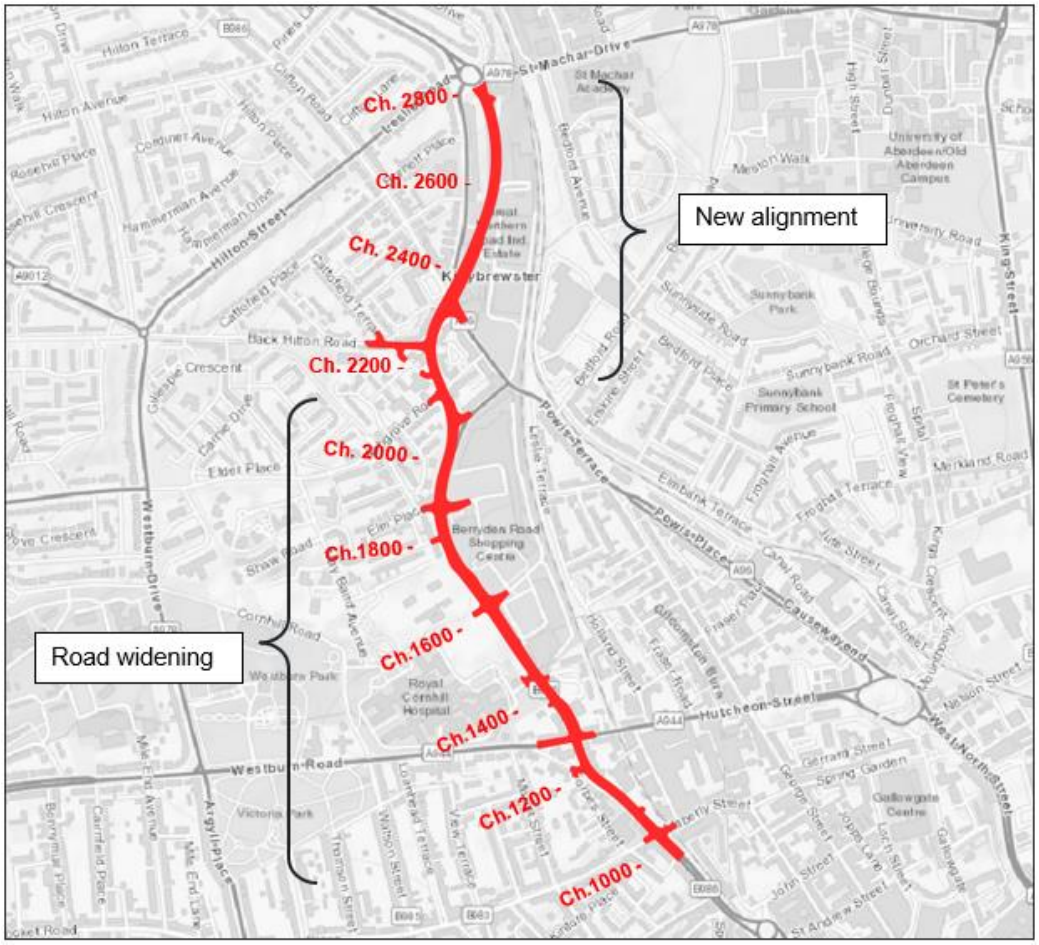
2.1 SITE LOCATION

2.1.1. The existing Berryden Corridor is located within the centre of Aberdeen, Scotland and facilitates journeys between the city centre and the north of Aberdeen. The corridor extends for approximately 1.9km from Skene Square in the south (NJ 93530 06722) to Kittybrewster roundabout in the north (NJ 93100 08326).

2.1.2. Figure 2-1 provides an overview of the extents of the Project marked in red. The Project can be described in two main sections, these being:

- Road Widening - From the junction of Skene Square with Rosemount Place following the route of the B986 then C156C Berryden Road generally in a north west direction until it meets the junction of the C156C Ashgrove Road/Back Hilton Road; and
- New road construction - From the junction of the C156C Berryden Road/Ashgrove Road/Back Hilton Road generally in a northerly direction running between the residential developments of Picktillum Place and Kittybrewster Square and to the rear of properties lying to the east of the A96 Great Northern Road until it meets with the A96 Kittybrewster Roundabout. Included is an additional link road from the proposed new road, to tie in with the C156C Back Hilton Road at its junction with the U308C Cattofield Terrace.

Figure 2-1 – Site Location and project extents



2.2 LAND USE, TOPOGRAPHY AND DRAINAGE

2.2.1. The southern extent of the Project generally comprises of road widening into a mix of residential and commercial premises comprising of permeable and impermeable areas.

2.2.2. The northern section of the Project generally comprises the construction of new road on a mix of impermeable areas of land that were reserved for the delivery of the Project and hardstanding areas used as part of the nearby Kittybrewster Council Depot.

2.2.3. A number of existing boundary walls and buildings adjacent to the existing road will be demolished and replaced as part the widening works. The proposals and flood mitigation will recommend locations for the reinstatement of the demolished walls.

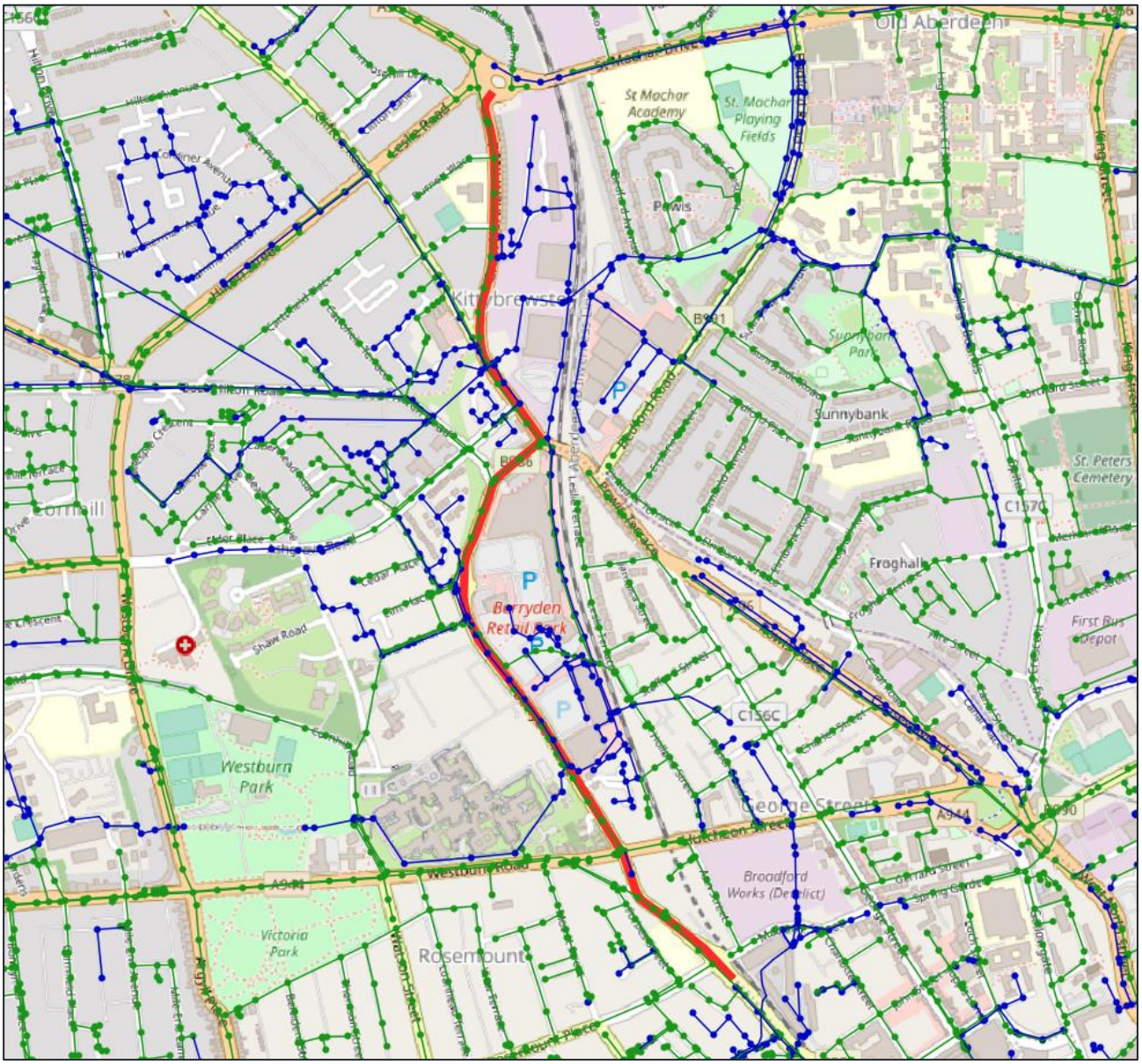
2.2.4. DTM data indicates that grounds levels generally fall in a south easterly direction. The maximum ground level, at the northern extent, is 42.10 mAOD lowering to approximately 21.10 mAOD, at the southern extent.

2.2.5. Two low lying areas along the Project length are located at the junction of Ashgrove Road and Powis Terrace (34.4 mAOD) and on Berryden Road to the north of Hutcheon Street (24.1 mAOD).

2.2.6. Details of the sewer network in Aberdeen have been extracted from the existing Scottish Water ICM model for Aberdeen (previously developed by WSP).

2.2.7. Figure 2-2 provides an overview of the existing combined and surface water drainage networks in and around the proposed improvement works.

Figure 2-2 – Details of existing Scottish Water sewer network (Blue – surface water, Green – combined)



2.3 GEOLOGY

2.3.1. Data has been obtained from the British Geological Survey (BGS) website to identify ground conditions. The BGS 1:50,000 geological sheet indicate that the site is situated on deposits of Aberdeen Pluton and Brig O'Balgownie Formation. The geological boundary between the two units runs approximately along Berryden Road from north to south.

2.3.2. More detailed data on local geology is available within a Ground Investigation Report (GIR) which was produced by WSP in February 2018. This report provides an outline of both the soil type and groundwater located on site.

2.4 GROUND WATER

2.4.1. The GIR includes information on estimated groundwater levels (recorded in mAOD) identified at eight boreholes across the length of the Project. Table 2-1 includes information on the depths of groundwater found at each borehole.

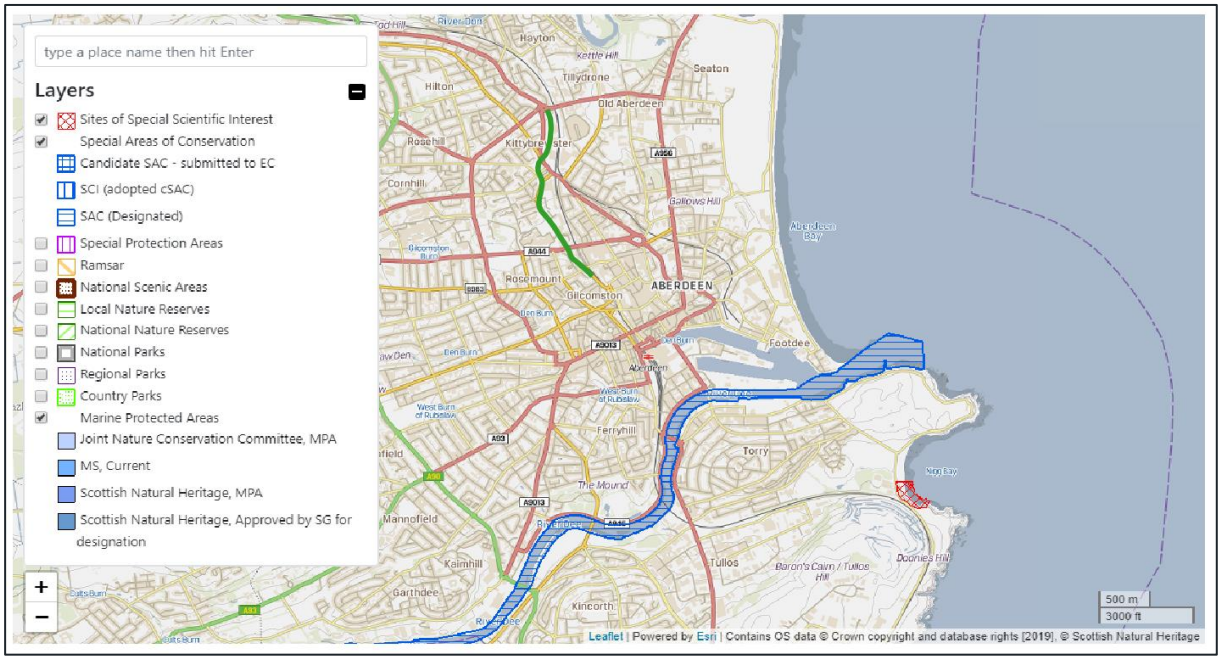
Table 2-1 - Summary of Groundwater Monitoring

Test Location (Chainage)	Ground Level (m AOD)	Response Zone of Installation (m AOD)	Geology of Response Zone	Recorded Groundwater Levels (mAOD)/ (mBGL)	
				Max	Min
BH02 (Ch 1+940)	36.49	35.49 - 30.49	Made Ground/ Granular Deposits/ Glacial Till	32.97/ 3.52	32.80/3.69
BH03 (Ch 2+010)	39.13	38.13 - 33.13	Made Ground/ Granular Deposits/ Glacial Till	35.58/ 3.70	35.43/5.55
BH04 (Ch 2+040)	38.70	36.70 – 30.70	Made Ground/ Granular Deposits/ Glacial Till	34.06/ 4.64	33.45/5.25
BH06 (Ch 2+460)	36.17	34.17 – 30.17	Possible Made Ground/ Granular Deposits	32.95/ 3.22	33.40/3.69
BH07 (Ch 2+480)	37.03	35.03 – 30.03	Granular Deposits	34.26/ 2.77	33.81/ 3.22
BH09A (Ch 2+520)	30.48	29.48 – 27.48	Granular Deposits	29.74/ 0.74	29.62/ 0.86
RBH01A (Ch 2+440)	30.86	29.86 – 24.36	Made Ground/ Glacial Till	29.43/ 1.43	28.98/ 1.88
RBH03A (Ch 2+640)	36.80	35.80 – 31.80	Made Ground/ Granular Deposits/ Glacial Till	34.50/ 2.30	34.37/ 2.43
WS08 (Ch 1+590)	27.74	26.74 – 25.59	Granular Deposits	dry	dry

2.5 ENVIRONMENTAL CONSIDERATIONS

2.5.1. The project extents are not located within a Site of Special Scientific Interest (SSSI) or a Special Area of Conservation (SAC). The nearest SSSI and SAC is a section of Aberdeen Harbour and the River Dee, and both some distance from the Project and planned works. Refer to Figure 2-3 for more information

Figure 2-3 – Site of Specific Scientific Interest (SSSI) map (proposed route in green)



Scottish Natural Heritage. *SSSI Map (2019)*. Not to scale.

3

FLOOD RISK ASSESSMENT METHODOLOGY

3 FLOOD RISK ASSESSMENT METHODOLOGY

3.1 METHODOLOGY

3.1.1. The methodology applied in this assessment is based on the Design Manual for Roads and Bridges (DMRB) guidance to set out a suitable assessment criterion to determine the significance of potential effects of the Project on local receptors resulting from the development of the Project.

3.1.2. The impact on flood risk has been assessed based on the sensitivity and magnitude matrix shown in Table 3-1.

Table 3-1 - Criteria used to Estimate the Significance of Potential Effects

Sensitivity	Magnitude			
	Major	Moderate	Minor	Negligible
Very High	Very Large	Large/Very Large	Moderate/ Large	Neutral
High	Large/ Very Large	Moderate/ Large	Slight/ Moderate	Neutral
Medium	Large	Moderate	Slight	Neutral
Low	Slight/ Moderate	Slight	Neutral	Neutral

3.1.3. The appraisal of flood risk impacts for the FRA considers changes to surface water flows where proposed changes to the road alignment may result in changes to flow pathways and locations of ponding water.

3.1.4. The magnitude and significance of these impacts have been assessed for the 1 in 200 event plus a suitable allowance for climate change based on latest climate change guidance for Scotland.

3.2 SENSITIVITY CRITERIA

3.2.1. Receptors of flood risk include anything from property to people and the surrounding environment. Receptors located within the Medium (1 in 200 event) flood event were identified along the length of the Project.

3.2.2. The sensitivity of water features in general takes into account their quality, rarity, scale and substitutability. With respect to flood risk, sensitivity is determined by the number and type of receptors that are hydrologically linked with the water feature (in this case surface water). The criteria used in determining the sensitivity of each water feature are detailed in Table 3-2.

Table 3-2 - Sensitivity Criteria - Flood Risk Examples

Sensitivity	General Criteria	Typical Examples for Flood Risk
Very High	Attribute has a high quality and rarity on regional or national scale.	Water feature with direct flood risk to > 100 residential properties or critical infrastructure (e.g. trunk roads, main line railways, hospitals, schools, safe shelters etc.).

Sensitivity	General Criteria	Typical Examples for Flood Risk
High	Attribute has a high quality and rarity on local scale.	Water feature with direct flood risk to 1 - 100 residential properties, > 10 industrial premises, and/or other land use of high value or indirect flood risk to critical infrastructure.
Medium	Attribute has a medium quality and rarity on local scale.	Water feature with direct flood risk to recreational land or high value agriculture (e.g. arable land, pastures, complex cultivation patterns and agro-forestry) and/or affecting < 10 industrial premises.
Low	Attribute has a low quality and rarity on low scale.	Water feature with little or no flood risk, affecting low value agricultural land (e.g. rough grazing land).

Table Source: DMRB Volume 11 Section 3 (LA 113)

3.3 SURFACE WATER FLOODPLAIN IMPACTS

3.3.1. This assessment uses the DMRB criteria for estimating magnitude of impact from flood risk, as shown in Table 3-3, with the exception that the 1 in 200 event has been used rather the 1 in 100 event.

Table 3-3 – Surface Water Floodplain Impact – Magnitude Criteria

Magnitude of Impact	Criteria	Typical Example
Major Adverse	Results in loss of attribute and/or quality and integrity of the attribute.	Increase in peak flood level (1 in 200 event) >100mm.
Moderate Adverse	Results in effect on integrity of attribute, or loss of part of attribute.	Increase in peak flood level (1 in 200 event) of between 50mm and 100mm.
Minor Adverse	Results in some measurable change in attribute quality or vulnerability.	Increase in peak flood level (1 in 200 event) of between 10mm and 50mm.
Negligible	Results in effect on attribute, but of insignificant magnitude to affect the use or integrity.	Negligible change in peak flood level (1 in 200 event) <+/-10mm.
Minor Beneficial	Results in some measurable improvement in attribute quality or vulnerability.	Moderate improvement over baseline conditions involving a reduction in 1 in 200 event peak flood level of between 10mm and 50mm.
Moderate Beneficial	Results in positive effect on integrity of attribute, or gain of part of attribute.	Moderate improvement over baseline conditions involving a reduction in 1 in 200 event peak flood level of between 50mm and 100mm.
Major Beneficial	Results in gain of attribute and/or quality and integrity of the attribute.	Moderate improvement over baseline conditions involving a reduction in 1 in 200 event peak flood level >100mm.

Source: DMRB Volume 11 Section 3 (LA 113)

3.3.2. A hydraulic model of the scheme was developed and used to estimate the magnitude of the impacts and to develop mitigation options when required. Details of the original Scottish Water and Aberdeen City Council model for Aberdeen are described in Section 4.3.

3.3.3. For impacts associated with floodplain loss a sequential test has been developed to determine the need for storage compensation. The test given in Table 3-4 to Table 3-6 are based on the approach used in Planning Policy Statement 25 (PPS25) relating to flood risk and development.

Table 3-4 - Floodplain Loss Sequential Test 1

Test 1	Pass?	Actions
Can the impact on the 1 in 200 event floodplain be avoided?	Yes	No action required.
	No	Can we adjust the alignment? Do we need to improve the accuracy of the floodplain extent? If the floodplain cannot be avoided, then go to Test 2.

Table 3-5 - Floodplain Loss Sequential Test 2

Test 1	Pass?	Actions
Is there is an overriding need for the development to be located on an area that is floodplain?	Yes	Proceed to Test 3
	No	Consider adjusting the alignment and reapply Test 1.

Table 3-6 - Floodplain Loss Sequential Test 3

Test 1	Pass?	Actions
Can direct or indirect full replacement of floodplain volume be provided subject to the following constraints? - Available land take. - No detrimental impact on the environment, landscape or cultural heritage. - No long-term issues relating to land ownership. - No increase in flood risk elsewhere. - Other site or scheme specific issues.	Yes	Preference will be given to direct compensatory storage which is located close to the point of impact, provides level for level compensation and is hydraulically linked with the floodplain. If necessary, in-direct compensatory storage will be used which should hydraulically connect the floodplain and storage area and be controlled to ensure level for level compensation.
	No	On the basis of a satisfactorily robust model it should be clearly demonstrated that there would be no increase in flood risk upstream or downstream of the development at sensitive receptors. The criteria to be satisfied should be agreed with SEPA and other stakeholders as necessary.

4

DATA COLLECTION

4 DATA COLLECTION

4.1 SITE VISIT

4.1.1. A site visit was undertaken on the 27th March 2019 attended by representatives from WSP and Aberdeen City Council. The site walkover covered the extents of the Project and allowed the identification of existing drainage elements, existing structures and areas allocated for sustainable drainage options.

4.1.2. The surrounding and contributing catchments were also inspected to develop an overview of the contributing catchments.

4.2 EXISTING ROAD DRAINAGE LAYOUT

4.2.1. Aberdeen City Council provided CAD drawings of the existing drainage networks in and around the project extents. The dataset includes the locations of existing network along with pipe diameters, manhole locations of the storm and combined networks as well as culverted watercourses.

4.2.2. All other road drainage was identified from the integrated catchment model of Aberdeen City.

4.3 HYDRAULIC MODEL

4.3.1. Scottish Water provided the existing integrated catchment model (built within InfoWorks ICM modelling software) (ref: STW001527_STW001543) of Aberdeen. The model was developed in 2015 by request of Scottish Water and ACC to develop an understanding of the surface water flooding risks and interactions across Aberdeen and support the surface water management planning process for the city in accordance with the requirements of the Flood Risk Management (Scotland) Act.

4.3.2. Within the context of this assessment, the hydraulic model has been used to identity the areas that are at risk of flooding and to assess the impacts on flood risk and to the surrounding drainage network. The model contains information on the existing surface water and combined networks as well as details and locations of CSOs in the Aberdeen area.

4.3.3. A 1 metre resolution LiDAR digital terrain model (DTM) was used as part of the ICM model of Aberdeen and has been utilised for this study. A DTM is a 3D representation of a terrains surface created from the terrain's elevation data, in this case ground level data. The DTM covers the full extents of the Project.

4.4 PROPOSED DESIGN

4.4.1. Aberdeen City Council provided general arrangement drawings of the proposed alignment in PDF and 3D CAD formats.

4.4.2. The drawings contain information of the extents of the works, and the proposed footway, carriageway and embankment levels of the new alignment, including the proposed location for compensation SuDS ponds.

4.5 HISTORIC FLOODING

4.5.1. The Local Flood Risk Management Plans prepared by each Lead Local Authority provides information on the implementation of the Flood Risk Management Strategies including details on recorded historic flooding within the relevant catchment areas.

4.5.2. The North East Local Flood Risk Management Plan includes a Potentially Vulnerable Area (PVA) for Aberdeen City at Deeside. The FRMP identifies a history of flooding in the area and states that:

"In October 2001 there was a surface water flood, which exceeded the capacity of the drainage systems and subsequently affected properties at Berryden Road…".

4.5.3. The plan also states that other flooding incidents have been reported in Berryden Road caused by surface water due to blocked or inadequate drainage however, no additional details have been documented.

4.6 CLIMATE CHANGE

Flooding from all sources is likely to increase as a direct result of climate change. Increased intensity and frequency of precipitation is likely to lead to a reduction in ground infiltration, an increase in overland flow, increased pressure on the drainage networks and increases in peak river flows.

The "Climate change allowances for flood risk assessment in land use planning" by SEPA sets out recommended allowances for climate change to be applied in Flood Risk Assessments in support of planning applications for all developments. The type of allowance varies depending on the type of flooding being considered and the size of the catchment being assessed and depend on River Basin Region being considered.

The Project is within Aberdeen which sits within the North-East River Basin district for fluvial uplifts and the East region for rainfall intensity uplifts. The following allowances have been applied for this assessment (total potential change up to 2100):

- Fluvial uplift – **24%** increase in peak river flows
- Rainfall intensity uplift – **35%** increase in peak rainfall intensity

5

BASELINE ASSESSMENT OF FLOOD RISK

5 BASELINE ASSESSMENT OF FLOOD RISK

5.1.1. In accordance with the Scottish Planning Policy (SPP) a prediction of the flood sources and levels is required for the design life of the Project.

5.1.2. SPP states no specific requirements for an allowance for climate change. However, since the Flood Risk Management (Scotland) Act 2009 specifically requires SEPA, in development of its hazard maps and FRM plans, to consider climate change, it is therefore probable that local authorities will adopt the same requirements. It is not national policy to add an additional allowance for climate change above the 1 in 200 year return period but planning authorities may do so if it can be justified, taking account of the most recent UKCP scenarios as applied to the area concerned.

5.1.3. The flood risk elements that need to be considered for any site are defined in the SEPA's *Technical Flood Risk Guidance for Stakeholders* as the "Forms of Flooding" and are listed as:

- Flooding from Rivers (fluvial flood risk);
- Flooding from the Sea (tidal flood risk);
- Flooding from the Land;
- Flooding from Groundwater;
- Flooding from Sewers (sewer and drain exceedance, pumping station failure etc).

5.2 FLOODING FROM RIVERS (FLUVIAL FLOOD RISK)

5.2.1. Fluvial flooding is caused by rivers exceeding their capacity due to large amounts of rainfall occurring during a long period of time across the river catchment.

5.2.2. The SEPA flood hazard maps indicate that there is an area at risk of flooding from fluvial sources at the southern extent of the proposed scheme. This localised area of flood risk corresponds to a medium likelihood of flooding (1 in 200 year return period). The watercourse responsible for this risk of flooding is Gilcomston Burn, which appears to spill from its left bank during higher return period flows.

5.2.3. The watercourses in the area are generally culverted and have therefore been modelled as part of the Aberdeen ICS model. More detail of flood risk from the culverted watercourses in included as part of the assessment referring to surface water and sewer flooding included in subsequent sections of this report.

5.3 SURFACE WATER (PLUVIAL) AND SEWER FLOOD RISK

5.3.1. Surface water flooding is caused by intense rainfall not being completely drained by ground infiltration or by drainage systems, instead the excess water flows over the ground. The SEPA surface water flood maps indicate that there are localised areas across the site where there is a medium likelihood (1 in 200 year return period) of flooding as a result of surface water and overland flow. In addition, there are areas that are identified to be at a high likelihood of flooding (1 in 10 year return period) adjacent to the proposed works at the Council Depot at Kittybrewster and Berryden Mills.

5.3.2. To improve the understanding of the risk of flooding from surface water and sewers, more detailed flooding information was taken from the existing Aberdeen ICS model which covers the whole of Aberdeen and including the area of the proposed Project. Based on the outputs of the hydraulic model, the Project has been defined and assessed as three distinct areas:

- Skene Square (chainage 1000-1400);
- Berryden Road (chainage 1400-2100); and
- Great Northern Road (chainage 2100-2800).

5.3.3. The assessment areas are shown in Figure 5-1.

5.3.4. Table 5-1 below summarises the areas at risk of flooding for the 1 in 200 year event with climate change allowance (35% uplift in peak rainfall intensity) for all assessment areas including the magnitude and receptor sensitivity combined to give the impact.

5.3.5. Mapped outputs of the baseline flood extents are provided in Appendix C.

5.3.6. The locations of the flood risk receptors are shown in Figure 5-2.

Figure 5-1 - Assessment Areas

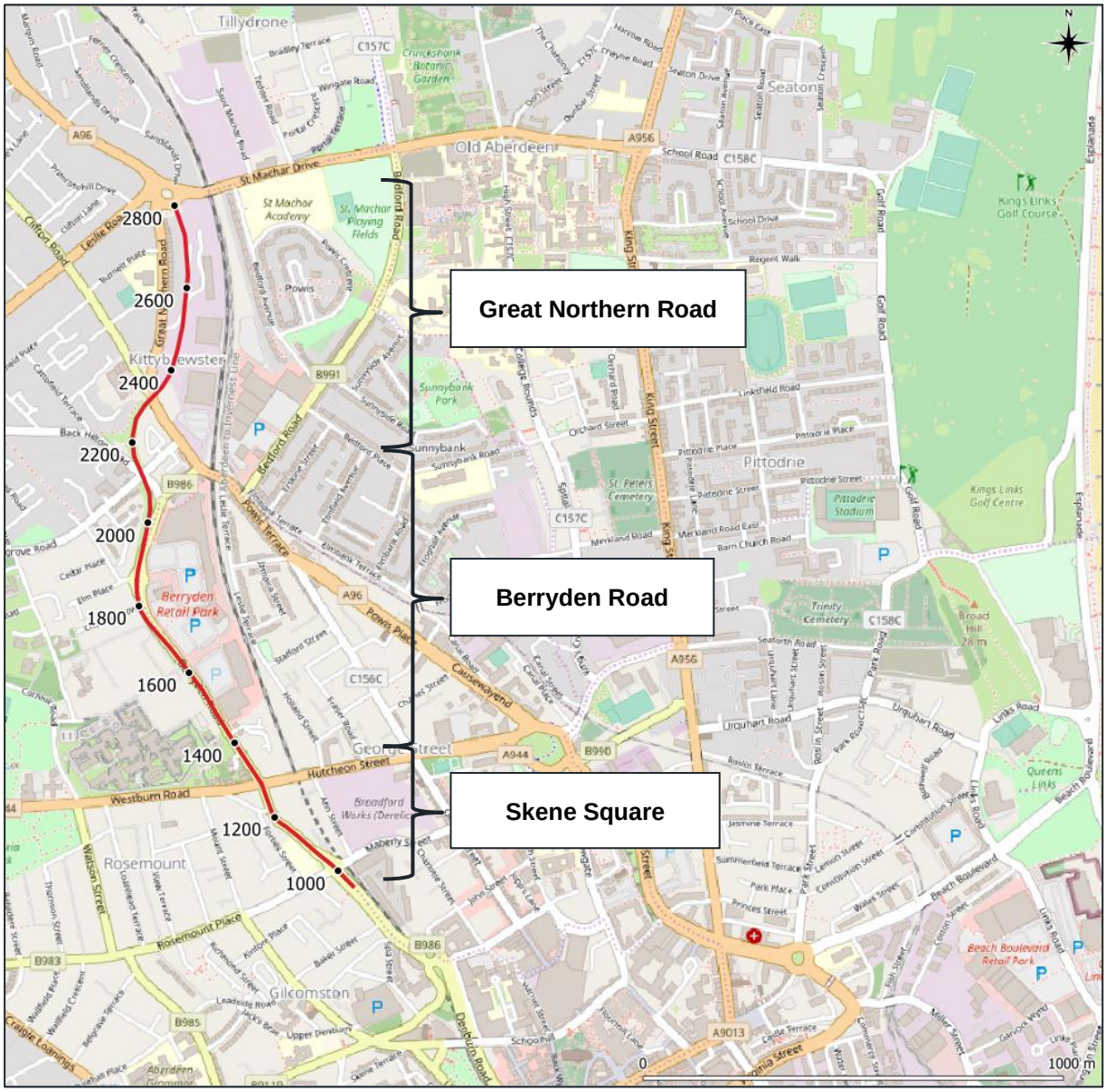


Figure 5-2 – Locations of Flood Risk Receptors

Table 5-1 – Project Corridor Receptors – Baseline Scenario (Without Project)

Location	Description of flooding	Receptor ID	Receptor Name	Location (NGR)	1 in 200 year +CC Maximum Flood Depth (m)	Sensitivity
Great Northern Road	There are two main flow pathways which both flow in a south easterly direction. Flows are routed primarily along existing roads which direct flows towards either residential or commercial properties. The model outputs indicate that there is ponding of surface water around residential or commercial buildings. Surface water is also diverted towards the railway line located to the east of the site. The source of flooding is from overland flows results from surface water and surcharging of the local sewer network.	A1	MOT centre	NJ 93205 08018	0.17	Medium
		A2	Railway line North	NJ 93225 08317	0.69	Very high
		A3	Railway line South	NJ 93222 07732	0.88	Very high
		A4	Residential properties (>100)	NJ 93045 07840	0.51	High
		A5	Kittybrewster Retail Park	NJ 93336 07941	0.36	High
		A6	Aberdeen City Council Depot	NJ 93190 07887	0.29	High
		A7	Aberdeen City Council Storage Building	NJ 93135 07889	0.34	Medium
		A8	Police Station	NJ 93210 08139	0.46	Very High
Berryden Road	Two main flow pathways have been identified within this section. A pathway flowing in a south easterly direction flows along Laurelwood Avenue before ponding within Berryden Road and entering the retail park car park. There is significant ponding	B1	Berryden Retail Park - Car Park North	NJ 93086 07489	0.00	Medium
		B2	Berryden Retail Park – Sainsbury's Supermarket	NJ 93162 07557	0.19	Medium

Location	Description of flooding	Receptor ID	Receptor Name	Location (NGR)	1 in 200 year +CC Maximum Flood Depth (m)	Sensitivity
	within the car park with maximum depths of 640mm. There is also accumulation of flows within the railway line to the east of Berryden Road which flows in a southerly direction resulting in ponding of surface water at residential properties at Holland Street and Fraser Road.	B3	Berryden Retail Park - Car Park South	NJ 93152 07315	0.00	Medium
		B4	Berryden Retail Park – 'Matalan'	NJ 93182 07375	0.80	Medium
		B5	Berryden Retail Park – Retails Units including Carphone Warehouse	NJ 93264 07189	0.64	Medium
		B6	Railway line	NJ 93314 07245	1.87	Very high
		B7	Residential Properties – Laurelwood Avenue	NJ 92996 07461	1.03	High
		B8	Residential Properties – Holland Street	NJ 93361 07177	1.21	High
Skene Square	The main flow pathway flows in an easterly direction with flows emanating from surface water runoff and sewer surcharging. Flows primarily divert around Royal Cornhill Hospital to the west of site and pond within a low-lying area of land before crossing Berryden Road and impacting residential properties at Berryden Mills. The flows continue to flow in an easterly direction mainly within the existing road network.	C1	Royal Cornhill Hospital	NJ 92990 07007	0.62	Very high
		C2	Residential properties – Fraser Road	NJ 93565 07028	1.60	Very high
		C3	Residential properties – Bob Cooney Court	NJ 93275 07073	0.51	High
		C4	Residential properties – Berryden Mills	NJ 93335 07013	0.42	High

Location	Description of flooding	Receptor ID	Receptor Name	Location (NGR)	1 in 200 year +CC Maximum Flood Depth (m)	Sensitivity
		C5	Railway line 1	NJ 93415 06975	2.20	Very high
		C6	Railway line 2	NJ 93551 06731	1.30	Very High
		C7	Industrial premises – Enterprise Rent a Car	NJ 93442 06851	0.00	Medium
		C8	Industrial Premises – Speedy Depot	NJ 93529 06783	0.03	Medium

5.3.7. The flood depths observed at the receptor B7, Laurelwood Avenue, occur within the rear courtyard of the properties as a result of surface water accumulation at the back of the building. It should be noted that this occurs due to depressions in the DTM and the way in which buildings have been represented within the hydraulic model – the hydraulic model simulates buildings as impermeable units and therefore no water can flow through buildings. This results in flows being unable to navigate through openings in the buildings / structures and entering adjacent or nearby drainage networks. Although high depths have been identified, the volumes are insignificant and in reality the flows would be accommodated within the local drainage network. The accumulation is not as a result of the Project.

FLOODING FROM THE SEA

5.3.8. Coastal flooding is caused by combination of high tides and storms. The site is located inland and is not within proximity of a tidally influenced watercourse. SEPA flood maps confirm the proposed site is not at risk of coastal flooding. Flood risk magnitude from coastal flooding is considered “Negligible”, therefore the significance is “Neutral”.

FLOODING FROM GROUNDWATER

5.3.9. Groundwater flooding is defined as the emergence of groundwater at the ground surface away from perennial river channels or the rising of groundwater into man-made ground, under conditions where the 'normal' ranges of groundwater level and groundwater flow are exceeded.

5.3.10. The SEPA flood maps indicate that the north end of the Project is near an area of low likelihood due to groundwater

FLOODING FROM RESERVOIRS, CANALS AND OTHER ARTIFICIAL STRUCTURES

5.3.11. Reservoir flooding risk is the event of flood occurring as the result of an uncontrolled release of water from a reservoir such as a dam break. Reservoirs are regulated in Scotland under the Reservoirs (Scotland) Act 2011. The SEPA reservoirs map shows a reservoir of Low Risk designation known as Parkhill House Reservoir, which is located approximately 8 km to the north west of the site. However, the proposed scheme is outside the indicative extent that is expected to flood the result of an uncontrolled release of water from a reservoir. Flood risk magnitude from reservoirs is considered “Negligible” therefore the significance is “Neutral”.

5.3.12. There are no canals within the vicinity of the site. On this basis, the risk magnitude of canal flooding to the proposed development is “Negligible” and the significance is “Neutral”.

FLOOD RISK SUMMARY

5.3.13. The primary source of potential flooding is from a combination of surface water and sewer flooding based on the outputs of the Aberdeen ICS model. The outputs indicate that there is a high risk of surface water and sewer flooding at the 1 in 200 year return period plus an allowance for climate change. Maximum flood depths in excess of 2m have been identified in some locations where low-lying areas allow ponding of surface water.

5.3.14. The flood risk at the proposed site due to reservoirs, groundwater and coastal flooding can be considered “Negligible”.

6

PROJECT ASSESSMENT OF FLOOD RISK

6 PROJECT ASSESSMENT OF FLOOD RISK

6.1 PROJECT MODEL UPDATES

6.1.1. To represent the Project and assess the impacts this may have on flood risk, the Aberdeen ICS model has been updated to represent the proposed road alignment and associated drainage strategy to account for increased runoff from the proposed development.

BERRYDEN CORRIDOR IMPROVEMENT PROJECT

6.1.2. The proposed project consists of widening of the existing road along with sections of new road resulting in changes to ground levels along the corridor and in some locations, increases in impervious areas and demolition of boundary walls, the replacement of which may influence overland flow paths.

6.1.3. Details of the proposed realignment, widening and improvement works are included within Appendix E.

PROPOSED DRAINAGE NETWORK

6.1.4. The proposals also involve the upgrade to the existing drainage network to accommodate changes to the surface water drainage regime in the area and account for increases in runoff potential.

6.1.5. The proposed drainage network consists of the following pipe arrangements and SuDS proposals:

- Network 1 - flowing south-east between CH1080 and CH960. No additional attenuation required and a conventional surface water drainage network is required utilising the existing Scottish Water network.
- Network 2 - flowing north-west between CH1080 and CH1400 and south between CH2080 and CH1400. At CH1400 both systems discharge into a detention basin at the east side of the proposed carriageway which then discharges into a culverted watercourse. The total volume of the detention basin is 1,284m^3 to accommodate the 1 in 200 year plus 35% allowance for climate change. The system from CH1080 to CH1400 consists single bore 225mm diameter pipes. The system from CH2080 to CH1400 consists of pipes which get progressively larger from 225mm to 450mm diameters. The reported pipe sizes have been proposed to accommodate a 1 in 30 year rainfall event plus an allowance for climate change which exceed the best practice guidance within DMRB of the 1 in 5 year return period. To assist in the alleviation of the potential increase in surface water flooding, pipe diameters will be reviewed as part of the mitigation measures which may propose local increases to pipe sizes depending upon the requirement to alleviate flood risk. More information can be found in Table 7.1 of this report.
- Network 3 - flowing north between CH2080 and CH2350 and south between CH2790 and CH2350. At CH2350 both systems discharge into Detention Basin 2 at the east side of the proposed carriageway which then itself discharges into a culverted watercourse. The total volume of the detention basin is 1,359m^3 to accommodate the 1 in 200 year plus 35% allowance for climate change. The system from CH2080 to CH2350 consists of pipes which get progressively larger from 225mm to 300mm diameters. The system from CH2790 to CH2350 consists of pipes which get progressively larger from 225mm to 450mm. The reported pipe sizes have been proposed to accommodate a 1 in 30 year rainfall event plus an allowance for climate change which exceed the best practice guidance within DMRB of the 1 in 5 year return period. To assist in the alleviation of the potential increase in surface water flooding, pipe diameters will be

reviewed as part of the mitigation measures which may propose local increases to pipe sizes depending upon the requirement to alleviate flood risk. More information can be found in Table 7.1 of this report.

6.2 FLOOD RISK IMPACT

6.2.1. The flood risk impact has been assessed by undertaking a direct comparison of the flood depths yielded by the hydraulic model of the Project and the baseline scenario for the receptors identified in the Section 5.3. The impact in this section has been assessed without any allowance for mitigation measures and is based entirely on the Project and initial proposals for the drainage strategy.

6.2.2. The impact on surface water flow paths and floodplains has been assessed using the hydrology and hydraulic modelling from the Aberdeen ICS model as described in Section 4.3.

6.2.3. The impact magnitude of flooding at the receptors has been estimated based on the criteria stated in Section 3.

6.2.4. The significance of impacts has been estimated based on the criteria stated in Table 3-2, according to the sensitivity of the receptor and the magnitude of impact.

6.2.5. Table 6-1 provides a summary of the flood impact at each receptor for the 1 in 200 year event with a 35% allowance for climate change for each assessment area as assigned in Section 5 of this report. Appendices D, F and H include mapped outputs of the flood depths including the locations of the flood risk receptors.

6.2.6. A comparison has been made between the baseline scenario and the ‘With Project’ scenario to assess the impacts on flood risk. Table 6.1 includes a summary of the changes in flood risk to each receptor.

Table 6-1 – Project Corridor Receptors – With Project Scenario (No mitigation)

Location	Receptor ID	Receptor Name	Location (NGR)	Summary of changes to flood risk	1 in 200 year +CC Baseline scenario maximum flood depth (m)	1 in 200 year +CC Proposed project maximum flood depth (m)	Sensitivity	Magnitude	Impact
Great Northern Road	A1	MOT centre	NJ 93205 08018	The flood depths at the MOT centre decrease due to the changes in ground elevations amending flow pathways. A maximum reduction of approximately 80mm has been recorded which provides a flood risk benefit to this key receptor.	0.17	0.09	Medium	Moderate beneficial	Neutral
	A2	Railway line North	NJ 93225 08317	The railway line benefits due to the elimination of flow pathways and increased capacity of the drainage network. There is a maximum reduction in depth of approximately 160mm with flooding being potentially eliminated at some locations long the railway line.	0.69	0.66	Very high	Minor beneficial	Moderate Beneficial
	A3	Railway line South	NJ 93222 07732		0.88	0.72	Very high	Major beneficial	Very Large Beneficial
	A4	Residential properties – Kittiebrewster Square, Clifton Road and Picktillum Place	NJ 93045 07840	There is a reduction in maximum depths at the residential properties at Kittybrewster Square, Clifton Road and Picktillum Place (ch. 2200 – 2400). the reduction in flood depths is due to additional flow paths allowing water to flow quickly away from the residential properties and also additional capacity within the drainage network. The maximum reduction is depth is approximately 30mm.	0.51	0.48	High	Minor beneficial	Slight Beneficial
	A5	Kittybrewster Retail Park	NJ 93336 07941	Kittybrewster Retail Park located to the east of the railway line at chainage 2300 does not experience any change in terms of flood depths.	0.36	0.36	High	Negligible	Neutral
	A6	Aberdeen City Council Depot building	NJ 93190 07887	The Aberdeen City Council depot located to the east of the scheme at the junction of Great Northern Road and Clifton Road (ch. 2300) experiences a reduction in flood depths of approximately 10mm.	0.29	0.28	High	Negligible	Neutral
	A7	Outbuilding and associated car parking	NJ 93135 07889	The Aberdeen City Council storage outbuilding directly adjacent to the council depot was not at risk of flooding at the baseline scenario. Due to changes to the ground levels, a new flow pathway appears which puts this building at risk of flooding. The maximum depth of flooding at the outbuilding is 400 mm.	0.34	0.40	Medium	Moderate Adverse	Moderate Adverse
	A8	Police Station	NJ 93210 08139	The police Station is located to the east of the Project. The receptor is affected by the changes to the ground levels. The new road eliminates a flowpath that went from the existing Great Norther Road eastwards, to this receptor	0.46	0.38	Very high	Moderate beneficial	Largely beneficial
Berryden Road	B1	Berryden Retail Park - Car Park North	NJ 93086 07489	The car park is impacted due to an additional flow pathway. Changes in ground levels and the removal of existing boundary walls (removed to assess impacts on flow paths	0.00	0.10	Medium	Moderate Adverse	Moderate Adverse

Location	Receptor ID	Receptor Name	Location (NGR)	Summary of changes to flood risk	1 in 200 year +CC Baseline scenario maximum flood depth (m)	1 in 200 year +CC Proposed project maximum flood depth (m)	Sensitivity	Magnitude	Impact
				and to determine replacement locations) allows flows to leave the carriageway and inundate the car park.					
	B2	Berryden Retail Park – Sainsbury's Supermarket	NJ 93162 07557	There is an increase in maximum flood depths to the east of the building due to a new flowpath that results in water accumulating at the northeaster corner. There is a maximum increase in depth of approximately 80mm.	0.19	0.27	Medium	Moderate Adverse	Moderate Adverse
	B3	Berryden Retail Park - Car Park South	NJ 93152 07315	The car park is impacted due to an additional flow pathway. Changes in ground levels and the removal of existing boundary walls (removed to assess impacts on flow paths and to determine replacement locations) allows flows to leave the carriageway and inundate the car park.	0.00	0.06	Medium	Moderate Adverse	Moderate Adverse
	B4	Berryden Retail Park – 'Matalan'	NJ 93182 07375	The flood risk to the commercial properties within the retail park does not increase. There is no change to maximum flood depths or extents.	0.80	0.80	Medium	Negligible	Neutral
	B5	Berryden Retail Park – Retails Units including Carphone Warehouse	NJ 93264 07189	The flood risk to the commercial properties within the retail park does not increase. There is no change to maximum flood depths or extents.	0.64	0.64	Medium	Negligible	Neutral
	B6	Railway line	NJ 93314 07245	There is no increase in flood depths of extents to the railway. Although there is no change to maximum flood depths, there is a decrease in total flood extent therefore providing a betterment to the railway line.	1.87	1.87	Very high	Negligible	Neutral
	B7	Residential Properties – Laurelwood Avenue	NJ 92996 07461	The Laurelwood Avenue residential properties (between ch. 1800 to 2000 (west of the project) experience reduction in maximum flood depth of 90mm. The Holland Street properties (ch.1400 to 1500 east of the scheme), do not experience any change in terms of flood depths. It should be noted that the residential properties are not adversely impacted by the Project. Although high depths have been identified here, this is as a result of model build limitations which are explained Section 5 of this report.	1.03	0.94	High	Moderate Beneficial	Moderate Beneficial
	B8	Residential Properties – Holland Street	NJ 93361 07177		1.21	1.21	High	Negligible	Neutral
Skene Square	C1	Royal Cornhill Hospital	NJ 92990 07007	Maximum modelled flood depths at this location decrease which is likely due to slight changes in flow pathways and increase in capacity of the proposed drainage network. There is a maximum 10mm reduction in peak flood depth.	0.62	0.61	Very high	Minor Beneficial	Moderate Beneficial
	C2	Residential properties – Fraser Road	NJ 93565 07028	The residential properties located to the east of the railway line (ch. 1200 – 1400) experience a reduction in maximum flood depth of approximately 50mm. this is due to the	1.60	1.55	Very high	Minor Beneficial	Moderate Beneficial

Location	Receptor ID	Receptor Name	Location (NGR)	Summary of changes to flood risk	1 in 200 year +CC Baseline scenario maximum flood depth (m)	1 in 200 year +CC Proposed project maximum flood depth (m)	Sensitivity	Magnitude	Impact
				proposed drainage network reducing flows entering the existing combined storm systems.					
	C3	Residential properties – Bob Cooney Court	NJ 93275 07073	This residential building at chainage 1425 experience a maximum flood depth increase of 60mm due to water ponding at the western side of the building.	0.51	0.57	High	Moderate Adverse	Moderate Adverse
	C4	Residential properties – Berryden Mills	NJ 93335 07013	There is an increase in maximum flood depths at the residential properties on Berryden Mills due to a new flowpath across the road. There is a maximum increase in depth of approximately 300mm.	0.42	0.72	High	Major adverse	Large Adverse
	C5	Railway line 1	NJ 93415 06975	Both sections of railway line identified experience reduction in flood depths by 30mm and 80mm to the northern and southern section respectively.	2.20	2.17	Very high	Minor beneficial	Moderate Beneficial
	C6	Railway line 2	NJ 93551 06731		1.30	1.22	Very high	Moderate beneficial	Large Beneficial
	C7	Industrial premises – Enterprise Rent a Car	NJ 93442 06851	There are some isolated cells that fill with surface water which are likely due to model discrepancies in the way in which the hydraulic model processes the ground level data. The maximum depth identified is 20mm and therefore not considered a significant impact.	0.00	0.02	Medium	Minor Adverse	Slight Adverse
	C8	Industrial Premises – Speedy Depot	NJ 93529 06783	The industrial premises (ch. 1100) experience an increase in maximum flood depth of approximately 220mm as a result of new flowpaths spilling from the proposed road towards the buildings.	0.03	0.25	Medium	Major Adverse	Large Adverse

7

FLOOD RISK MITIGATION

7 FLOOD RISK MITIGATION

7.1.1. Although this assessment has identified that the project has had a beneficial impact on a number of key receptors along the proposed alignment, some locations are shown to be negatively impacted by the works. These locations are:

- A7 – Council outbuilding and associated car parking
- B1 – Berryden Retail Park – Car Park North
- B2 – Berryden Retail Park – Sainsbury' Supermarket
- B3 – Berryden Retail Park – Car Park South
- B5 – Berryden Retail Park – Units including Carphone Warehouse
- C3 – Residential property at Bob Clooney Court
- C4 – Residential property at Berryden Mills
- C7 – Industrial premises – Enterprise Rent a Car
- C8 – Industrial premises – Speedy Depot

7.1.2. To manage the localised increase of flood risk to key receptors, a number of mitigation measures have been proposed:

- Upsizing pipes of the proposed drainage network – to provide additional storage within the drainage network and reduce volumes of ponding water above ground, the pipe sizes were increased to provide additional storage capacity.
- Upsizing compensation ponds – to provide additional storage within the drainage network and reduce volumes of ponding water within the carriageway at the 1 in 200 year return period flood event with a suitable allowance for climate change; and
- Reinstatement and addition of walls / upstand - as a result of the road widening, various walls are proposed to be demolished which, if not replaced, would result in the introduction of new flow pathways diverting water to places where it originally could not flow. However, it has been proposed to reinstate boundary along sections of the road, which will prevent the flow of water towards sensitive receptors.

7.1.3. The proposed locations of the walls and upstands and details of the final drainage strategy are provided within Appendix D and Appendix E respectively.

7.1.4. The sequential test summarised in Section 3 of this report has not been applied to the surface water floodplains as the project does not result in a direct loss of floodplain. Rather the works result in a diversion of surface water flow pathways which have locally resulted in changes to local flow regime and sewer capacities, whether that be a beneficial or adverse impact. All mitigation measures have been proposed to manage the changes in flow paths and increase in ponding water from surface water runoff.

7.1.5. Table 7-1 summarises the risks with proposed mitigation measures to manage the increases in flood risk to key receptors based on the project.

7.1.6. Appendix E shows the flood depth maps of the project including the proposed mitigation measures for a range of return periods.

Table 7-1 - Project Corridor Receptors – With Project Scenario and with mitigation

Location	Receptor ID	Receptor Location	Sensitivity	No Mitigation		Proposed Mitigation	With Mitigation	
				Magnitude	Significance		Magnitude	Significance
Great Northern Road	A1	MOT centre	Medium	Moderate beneficial	Neutral	None	Major beneficial	Large beneficial
	A2	Railway line North	Very high	Minor beneficial	Moderate Beneficial	None	Minor beneficial	Moderate beneficial
	A3	Railway line South	Very high	Major beneficial	Very Large Beneficial	None	Major beneficial	Very large beneficial
	A4	Residential properties – Kittybrewster Square, Clifton Road and Picktillum Place	High	Minor beneficial	Slight Beneficial	None	Minor beneficial	Slight beneficial
	A5	Kittybrewster Retail Park	High	Negligible	Neutral	None	Negligible	Neutral
	A6	Aberdeen City Council Depot building	High	Negligible	Neutral	None	Negligible	Neutral
	A7	Outbuilding and associated car parking	Medium	Negligible	Neutral	It has been identified that there is an additional flow path diverting runoff from the new road alignment towards the ACC outbuilding and associated car parking. To account for this flow path, the capacity of the drainage network has been increased as a precautionary measure. The pipe sizes have increased locally from a maximum 375mm pipe to 450mm pipes. As a result, although the new flow path encourages runoff towards the building, there have been no recorded increases in depths and therefore no increase in magnitude of impact.	Negligible	Neutral
	A8	Police Station	Very high	Moderate Beneficial	Largely Beneficial	None	Moderate Beneficial	Largely Beneficial
Berryden Road	B1	Berryden Retail Park - Car Park North	Medium	Moderate Adverse	Moderate Adverse	Along the route of existing road alignment, there are a series of walls bounding the car park and road. As the walls are to be reinstated, flows remains within the carriageway and eliminate a flow pathway which prevents surface water from entering the car park. To account for additional flows	Moderate Adverse	Neutral

Location	Receptor ID	Receptor Location	Sensitivity	No Mitigation		Proposed Mitigation	With Mitigation	
				Magnitude	Significance		Magnitude	Significance
						remaining within the carriageway, pipe sizes have been locally increased from 375mm pipes to 450mm pipes.		
	B2	Berryden Retail Park – Sainsbury's Supermarket	Medium	Moderate Adverse	Moderate Adverse	Although there is a localised increase in depths to the north eastern corner of the supermarket building, further investigation of the modelled outputs indicates that the models triangulated mesh is resulting in varying ground models between the baseline model and the 'With Project' model. The 'With Project' model is not identifying a high point in the land which would prevent the new flowpath from forming resulting in the increase in depth. An assessment made of the volumes of water accumulating at the north east of the scheme indicates that there is an overall reduction in flood volume and therefore, no further mitigation measures are proposed.	Moderate Adverse	Neutral
	B3	Berryden Retail Park - Car Park South	Medium	Moderate Adverse	Moderate Adverse	Along the route of existing road alignment, there are a series of walls bounding the car park and road. As the walls are to be reinstated, flows remains within the carriageway and eliminate a flow pathway which prevents surface water from entering the car park. To account for additional flows remaining within the carriageway, pipe sizes have been locally increased from 375mm pipes to 450mm pipes.	Moderate Adverse	Neutral
	B4	Berryden Retail Park – 'Matalan'	Medium	Negligible	Neutral	None	Negligible	Neutral
	B5	Berryden Retail Park – Retails Units including Carphone Warehouse	Medium	Negligible	Neutral	None	Negligible	Neutral
	B6	Railway line	Very high	Negligible	Neutral	None	Negligible	Neutral
	B7	Residential Properties – Laurelwood Avenue	High	Moderate Beneficial	Moderate Beneficial	None	Moderate Beneficial	Moderate Beneficial
	B8	Residential Properties – Holland Street	High	Negligible	Neutral	None	Negligible	Neutral

Location	Receptor ID	Receptor Location	Sensitivity	No Mitigation		Proposed Mitigation	With Mitigation	
				Magnitude	Significance		Magnitude	Significance
Skene Square	C1	Royal Cornhill Hospital	Very high	Minor Beneficial	Moderate Beneficial	None	Minor Beneficial	Moderate Beneficial
	C2	Residential properties – Fraser Road	Very high	Minor Beneficial	Moderate Beneficial	None	Minor Beneficial	Moderate Beneficial
	C3	Residential properties – Bob Cooney Court	High	Moderate Adverse	Moderate Adverse	Upon assessment of the flood depths and extents in this location, it was identified that surface water was ponding as a result of a 'false blockage' where there is a pend to allow vehicular and pedestrian access to the rear of the courtyard of the property. This is a false representation of ponding water and in reality, runoff will be allowed to flow freely through this section and therefore, no ponding of water will occur. The magnitude has therefore been reduced to negligible to reflect this resulting in a neutral impact.	Negligible	Neutral
	C4	Residential properties – Berryden Mills	High	Major adverse	Large Adverse	There is a small accumulation of surface water ponding at an isolated corner of the property. On the whole, water levels reduce. The isolated area of increased depth results from a small flow path from the proposed road alignment to the northern corner of the building. A 60mm increase in kerb or embankment would eliminate this flow path, keep flows within the road and prevent the local increase in flood depth. This minor adjustment would reduce the magnitude from 'Major Adverse' to 'Negligible'.	Negligible	Neutral
	C5	Railway line 1	Very high	Minor beneficial	Moderate Beneficial	None	Minor beneficial	Moderate Beneficial
	C6	Railway line 2	Very high	Moderate beneficial	Large Beneficial	None	Moderate beneficial	Large Beneficial
	C7	Industrial premises – Enterprise Rent a Car	Medium	Minor Adverse	Slight Adverse	Upon investigation of the flood depths and extents at this location, it was identified that there was one cell showing a flood depth adjacent to the building with no direct flow pathway impacting on the building. The maximum depth of flooding was also identified as 20mm which is likely below the threshold of the property. Therefore, no additional mitigation has been proposed and the magnitude has been reduced to 'Negligible' to reflect this.	Negligible	Neutral

Location	Receptor ID	Receptor Location	Sensitivity	No Mitigation		Proposed Mitigation	With Mitigation	
				Magnitude	Significance		Magnitude	Significance
	C8	Industrial Premises – Speedy Depot	Medium	Major Adverse	Large Adverse	That there is a small wall approximately 600mm in height bounding the property and the proposed road alignment. This wall has not been modelled or represented within the DTM. The location of this walls and the small water depths (250mm) lower than the wall height indicate that the surface water runoff would diverted away from the property and remain with the road. In addition, gulley's are not represented within the modelling which would likely mitigate such small volumes of water within the drainage network. This could be further refined at detailed design within a suitable drainage design in the local area. Consequently, no additional mitigation measures have been proposed and the magnitude has been reduced to 'Negligible'.	Negligible	Neutral

AVERAGE CHANGE IN FLOOD VOLUMES

7.1.9. Table 7-2 summarises the changes in maximum volume capacity at key receptors for a range of key return periods. The assessment has been made within a 10m buffer surrounding the receptors and an overall assessment of total volume difference has been made for each receptor.

Table 7-2 - Changes in Maximum Volume

Location	Receptor ID	Receptor Location	Sensitivity	Change in Maximum Volume (m^3 (%))		
				1 in 30 event	1 in 200 event	1 in 200 event +CC
Great Northern Road	A1	MOT centre	Medium	-31 (-100%)	-49 (-92%)	-41 (-63%)
	A2	Railway line North	Very high	-4 (-29%)	-97 (-46%)	-122 (-32%)
	A3	Railway line South	Very high	-44 (-57%)	-51 (-22%)	-33 (-12%)
	A4	Residential properties – Kittybrewster Square, Clifton Road and Picktillum Place	High	-1 (-2%)	0 (0%)	2 (2%)
	A5	Kittybrewster Retail Park	High	11 (28%)	-28 (-14%)	-53 (-17%)
	A6	Aberdeen City Council Depot building	High	7 (19%)	3 (2%)	9 (3%)
	A7	Outbuilding and associated car parking	Medium	24 (73%)	23 (21%)	37 (26%)
	A8	Police Station	Very high	-11 (-100%)	-122 (-82%)	-115 (-39%)
Berryden Road	B1	Berryden Retail Park - Car Park North	Medium	0 (0%)	0 (0%)	0 (0%)
	B2	Berryden Retail Park – Sainsbury's Supermarket	Medium	0 (0%)	0 (0%)	-11 (-34%)

Location	Receptor ID	Receptor Location	Sensitivity	Change in Maximum Volume (m^3 (%))		
				1 in 30 event	1 in 200 event	1 in 200 event +CC
	B3	Berryden Retail Park - Car Park South	Medium	-1 (-3%)	-18 (-20%)	-52 (-32%)
	B4	Berryden Retail Park – 'Matalan'	Medium	-2 (-2%)	-5 (-3%)	-35 (-10%)
	B5	Berryden Retail Park – Retails Units including Carphone Warehouse	Medium	6 (5%)	-1 (0%)	-44 (-4%)
	B6	Railway line	Very high	-2 (-1%)	-4 (-2%)	-1 (0%)
	B7	Residential Properties – Laurelwood Avenue	High	0 (0%)	-3 (-8%)	-3 (-4%)
	B8	Residential Properties – Holland Street	High	-32 (-7%)	-7 (-1%)	-26 (-3%)
Skene Square	C1	Royal Cornhill Hospital	Very high	-34 (-6%)	-33 (-2%)	-176 (-4%)
	C2	Residential properties – Fraser Road	Very high	-82 (-23%)	-330 (-20%)	-171 (-6%)
	C3	Residential properties – Bob Cooney Court	High	5 (500%)	-11 (-10%)	-8 (-5%)
	C4	Residential properties – Berryden Mills	High	0 (0%)	-36 (-42%)	-31 (-19%)
	C5	Railway line 1	Very high	Refer to section 7.1.16	-27 (-3%)	-63 (-6%)
	C6	Railway line 2	Very high	-4 (-100%)	-13 (-18%)	-34 (-16%)

Location	Receptor ID	Receptor Location	Sensitivity	Change in Maximum Volume (m^3 (%))		
				1 in 30 event	1 in 200 event	1 in 200 event +CC
	C7	Industrial premises – Enterprise Rent a Car	Medium	0 (0%)	0 (0%)	1
	C8	Industrial Premises – Speedy Depot	Medium	0 (0%)	4 (200%)	13 (144%)
TOTAL CHANGE IN VOLUME				-195 (-13%)	-805 (-11%)	-957 (-7%)

7.1.10. The assessment indicates that there is an overall reduction in flood levels at key receptors – the exception being at receptor C5, where there is a volume increase at lower return periods which is discussed later in the report. This is as a consequence of a number of flow pathways being entirely eliminated, such as flow paths from the Great Northern Road, and an increase in capacity of the proposed drainage network based on the drainage strategy undertaken by WSP. This includes significant reductions at very sensitive receptors such as the railway line, residential and commercial properties and the Royal Cornhill Hospital.

7.1.11. Model discrepancies due to the ground model triangulation process results in discrepancies in ground levels between the baseline and with project scenarios. This explains small changes in volumes between the scenarios however, where larger changes occur, a more detailed assessment of the changes has been undertaken. The following sections summarise the residual flood risk at each of the receptors that experience a negative impact.

A6 – Aberdeen City Council Depot

7.1.12. The proposed detention basin to compensate additional surface water flows has been modelled has a one-dimensional element, which means that surface water runoff that flows across the pond within the 2D element of the model is not collected by the pond (as the pond levels are not included within the underlying ground model).

7.1.13. The results show that the time at which the flood volume around the depot building reaches its maximum is at hour 12:15:00, fifteen minutes after the peak rainfall occurs. At this equivalent time, the total storage capacity within the detention basin 420m^3. Therefore, overland flow towards the depot building will be attenuated within the detention basin and therefore storing the far in excess of the increased flood volumes recorded at the depot.

A7 – Aberdeen City Council Storage Building

7.1.14. The proposed detention basin to compensate additional surface water flows has been modelled has a one-dimensional element, which means that surface water runoff that flows across the pond within the 2D element of the model is not collected by the pond (as the pond levels are not included within the underlying ground model).

7.1.15. The results show that the time at which the flood volume around the depot building reaches its maximum is at hour 12:15:00, fifteen minutes after the peak rainfall occurs. At this equivalent time, the total storage capacity within the detention basin 420m^3. Therefore, overland flow towards the depot building will be attenuated within the detention basin and therefore storing the far in excess of the increased flood volumes recorded at the depot.

C5 – Railway Line

7.1.16. There are significant differences in flood volumes calculated at the 1 in 30 year return period at the railway line at receptor C7. There is a total increase in over 500m^3 volume at the 30 year return period and investigation of the ground model in this location indicates that there are discrepancies in the triangulated ground levels assigned to the baseline model and the 'with project' model.

7.1.17. The difference in flood volume is limited of the 30 year return period and therefore, the change is understood to be a limitation in the way in which the hydraulic model generates the ground model to represent the ground levels. In the baseline model, the triangulated mesh identified the railway line as the ground level however, in the proposed model, it identified the top of the railway embankment as the ground level. This is a limitation in the way in which InfoWorks undertakes triangulation of the mesh and has resulted in water ponding falsely on the railway and is not reflective of reality.

7.1.18. At the 1 in 200 and 1 in 200 year with climate change return period, there is a positive impact on this receptor with a total reduction in maximum depths and volumes.

C8 – Speedy Depot

7.1.19. There is a boundary wall approximately 600mm in height located between the proposed road and the Speedy Depot building. These walls are not identified within the DTM due to the resolution of the ground model.

7.1.20. The location of the walls and the small water depths (maximum 250mm) at this area suggest that the runoff would be intercepted, and flows would not reach the western side of the property and diverted away from the building.

7.1.21. At the entrance to the Speedy Depot, accumulations of water would be managed by the local drainage network and intercepted by gully's which are not represented within the hydraulic model.

8

DRAINAGE IMPACT ASSESSMENT

8 DRAINAGE IMPACT ASSESSMENT

8.1 ASSESSMENT CRITERIA

8.1.1. To identify and assess any detriment to the network performance caused the proposed developments the following criteria are considered:

- Flood volumes at manholes upstream and downstream of the development.
- Flood volumes at sites where flooding has been historically reported or confirmed.
- Spill frequency and volume at Combined Sewer Overflows (CSO) affected upstream and downstream of the development.

8.2 METHODOLOGY

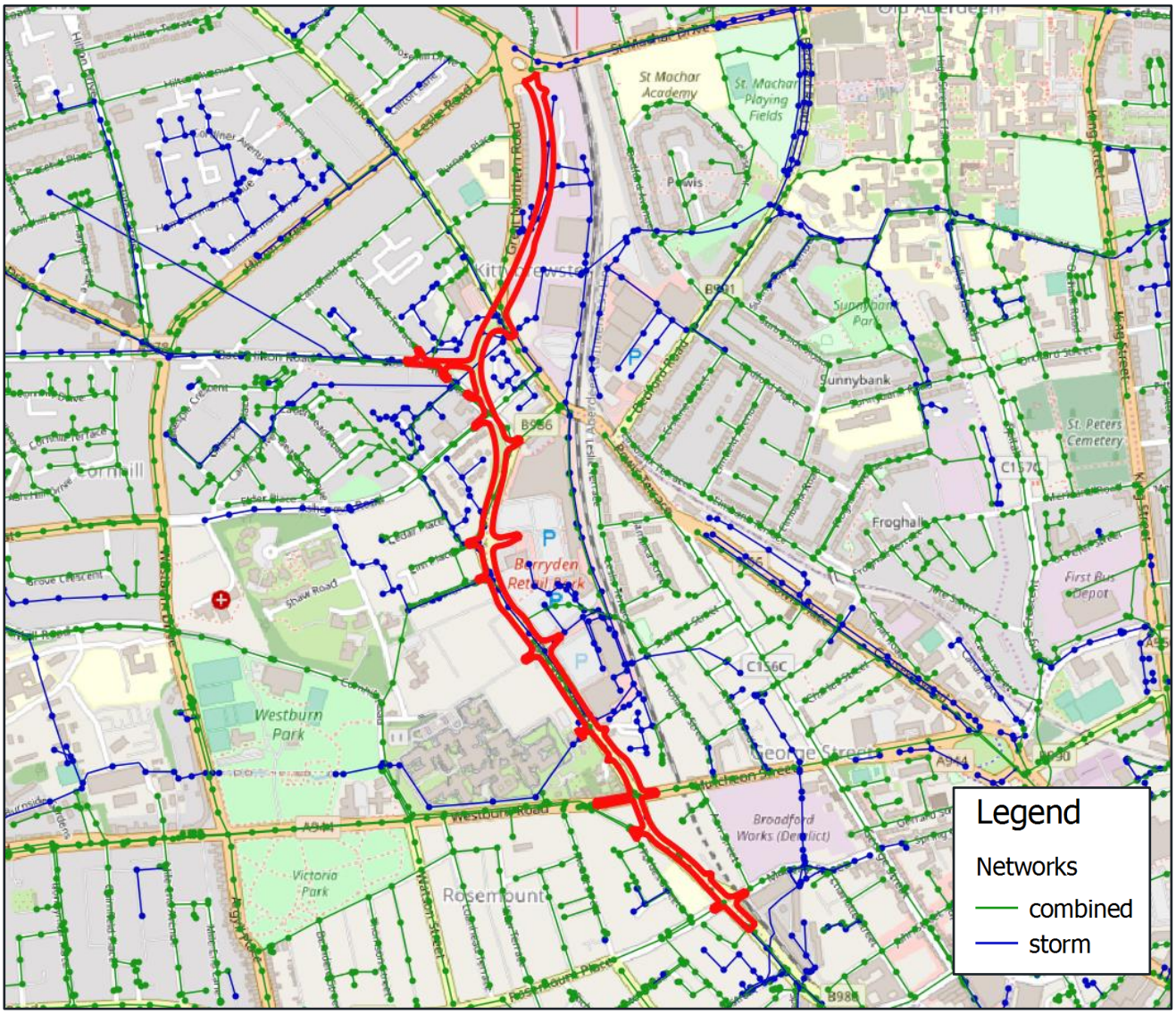
8.2.1. The methodology adopted to undertake this DIA is summarised below:

- Calculate flows from the proposed road and include them in the ‘developed model’ scenario.
- Using the model with the proposed road, re-run the critical duration storms and recalculate the CSO spill frequencies and flood volumes downstream of the proposed development.
- Compare the results of the ‘baseline’ model and the ‘With Mitigation’ model with the proposed road and establish if network performance, in terms of flood volumes, CSO spill frequencies and volumes and pass forward flow before CSO spillages (Formula A assessment).

8.3 EXISTING SYSTEM

8.3.1. The existing system in the locality of the project is shown in Figure 8-1 below.

Figure 8-1 - Sewer networks (Proposed alignment in red)



SITE DETAILS

8.3.2. Table 8-1 below provides an overview of the proposed site.

Table 8-1 - Site Details

Size	4.43 ha
Location	Aberdeen
Topography	Proposed site slopes from north west to south east

Current usage	The project extents currently consist of a number of roads and other spaces, including Skene Square, Caroline Place, Berryden Road, Great Northern Road and also grassed areas at the northern sections.
Sewerage connection details	The project will be connected to manholes associated to the subcatchments summarised in the Appendix F.

INTERMITTENT DISCHARGE IMPACTED BY PROPOSED DEVELOPMENT

8.3.3. An assessment has been undertaken of all CSOs and EOs that may be impacted. The locations of the CSOs have been sourced from the Aberdeen sewered area model, STW Reference STW001543.

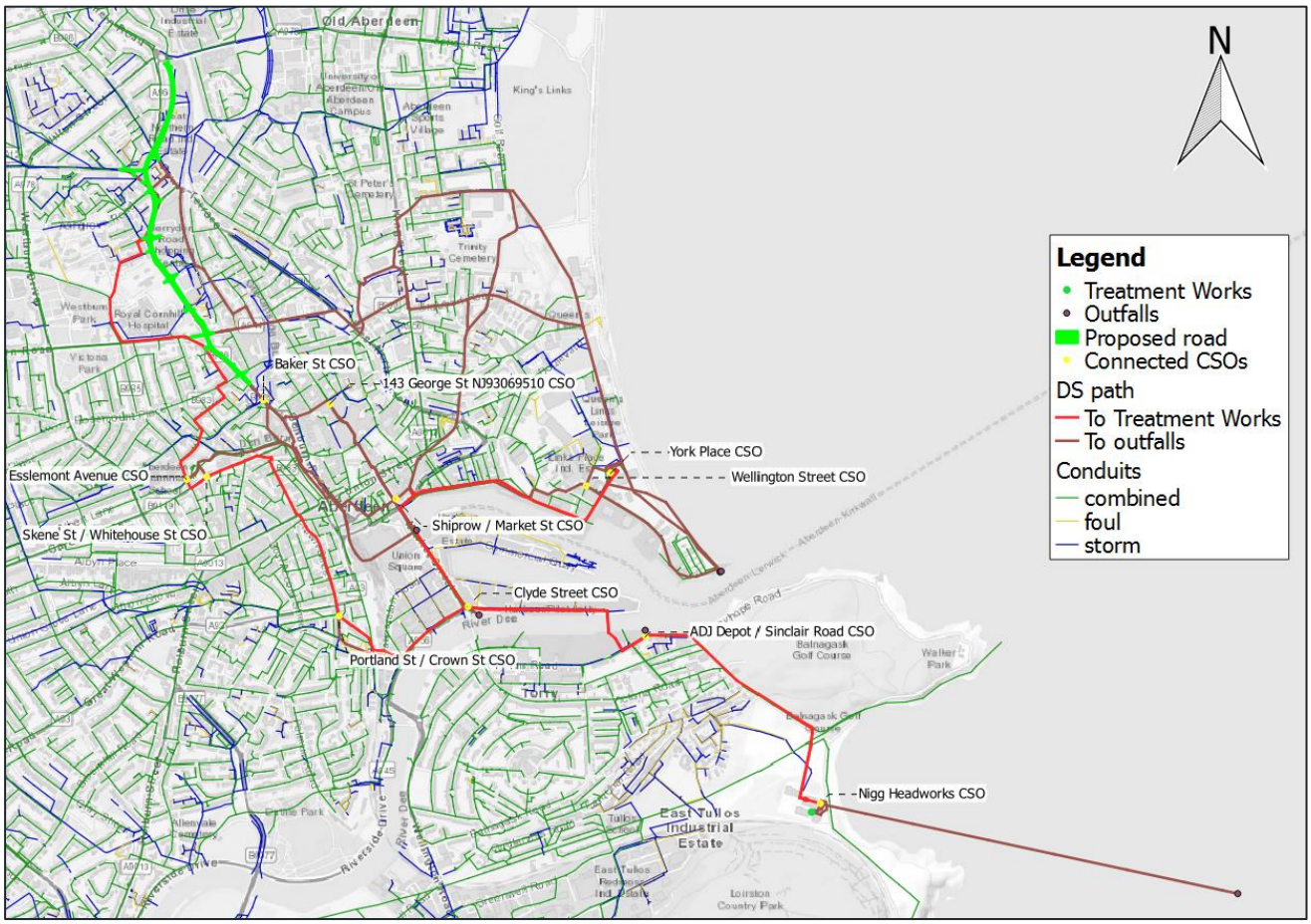
8.3.4. The CSOs located in the downstream path are summarise in Table 8-2 below and their respective location is shown in Figure 8-2 - CSOs locations. In addition to the CSOs mentioned below, two overflow connections from the combined system to the surface water system have been identified: NJ930772102 and NJ93070804. However, these overflows are controlled by sluices that have been identified as closed and not currently operational and therefore have not been included in the assessment.

Table 8-2 - Intermittent Discharges – DAS Model

Intermittent Discharges	No.	CSOs (Link Reference)
D/S of project – including branches (potentially impacted by development)	11	Aberdeen, Gilcomston Steps / Baker St CSO (NJ93066613.2) Aberdeen, 143 George St NJ93069510 CSO (NJ93069509.2) Aberdeen, Shiprow / Market St CSO (NJ94062108.2) Aberdeen, Clyde Street CSO (NJ94056507.3) Aberdeen, York Place CSO (NJ95063202_PENSTOCK No.16.1 & NJ95063202_PENSTOCK No.15.1) Wellington Street CSO (NJ95062108.1) Aberdeen, ADJ Depot / Sinclair Road CSO (NJ95055402.2) Nigg, Nigg Headworks CSO (Nigg DWF Channel1.2) Aberdeen, 2 Esslemont Avenue CSO (NJ93062204.2)

Intermittent Discharges	No.	CSOs (Link Reference)
		Aberdeen, Skene St / Whitehouse St CSO (NJ93063201.2) Aberdeen, Portland St / Crown St CSO (NJ94050505.2)

Figure 8-2 - CSOs locations



8.4 BASELINE & DEVELOPED SYSTEM AMENDMENTS

8.4.1. The project scheme will extend across a surface of approximately 4.43 ha. The new road will cover existing paved areas and roughly 2.99 ha of existing permeable areas. This expansion in permeable area will cause an increase of flows in the storm and combined sewer networks.

8.4.2. A breakdown of the additional road surface in each modelled subcatchment is contained in the Appendix F.

8.5 ASSESSMENT – EXISTING / DEVELOPED COMPARISONS

FLOODING ASSESSMENT

8.5.1. A range of 30-year (winter and summer) storms were simulated on Baseline v Future (with mitigation) scenarios. The results were then compared to assess the impact of the project.

8.5.2. Table 8-3 below summarises the locations where flood increases were predicted downstream of the full development..

Table 8-3 – Impacted manholes - Comparative Hydraulic Analysis for Proposed Scenario with Mitigation (200-Year Return + Climate Change – Summer)

Node ID	Volumes (m^3)		
	Baseline	Proposed	Difference
NJ93072211	194.7	256.3	61.6
NJ93073205	17328.2	17344.5	16.3
NJ93071301	0.0	13.1	13.1

8.5.3. The flood volume increase observed at manholes NJ93072211 and NJ93071301 is a consequence of 200m^3 of additional overland flow entering the combined system. The flood volume increase observed at manholes NJ93072211 and NJ93071301 is a consequence of 200m3 of additional overland flow entering the combined system. The modelled network only accepts flows through manholes nodes as gullies are not represented within the model. In reality, the overland flows would be intercepted by gullies associated with the new drainage network which will collect overland flows into a new pipe system and not to these manholes.

8.5.4. The flood volume increase experienced at the manhole NJ93073205 is approximately 0.1% in volume. This can be attributed to slight instabilities of the model.

8.5.5. Potential solutions to neutralise the flood increase at these manholes include:

- Online storage by upsizing pipes. This solution could easily be adopted for the manholes NJ93073205 and NJ93071301, where volume increase is relatively small.

8.5.6. Storages solutions such as underground tanks or SuDS ponds that can contain the excess flood volumes Table 8-4 summarises the manholes that experience flood increase but these increases are compensated by flood reduction in manholes upstream or downstream. As a result, there will be no negative impacts on the SAC at the River Dee as overall, there is an overall reduction in flooding.

Table 8-4 – Localised flood increase - Comparative Hydraulic Analysis for Proposed Scenario with Mitigation (200-Year Return + Climate Change – Summer)

Node ID	Volumes (m^3)			Comments
	Baseline	Proposed	Difference	
NJ93072010	124.2	1262.4	1138.2	Manholes US experience benefits. Total flooding decreases by 70m^3

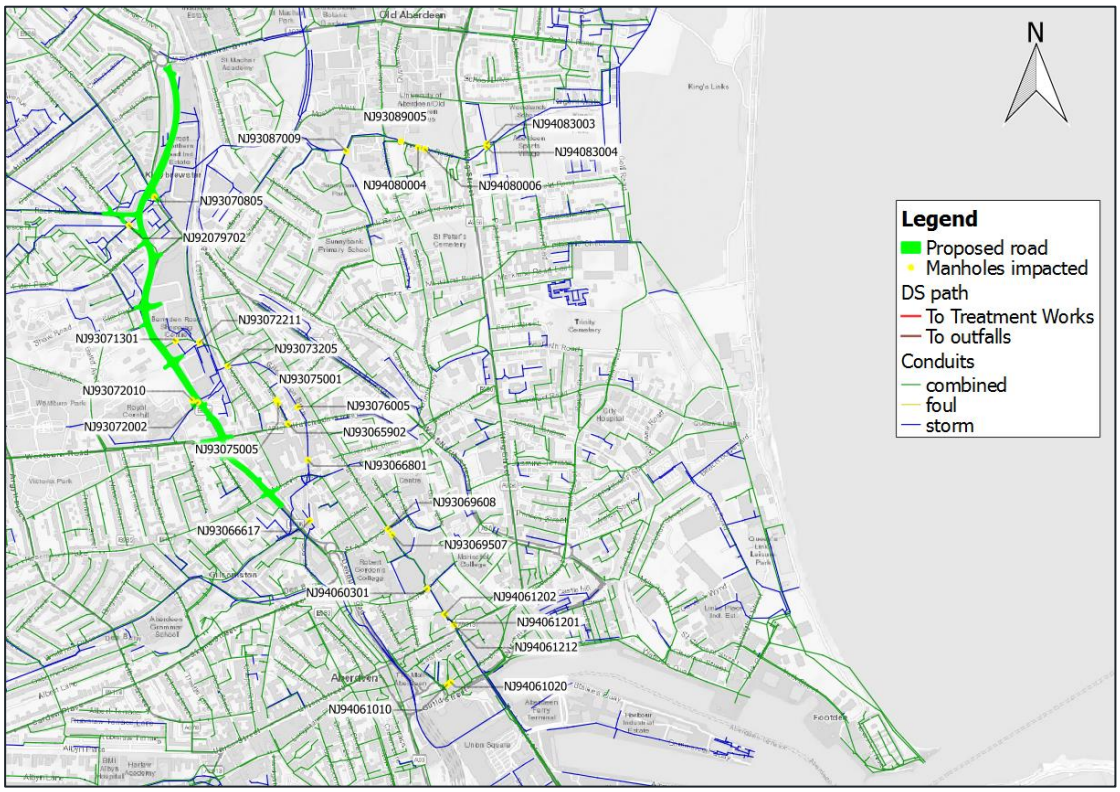
Node ID	Volumes (m^3)			Comments
	Baseline	Proposed	Difference	
NJ93066617	335	640.7	305.7	Manholes US experience benefits. Total flooding decreases by 2900m^3
NJ94061201	92.1	352.1	260	Manholes US experience benefits. Total flooding decreases by 1900m^3
NJ94061202	388.2	595.7	207.5	Manholes US experience benefits. Total flooding decreases by 1400m^3
NJ94083003	3819.9	4000.7	180.8	Manholes US and DS experience benefits. Total flooding decreases by 200m^3
NJ93069608	2921.8	3056	134.2	Manholes US experience benefits. Total flooding decreases by 900m^3
NJ93065902	13632.8	13763.6	130.8	Manholes US experience benefits. Total flooding decreases by 600m^3
NJ93070805	0.0	123.3	123.3	Manholes US and DS experience benefits. Total flooding decreases by 80m^3
NJ94061010	6173.2	6292.5	119.3	Manholes US and DS experience benefits. Total flooding decreases by 100m^3
NJ93075005	6567.6	6648.4	80.8	Manholes US and DS experience benefits. Total flooding decreases by 80m^3
NJ93075001	1244.1	1317.4	73.3	Manholes US and DS experience benefits. Total flooding decreases by 80m^3
NJ93087009	3747.1	3801.8	54.7	Manholes US and DS experience benefits. Total flooding decreases by 200m^3
NJ94060301	464.4	514.6	50.2	Manholes US and DS experience benefits. Total flooding decreases 1600m^3
NJ93089005	3554.9	3599.2	44.3	Manholes US and DS experience benefits. Total flooding decreases by 900m^3
NJ94080006	1562.7	1591	28.3	Manholes US and DS experience benefits. Total flooding decreases by 900m^3
NJ94080004	3230.4	3256.9	26.5	Manholes US and DS experience benefits. Total flooding decreases by 900m^3
NJ94061020	3547.6	3570.3	22.7	Manholes US and DS experience benefits. Total flooding volume does not change
NJ93069507	160.8	182.9	22.1	Manholes US and DS experience benefits. Total flooding volume is reduced by 500 m^3

Node ID	Volumes (m^3)			Comments
	Baseline	Proposed	Difference	
NJ94061212	2278	2294.9	16.9	Manholes US experience benefits. Total flooding decreases by 1300m^3
NJ94083004	418.8	423	4.2	Manholes US and DS experience benefits. Total flooding decreases by 200m^3
NJ93066801	54.6	58.6	4	Manholes US and DS experience benefits. Total flooding decreases by 400m^3
NJ93072002	12.2	14.9	2.7	Manholes US and DS experience benefits. Total flooding decreases by 40m^3
NJ93076005	25.2	27.9	2.7	Manholes US and DS experience benefits. Total flooding decreases by 1100m^3
NJ92079702	154	156.3	2.3	Manholes US and DS experience benefits. Total flooding decreases by 10m^3

8.5.7.

8.5.8. Figure 8-3 indicates the location of the impacted manholes.

Figure 8-3 - Overview of Flood Change Locations in Relation to Proposed Development



CSO SPILL FREQUENCY AND VOLUME ASSESSMENT

8.5.9. The CSO assessment was undertaken using a 'Typical Year' Time Series Rainfall (TSR) set of 197 events provided by SW.

8.5.10. Table 8.5 summarises the CSOs with a change in spill volume or frequency downstream of the project.

Table 8-5 - CSO Comparative Assessment for the Proposed Development

Overflow name or Location	Overflow ID (CSO/ EO Spill Link)	Annual Totals					
		Existing Scenario		With Proposed Development		Differences	
		Spills (>50 m³)	Spill Volume (m³)	Spills (>50 m³)	Spill Volume (m³)	Volume (m³)	%
Aberdeen, Gilcomston Steps / Baker St CSO	NJ93066613.2	3	373	3	341	-32	-8.59%
Aberdeen, 143 George St NJ93069510 CSO	NJ93069509.2	26	27194	26	26299	-895	-3.29%
Aberdeen, Shiprow / Market St CSO	NJ94062108.2	51	316877	51	316508	-370	-0.12%

Overflow name or Location	Overflow ID (CSO/ EO Spill Link)	Annual Totals					
		Existing Scenario		With Proposed Development		Differences	
		Spills (>50 m³)	Spill Volume (m³)	Spills (>50 m³)	Spill Volume (m³)	Volume (m³)	%
Aberdeen, Clyde Street CSO	NJ94056507.3	6	4095	6	4032	-63	-1.55%
Aberdeen, York Place CSO	NJ95063202_PENSTOCK No.15.1	35	80087	34	79642	-445	-0.56%
Aberdeen, York Place CSO	NJ95063202_PENSTOCK No.16.1	0	180	0	157	-23	-12.82%
Wellington Street CSO	NJ95062108.1	3	322	3	318	-4	-1.19%
Aberdeen, ADJ Depot / Sinclair Road CSO	NJ95055402.2	12	12254	12	12604	351	2.86%
Nigg, Nigg Headworks CSO	Nigg DWF Channel1.2	92	2892629	92	2883287	-9342	-0.32%
Aberdeen, 2 Esslemont Avenue CSO	NJ93062204.2	47	107896	47	107151	-745	-0.69%
Aberdeen, SkenE St / Whitehouse St CSO	NJ93063201.2	65	84161	65	83969	-192	-0.23%
Aberdeen, Portland St / Crown St CSO	NJ94050505.2	0	77	0	77	0	0.40%

Note

1. Spill frequency results are presented such that spills which commence within 6 hours of the previous spill finishing are considered to be a single spill.
2. Due to MS Excel rounding errors comparative results may show ± 1 m^3 errors.

FORMULA "A" AND CSO SETTING ASSESSMENT

8.5.11. Formula A refers to the flow that needs to undergo to primary treatment and all sewage up to the 3DWF (Dry Weather Flow) flow needs to undergo full treatment.

8.5.12. In order for a CSO to pass the Setting Assessment its Setting flow (minimum flow passed forward from a CSO during a spill) must be larger than the Formula A flow.

The calculation of Formula 'A' and the CSO settings for those **directly downstream** is summarised in

Table 8-6.

Table 8-6 - Formula 'A' Assessment

Overflow Name or location	Setting (l/s)	Existing Baseline		With Proposed Development	
		Formula 'A' (l/s)	Passes Formula 'A'	Formula 'A' (l/s)	Passes Formula 'A'
Aberdeen, Gilcomston Steps / Baker St CSO	102.95	62.65	Yes	62.65	Yes
Aberdeen, 143 George St NJ93069510 CSO	-15.74	95.64	No	95.64	No
Aberdeen, Shiprow / Market St CSO	-815.9	138.78	No	138.78	No
Aberdeen, Clyde Street CSO	1162.36	1715.17	No	1715.17	No
Aberdeen, York Place CSO (NJ95063202_PENSTOCK No.16.1)	198	1375.04	No	1375.04	No
Aberdeen, York Place CSO (NJ95063202_PENSTOCK No.15.1)	198	1375.04	No	1375.04	No
Wellington Street CSO	198	1345.32	No	1345.32	No
Aberdeen, ADJ Depot / Sinclair Road CSO	1131.38	1825.13	No	1825.13	No
Nigg, Nigg Headworks CSO	1450	2983.68	No	2983.68	No
Aberdeen, 2 Esslemont Avenue CSO	415	333.64	Yes	333.64	Yes
Aberdeen, Skene St / Whitehouse St CSO	406.69	407.51	No	407.51	No
Aberdeen, Portland St / Crown St CSO	1256.07	474.15	Yes	474.15	Yes

PASS FORWARD TO TREATMENT WORKS

8.5.13. The 'Pass Forward' assessment was undertaken using a set of 197 'Typical Year' TSR events provided by SW.

8.5.14. Table 8-7 shows the comparative summary of pass forward flow to the WwTW.

Table 8-7 - Pass Forward WwTW Inlet

WwTW	Annual Totals			
	Existing Scenario	With Proposed Development	Difference	
	Pass Forward (m^3)	Pass Forward (m^3)	Volume (m^3)	%
Nigg Treatment	96,231,633	96,230,828	-805	0.00%

Note

1. Due to Ms Excel rounding error comparative results may show ± 1 m^3 errors.

8.6 NETWORK PERFORMANCE ASSESSMENT

8.6.1. The following can be concluded from the results:

- 200-year plus Climate Change storms were simulated for the Aberdeen model. Flood increases for the full development were predicted at nodes: NJ93072211, NJ93073205 and NJ93071301. Other manholes that although experience flood increase locally, total flood volumes decrease upstream and downstream are: NJ93072010, NJ93066617, NJ94061201, NJ94061202, NJ94083003, NJ93069608, NJ93065902, NJ93070805, NJ94061010, NJ93075005, NJ93075001, NJ93087009, NJ94060301, NJ93089005, NJ94080006, NJ94080004, NJ94061020, NJ93069507, NJ94061212, NJ94083004, NJ93066801, NJ93072002, NJ93076005 and NJ92079702.

- Following a 'typical year' analysis of CSO spill performance the model predicts annual volumetric changes of:
  - Aberdeen, Gilcomston Steps / Baker St CSO - **(-32 m^3 (-8.59%))**
  - Aberdeen, 143 George St NJ93069510 CSO - **(-895 m^3 (-3.29%))**
  - Aberdeen, Shiprow / Market St CSO - **(-370 m^3 (-0.12%))**
  - Aberdeen, Clyde Street CSO - **(-63 m^3 (-1.55%))**
  - Aberdeen, York Place CSO (NJ95063202_PENSTOCK No.15.1) - **(-445 m^3 (-8.59%))**
  - Aberdeen, York Place CSO (NJ95063202_PENSTOCK No.16.1) - **(-23 m^3 (-12.82%))**
  - Wellington Street CSO - **(-4 m^3 (-1.19%))**
  - Aberdeen, ADJ Depot / Sinclair Road CSO - **(351 m^3 (2.86%))**
  - Nigg, Nigg Headworks CSO - **(-9342 m^3 (-0.32%))**
  - Aberdeen, 2 Esslemont Avenue CSO - **(-745 m^3 (-0.69%))**
  - Aberdeen, SkenE St / Whitehouse St CSO - **(-192 m^3 (-0.23%))**
  - Aberdeen, Portland St / Crown St CSO - **(-0 m^3 (0.40%))**

- Aberdeen, Clyde Street CSO, Aberdeen, York Place CSO (NJ95063202_PENSTOCK No.16.1), Aberdeen, York Place CSO (NJ95063202_PENSTOCK No.15.1), Wellington Street CSO, Aberdeen, ADJ Depot / Sinclair Road CSO, Nigg, Nigg Headworks CSO, Aberdeen, Skene St / Whitehouse St CSO are predicted to fail both pre-development and post-development in the Formula 'A' assessment.

Consequently, due to the overall reduction in total discharges at the CSO's, there will be no adverse impacts to the SAC at the River Dee resulting from the Project,

9 CONCLUSIONS

9.1.1. The widening of the existing road between Skene Square and Ashgrove Road and the construction of a new section of road between Ashgrove Road and Kittybrewster roundabout, will have an effect in the surface runoff at the site as a consequence of increasing impervious surfaces.

9.1.2. An InfoWorks ICM hydraulic model has been developed aims to identify those areas that experience increases in flood depth. In order to provide an accurate representation of the site, features such as ground model (DTM 1m), sewer networks, roads, walls and buildings have been modelled to represent flowpath and areas where water accumulates. The model has been run for a full range of return periods (2, 10, 20, 30, 50, 100, 200, 200 plus climate change) where 24 areas at potential flooding increase were identified.

9.1.3. A hydraulic model with the Project in place including an additional drainage network and compensation ponds was built and run for the same storms. The results were subsequently compared to the baseline model. Out of the 24 receptors identified, the project impacted positively 16 receptors at the 200 plus climate change return period, two were not impacted in any significant way and five experienced detriments.

9.1.4. A series of measures were developed to mitigate the negative impacts, eliminate new flowpaths and optimise the storage provided by the compensation ponds. The mitigation measures included:

- Upsize of pipes of the new drainage system
- Upsize of the proposed compensation ponds
- Construction of walls on the sides of the proposed road.

9.1.5. The results of the proposed model “with mitigation” revealed that eight of the 24 receptors are impacted positively from the proposed development, seven of them are not impacted in any significant way and nine receptors experience negative impacts.

9.1.6. With mitigation, nine properties / receptors are shown to be negatively impacted, however further assessment indicates the changes are due to model discrepancies and failure of the DTM to pick up key ground features rather than as a predicted result of the implementation of the Project.

9.1.7. Considering all of this, it can be determined that the project, with the mitigation measures, results in an overall benefit to the key receptors at risk of flooding. For the 1 in 200 year return period flood event with a 35% allowance for climate change, there is a total reduction in flood volume of over 900 m^3.

9.1.8. The manholes NJ93072211 and NJ9307130 experience an impact caused by the widening of the existing road. The hydraulic model does not represent gullies and only accepts flows through manholes. In reality flows would enter gullies and be accepted by a new drainage network rather than to the manholes.

9.1.9. The flood volume increase experienced at the manhole NJ93073205 can be considered acceptable on the basis that the percentage increments smaller than 1% can be attributed to slight instabilities of the model. Surrounding manholes experience a reduction in volume and therefore there is an overall improvement in the network.

9.1.10. The CSOs *ADJ Depot / Sinclair Road CSO* and *Portland St / Crown St CSO* experience increase in volumes of water spilled. These increases are compensated by an overall reduction in volume

spilled by the manholes downstream of the Project, and therefore the impact is negligible. Therefore, there will be no negative impacts on the SAC at the river Dee as a result of the Project.

9.1.11.

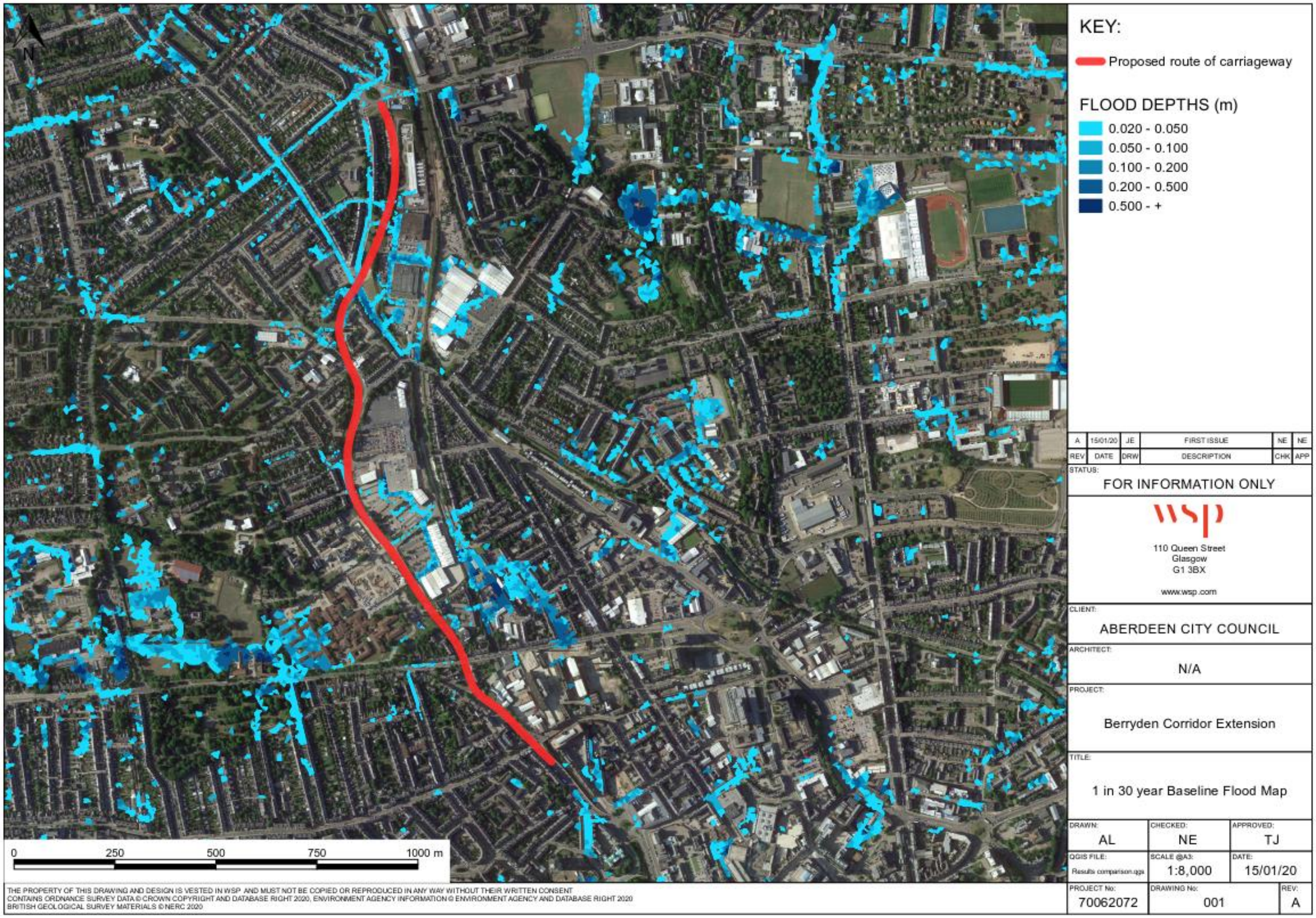
10 REFERENCES

Osborne, M. (2012). Design storms – have we been getting it wrong all this time? *WaPUG Spring Conference.* Mouchel.

Scottish Environment Protection Agency. (2019). Climate change allowances for flood risk assessment in land use planning. 9.

Appendix A

BASELINE FLOOD DEPTH MAPS



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Proposed route of carriageway

FLOOD DEPTHS (m)

- 0.020 - 0.050
- 0.050 - 0.100
- 0.100 - 0.200
- 0.200 - 0.500
- 0.500 - +

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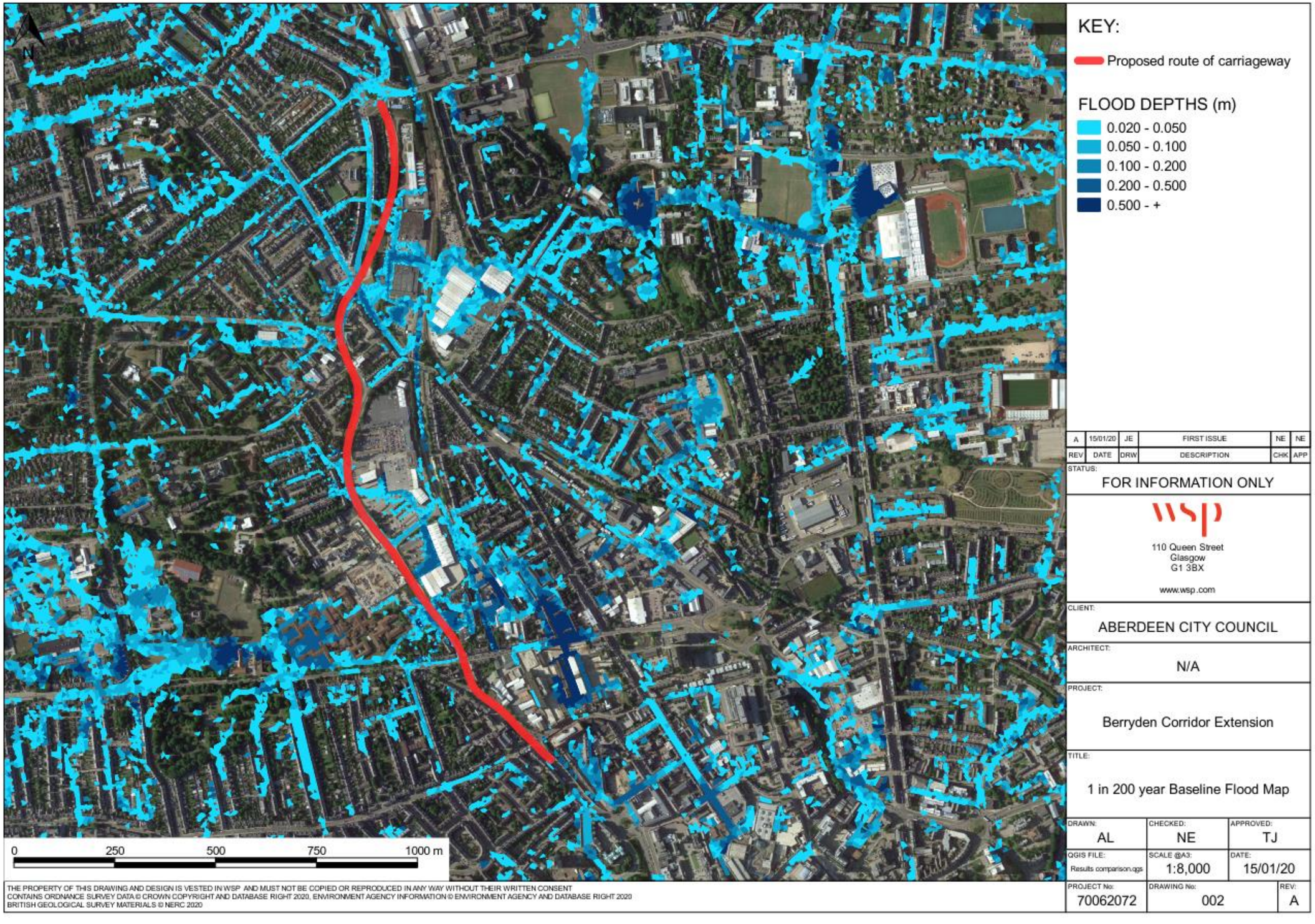

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- 0.100 - 0.200
- 0.200 - 0.500
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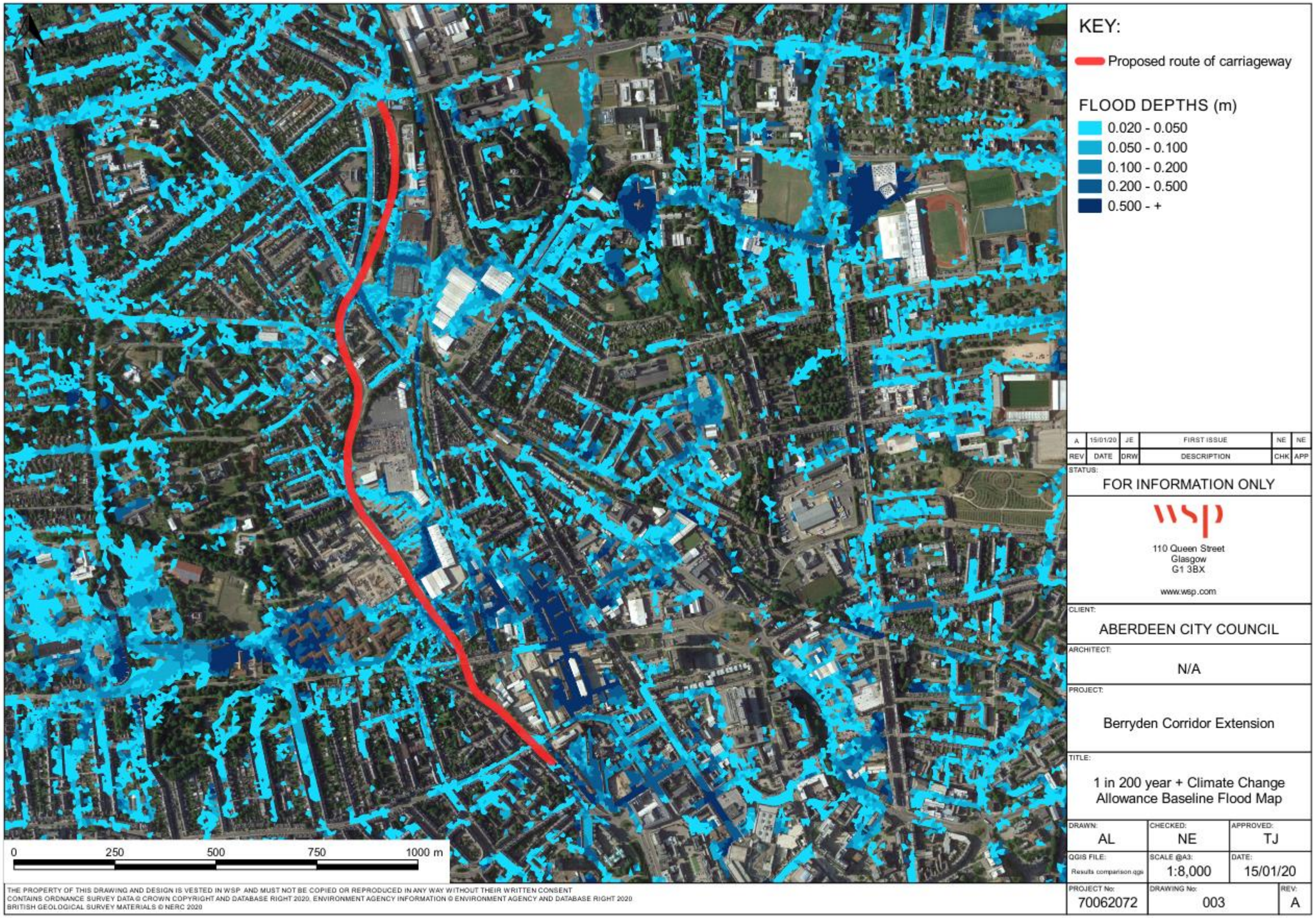

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FLOOD DEPTHS (m)

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- 0.200 - 0.500
- 0.500 - +

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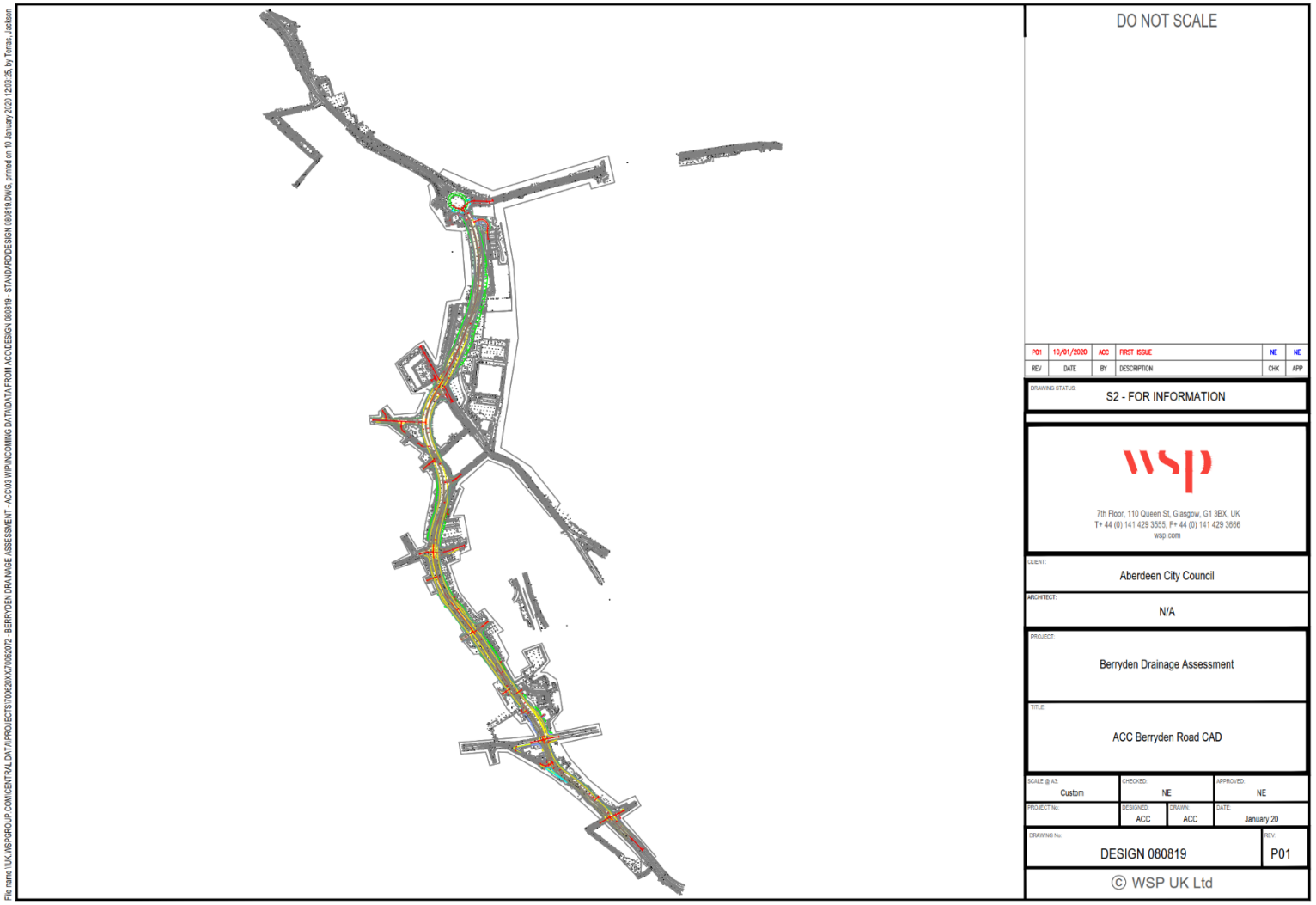
Appendix B

ACC CAD WITH PROPOSED IMPROVEMENT WORKS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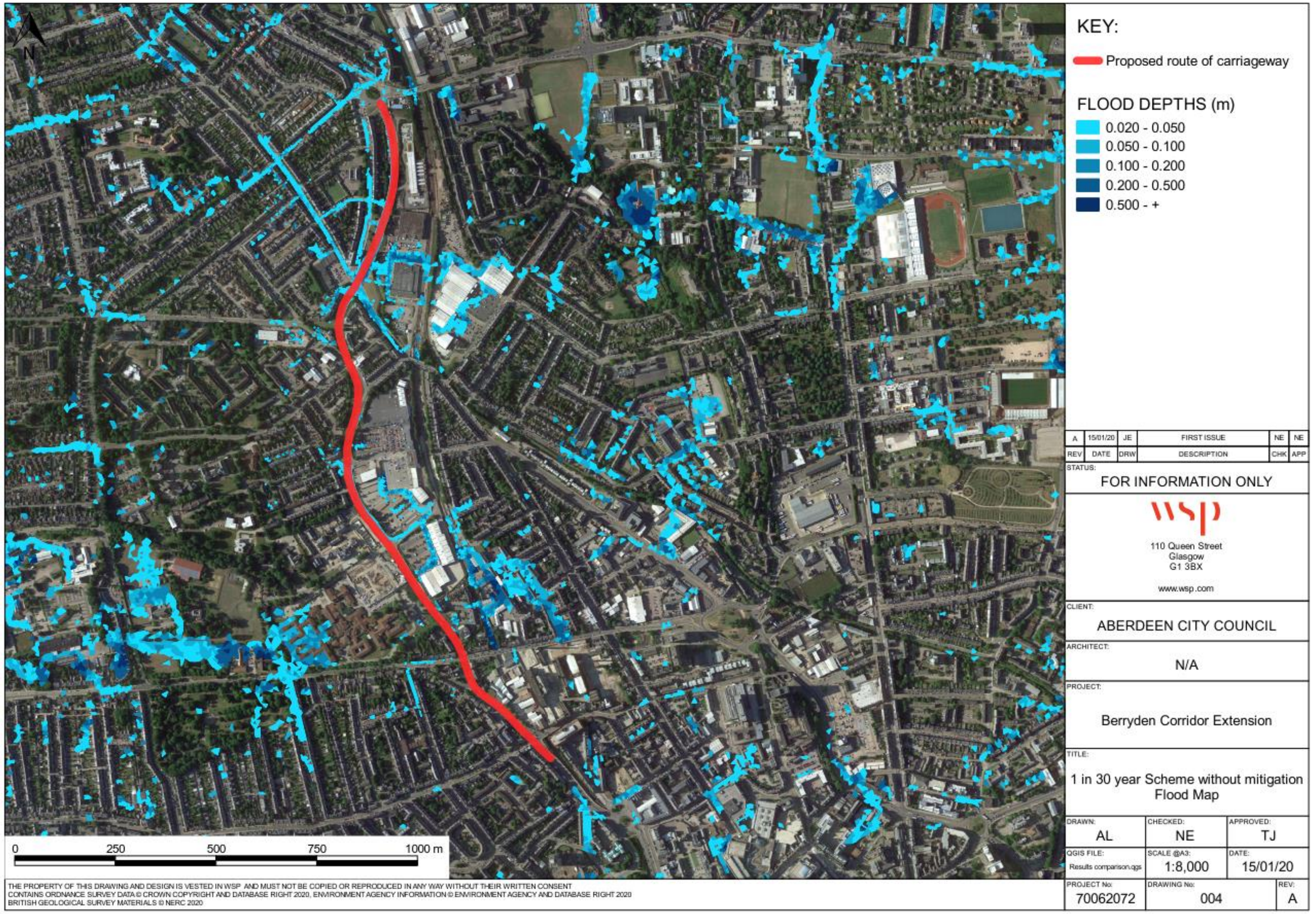
Appendix C

WITH PROJECT FLOOD DEPTH MAPS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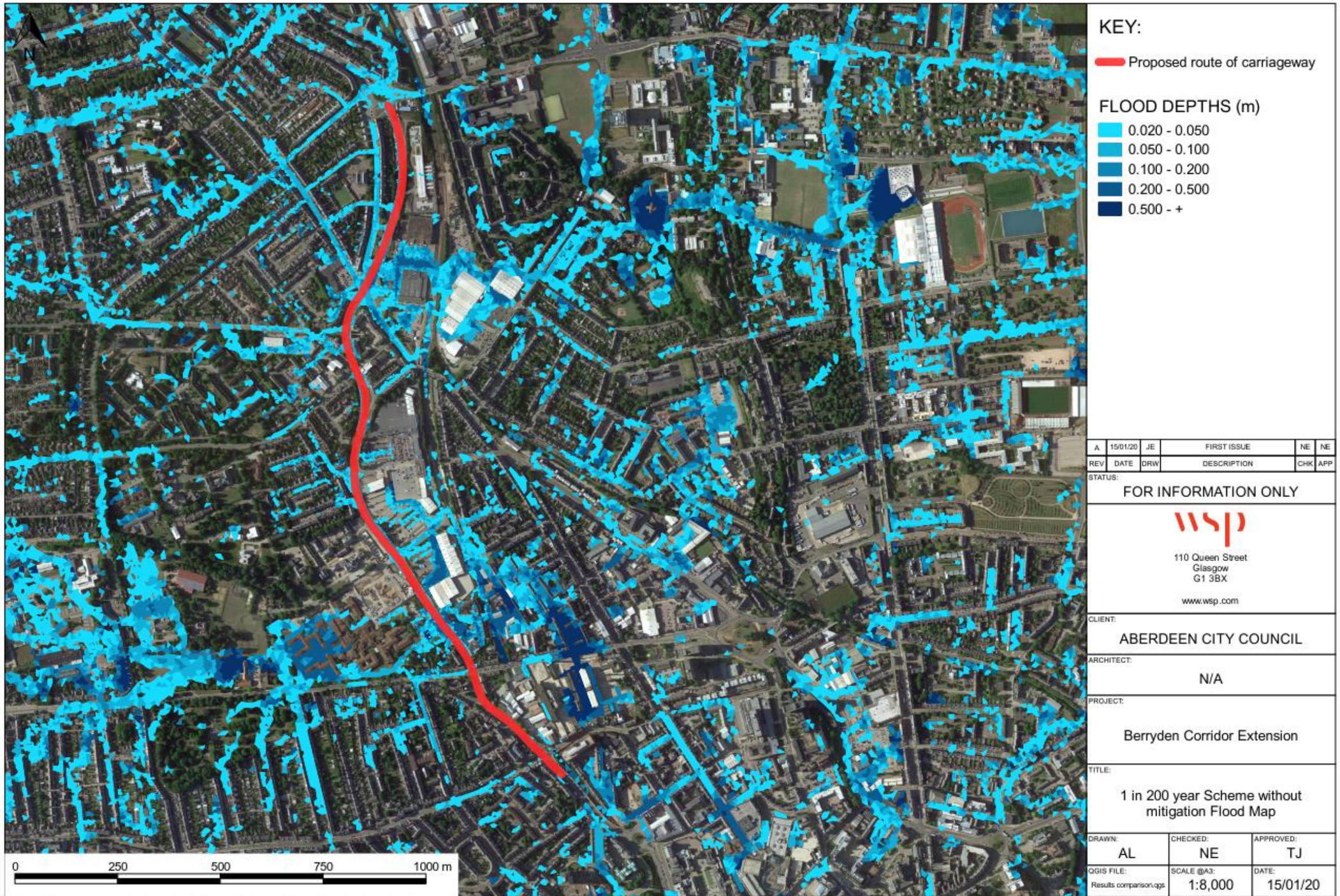

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Proposed route of carriageway

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- 0.200 - 0.500
- 0.500 - +

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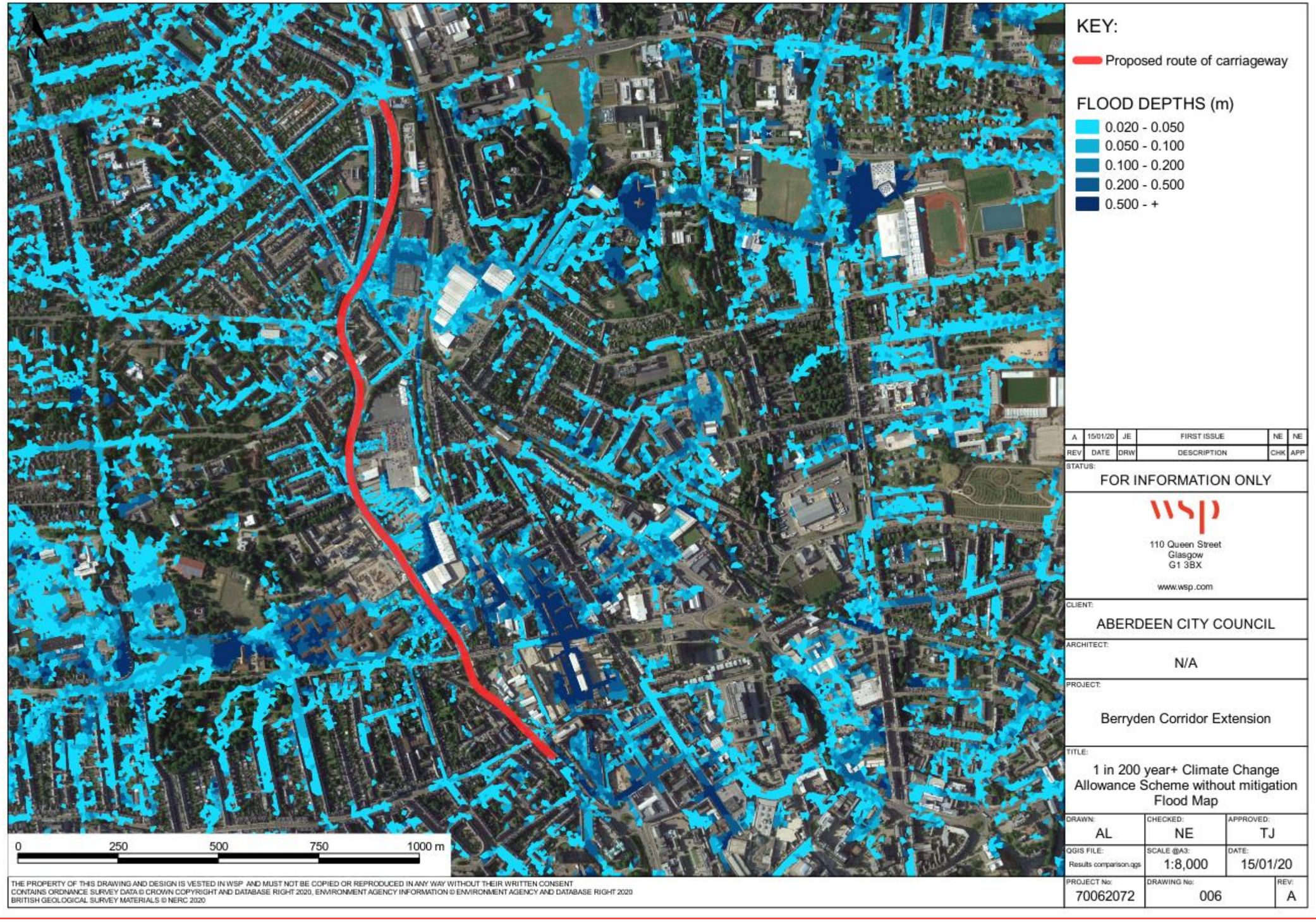

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PROJECT No: 70062072	DRAWING No: 006	REV: A

Appendix D

PROPOSED WALL AND UPSTAND LOCATIONS


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250
500 m
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Walls proposed
Proposed location of SUDs
Proposed route of carriageway
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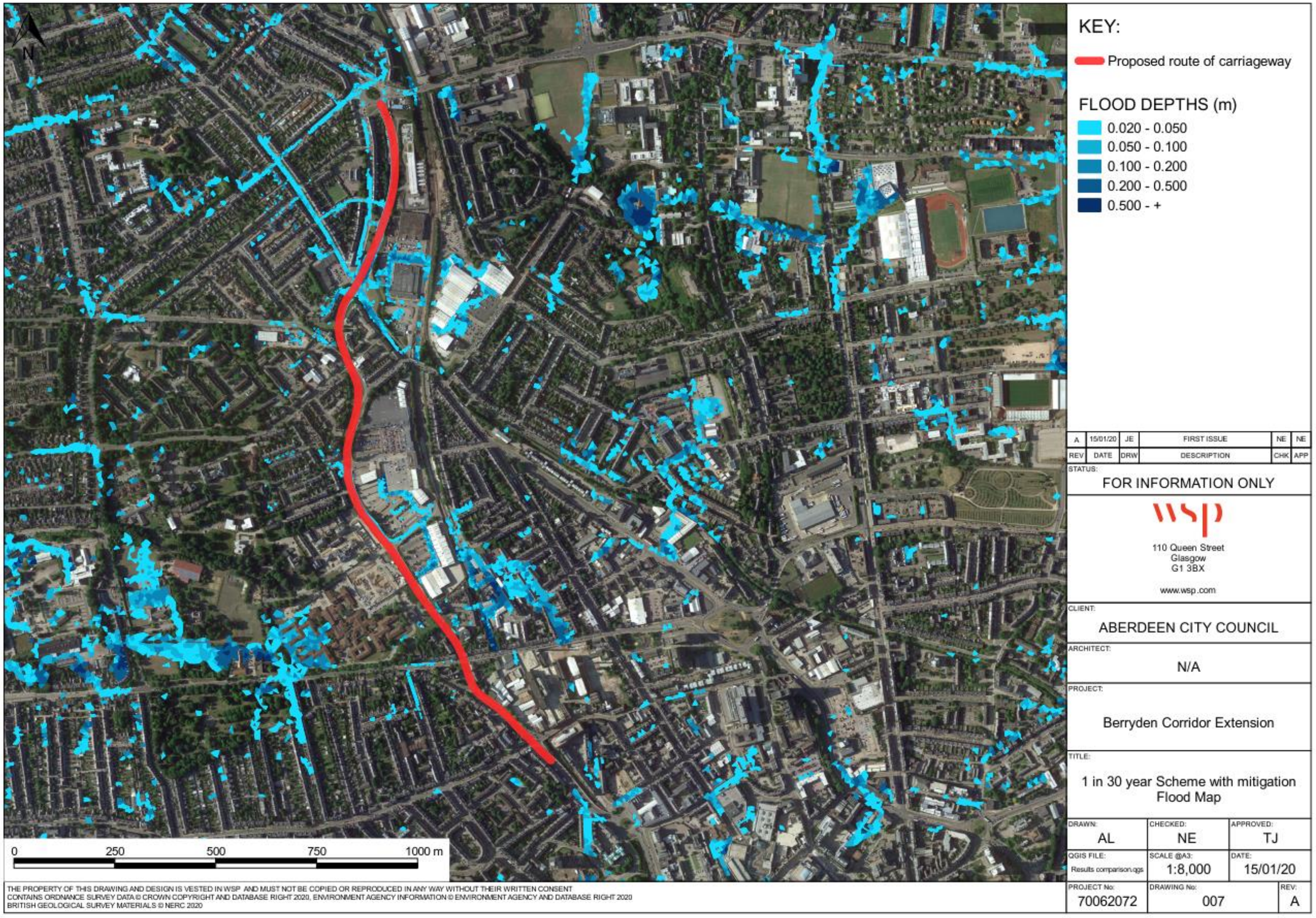
Appendix E

WITH PROJECT AND MITIGATION FLOOD DEPTH MAPS



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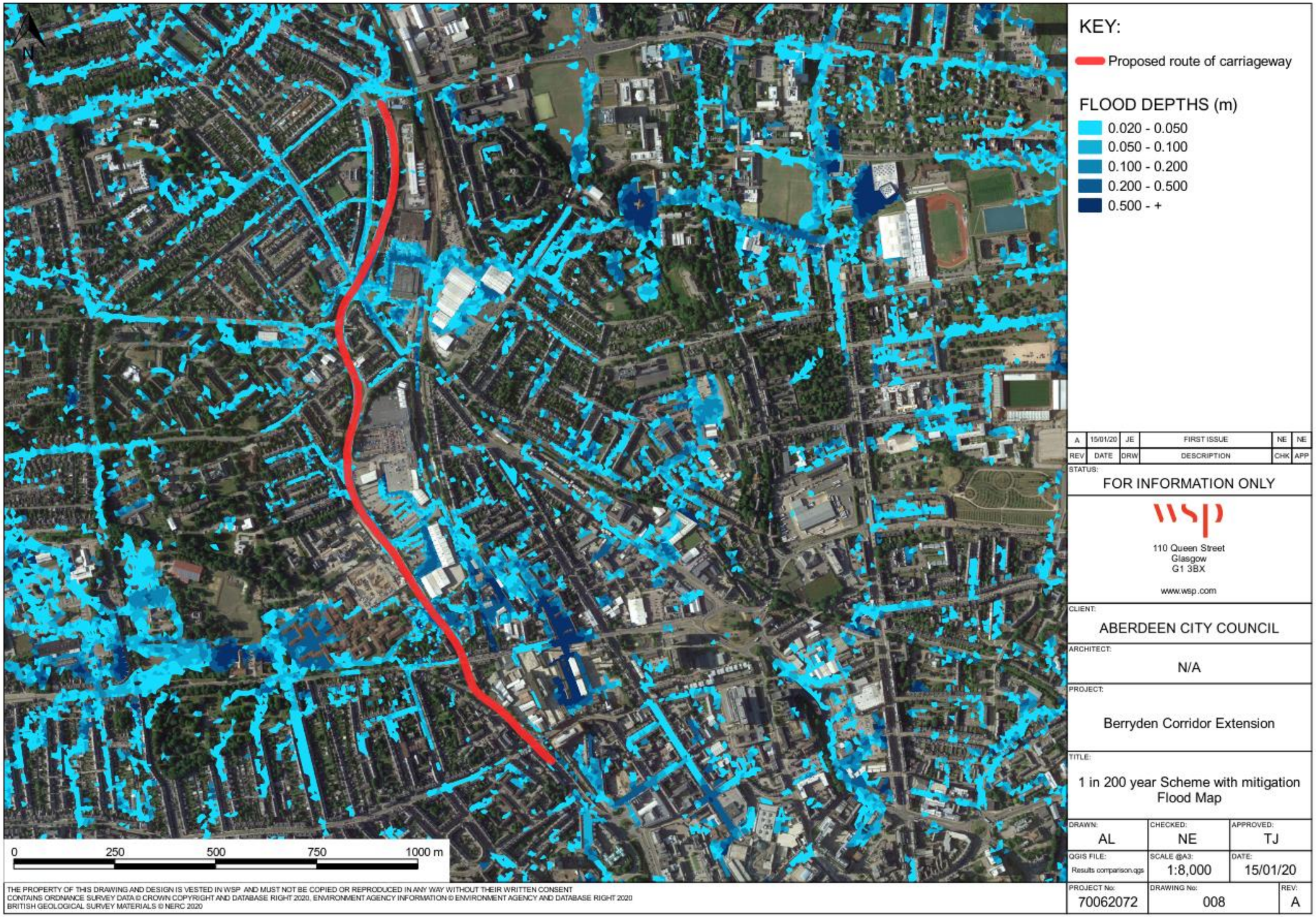
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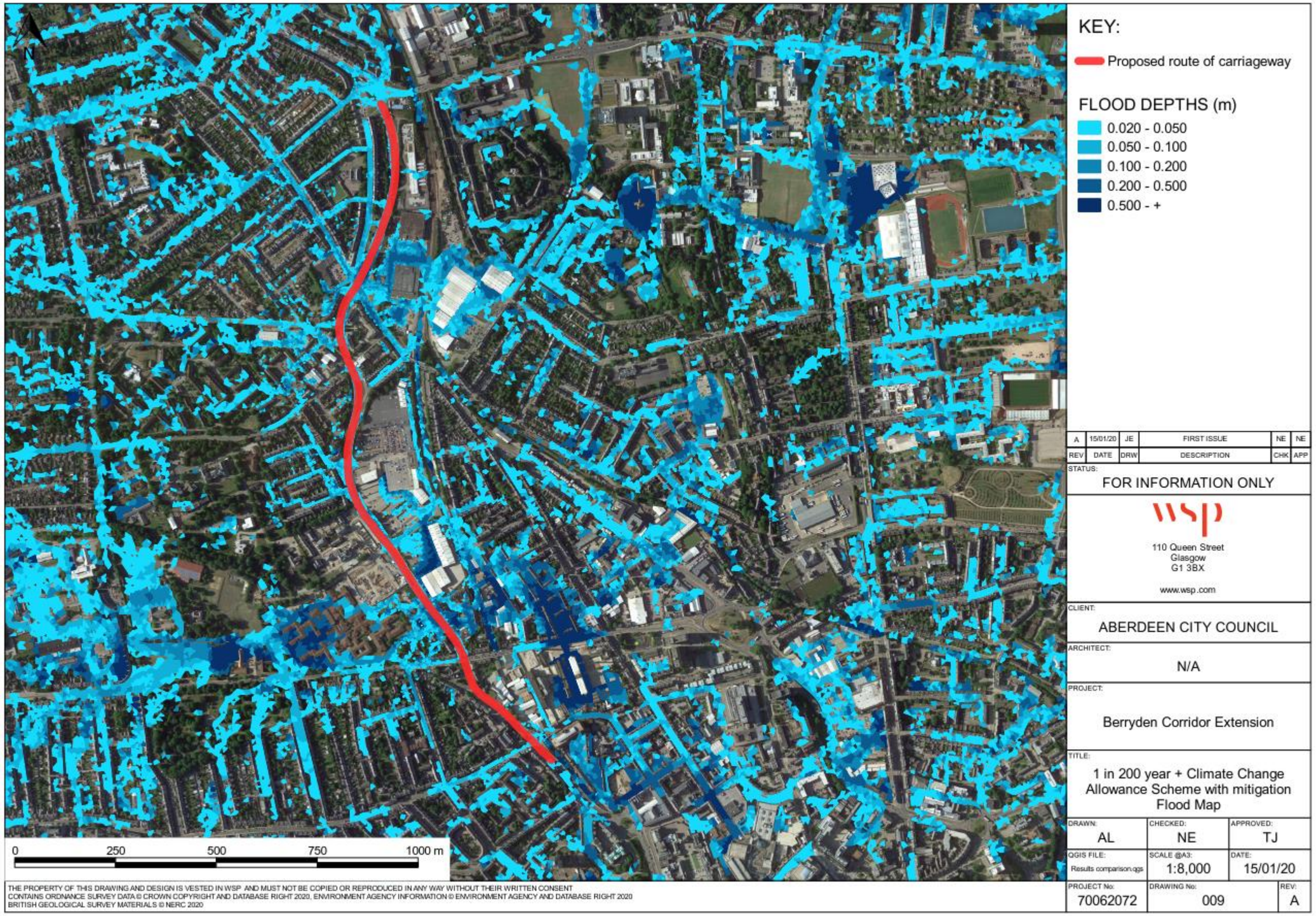
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TITLE:
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DRAWN: AL
CHECKED: NE
APPROVED: TJ
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DATE: 15/01/20
PROJECT No: 70062072
DRAWING No: 009
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Appendix F

CORRECTION TO RUNOFF SURFACE IN PROPOSED MODEL

Proposed subcatchments in existing pervious land		Existing Subcatchments								
ID	Area	ID	type	Area (ha)	Existing model Runoff area 1 (ha)	Proposed model Runoff area 1 (ha)	Existing model Runoff area 3 (ha)	Proposed model Runoff area 3 (ha)	Existing model Runoff area 6 (ha)	Proposed model Runoff area 6 (ha)
imp1	0.01	NJ93080202	Storm	1.007	0.081	0.071				
imp2	0.013	NJ93081302	Storm	1.207	0.414	0.401				
imp3	0.004	NJ93080202	combined	1.007	0.071	0.067				
imp4	0.002	NJ93080202	combined	1.007	0.067	0.065				
imp5	0.003	NJ93080202	combined	1.007	0.065	0.062				
imp6	0.009	NJ93080202	combined	1.007	0.062	0.053				
imp7	0.044	NJ93081201	combined	1.249	0.098	0.054				
imp8	0.019	NJ93081008	Storm	0.909			0.363	0.344		
imp9	0.09	NJ93081008	Storm	0.909			0.344	0.254		
imp10	0.001	NJ93080101	combined	1.165	0.2	0.199				
imp11	0.002	NJ93080001	combined	1.763	0.121	0.119				
imp12	0.008	NJ93080001	combined	1.763	0.119	0.111				
imp13	0.055	NJ93080001	combined	1.763	0.111	0.056				
imp14	0.003	NJ93080001	combined	1.763	0.056	0.053				
imp15	0.04	NJ93071704	combined	3.285	0.076	0.036				
imp16A	0.033	NJ92079714	storm	0.627	0.188	0.155				
imp16B	0.023	NJ93070813	storm	1.417	0.236	0.213				
imp16C	0.03	NJ93070502	combined	0.902					0.902	0.872
imp16D	0.014	NJ93070603	combined	0.13	0.024	0.01				
imp16E	0.014	NJ92079715	Storm	0.327	0.07	0.056				
imp17	0.013	NJ92079714	storm	0.627	0.155	0.142				
imp18A	0.003	NJ92079815	combined	0.232	0.068	0.065				
imp18B	0.006	NJ92079714	storm	0.627	0.142	0.136				
imp18C	0.06	NJ92079706	storm	0.254	0.214	0.154				
imp19	0.015	NJ92079714	storm	0.627	0.136	0.121				
imp20	0.003	NJ92079812	storm	1.811	0.347	0.344				
imp21A	0.116	NJ93070815	storm	0.187	0.182	0.066				
imp21B	0.007	NJ93070812	storm	0.262	0.193	0.186				
imp21C	0.019	NJ92079812	storm	1.811	0.344	0.325				
imp22A	0.027	NJ93071604	combined	0.634	0.159	0.132				
imp22B	0.051	NJ93070502	combined	0.902					0.872	0.821
imp23	0.104	NJ93070502	combined	0.902					0.821	0.717
imp24A	0.028	NJ93070502	combined	0.902					0.717	0.689
imp24B	0.155	NJ93072504	combined	3.159	0.109	0.0315				
		NJ93072506	Storm	3.17	0.13	0.0525				
imp24C	0.02	NJ93070407	Storm	0.14	0.065	0.045				
imp24D	0.066	NJ92079412	Storm	0.77	0.27	0.204				

imp25A	0.125	NJ93064801	Combined	0.598	0.179	0.054					
imp25B	0.013	NJ93065701	Combined	0.244	0.063	0.05					
imp25C	0.095	NJ93066618	Storm	1.789	0.677	0.582					
imp25D	0.046	NJ93065606	Storm	0.443	0.164	0.118					
imp25E	0.054	NJ93064701	Combined	0.53	0.136	0.082					

Proposed subcatchments in existing impervious land		Existing Subcatchment								
ID	Area (ha)	ID	type	Area (ha)	Existing model Runoff area 1 (ha)	Proposed model Runoff area 1 (ha)	Existing model Runoff area 3 (ha)	Proposed model Runoff area 3 (ha)	Existing model Runoff area 6 (ha)	Proposed model Runoff area 6 (ha)
per1	0.006	NJ93081302	storm	1.207					0.793	0.787
per2	0.087	NJ93070502	combined	0.902					0.717	0.63
per3	0.089	NJ93081104	storm	0.911					0.447	0.358
per4	0.006	NJ93070502	combined	0.902					0.63	0.624
per5	0.055	NJ93081008	storm	0.909					0.361	0.306
per6A	0.013	NJ93072506	storm	3.17					0.769	0.756
per6B	0.075	NJ93071309	storm	1.912					0.645	0.57
per7	0.005	NJ93081008	storm	0.909					0.306	0.301
per8A	0.026	NJ93071309	storm	1.912					0.57	0.544
per8B	0.051	NJ93071303	storm	0.432					0.122	0.071
per9	0.012	NJ93070812	storm	0.262					0.05	0.038
per10	0.017	NJ93071303	storm	0.432					0.071	0.054
per11A	0.023	NJ93072111	storm	1.1					0.087	0.064
per11B	0.029	NJ93073105	storm	0.912					0.068	0.039
per12A	0.03	NJ93073105	storm	0.912					0.039	0.009
per12B	0.006	NJ93072004	storm	0.267					0.081	0.075
per13A	0.071	NJ93081302	storm	1.207					0.787	0.716
per13B	0.007	NJ93080202	combined	1.007					0.842	0.835
per13C	0.222	NJ93081202	storm	1.007					0.649	0.427
per14	0.002	NJ93081202	storm	0.694					0.427	0.425
per15	0.101	NJ93081104	storm	0.911					0.358	0.257
per16	0.028	NJ93081008	storm	0.909					0.301	0.273
per17	0.119	NJ93081013	storm	1.518					0.703	0.584
per18	0.033	NJ93081013	storm	1.518					0.584	0.551
per19A	0.054	NJ93081013	storm	1.518					0.551	0.497
per19B	0.217	NJ93071802	storm	2.868					1.222	1.005
per19B	0.032									
per20	0.004	NJ93081013	storm	1.518					0.497	0.493
per21	0.059	NJ92079714	storm	0.627					0.292	0.233
per22A	0.001	NJ92079812	storm	1.811					1.005	1.004
per22B	0.001	NJ92079714	storm	0.627					0.233	0.232
per22C	0.004	NJ92079706	storm	0.254					0.04	0.036
per23A	0.01	NJ93070815	storm	0.187					0.004	0
		NJ92079812	storm	1.811					1.004	0.998
per23B	0.021	NJ92079812	storm	1.811					0.998	0.977
per24	0.01	NJ93071802	storm	2.868					1.005	0.995

per25	0.198	NJ93070502	combined	0.902					0.624	0.426
per26A	0.016	NJ93070502	combined	0.902					0.426	0.41
per26B	0.025	NJ93072506	storm	3.17					0.756	0.731
per27	0.041	NJ93072506	storm	3.17					0.731	0.69
per28	0.022	NJ93072506	storm	3.17					0.69	0.668
per29	0.037	NJ93072111	storm	1.1					0.064	0.027
per30	0.02	NJ93071222	combined	1.607					1.514	1.494
per31A	0.034	NJ93071222	combined	1.607					1.494	1.46
per31B	0.041	NJ93072002	combined	1.253					1.127	1.086
per32	0.017	NJ93072002	combined	1.253					1.086	1.069
per33A	0.007	NJ93072004	storm	0.267					0.075	0.068
per33B	0.031	NJ93073022	storm	0.354					0.259	0.228
per34A	0.055	NJ93064803	combined	0.374					0.105	0.05
per34B	0.053	NJ93064801	combined	0.598					0.106	0.053
per35	0.042	NJ93064801	combined	0.598					0.053	0.011
per36	0.013	NJ93063801	combined	0.452					0.147	0.134
per37	0.029	NJ93063801	combined	0.452					0.134	0.105
per38	0.006	NJ93064915	combined	0.44					0.251	0.245
per39A	0.06	NJ93073022	storm	0.354					0.228	0.168
per39B	0.048	NJ93073020	storm	0.379					0.245	0.197
per40	0.07	NJ93070502	combined	0.902					0.41	0.34
per41A	0.019	NJ93063904	storm	0.148					0.073	0.054
per41B	0.007	NJ93064803	combined	0.374					0.05	0.043
per42A	0.071	NJ93070813	storm	1.417					0.558	0.487
per42B	0.131	NJ92079714	storm	0.627					0.232	0.101
per43A	0.003	NJ93073020	storm	0.379					0.197	0.194
per43B	0.019	NJ93064915	combined	0.44					0.245	0.226
per44	0.199	NJ93070813	storm	1.417					0.487	0.288
per45	0.019	NJ93064701	combined	0.53					0.039	0.02
per46	0.016	NJ93066618	storm	1.789					0.607	0.591
per47	0.007	NJ93064801	combined	0.598					0.011	0.004
per48A	0.007	NJ93070813	storm	1.417					0.288	0.281
per48B	0.101	NJ92079714	storm	0.627					0.101	0

*Highlighted rows are the final values of those catchment in the proposed model.

110 Queen Street
Glasgow
G1 3BX

wsp.com