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Background Report

Green Networks Integrated Urban Infrastructure, Johnstone South West, Surface Water Management Strategy

Renfrewshire Local Development Plan
Main Issues Report December 2011

Renfrewshire Council

Green Networks Integrated Urban Infrastructure

6 Candidate Sites

Johnstone South West

Surface Water Management Strategy

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Executive Summary

This report has been produced for the purpose of presenting a Surface Water Management Strategy (SWMS) for the Johnstone study site area.

The Johnstone site is proposed by Renfrewshire Council for both refurbishment and re-development in parts. The objective is to implement a holistic, design lead approach to the site. This incorporates the understanding of the existing water opportunities and constraints at the site and to ensuring that appropriate decisions are made in developing areas where future communities will be able to thrive and be engaged.

The Johnstone study site covers approximately 292 hectares. Three individual watercourses transverse the site, all ultimately flowing into the Black Cart River which is located outside of the site boundary to the north. The Black Cart flows in a north-easterly direction branching into the River Clyde.

Large sections of the sewer network in the Johnstone site drain to combined sewer systems which during times of heavy rainfall connects to the adjacent burns through Combined Sewer Overflows (CSO's), e.g. Cartside area. Other CSO's are located further downstream of the Johnstone site, also discharging directly to the Black Cart River. Other areas in the site, particularly the Spateston area, consist of separate foul and storm water systems.

The burns themselves are each culverted at least once along their extents at the site and have been reported by Renfrewshire Council as acting as obstructions causing the back up of flows and subsequent overland flooding.

The strategy for the SWMS has been developed following base lining of the site to support the design study process. All sources of flooding have been investigated and following on from a previous JBA study, pluvial flooding has been identified as the most significant constraint at the Johnstone site. Appropriate management of surface water from the future development would inevitably lead to tangible benefits for the future regeneration aspiration of sustainable surface water management.

This document sets out the principles for future drainage provision which optimise the balance of environmental constraints with the regeneration and design aspirations and introduces a concept for how the future surface water management of the site can be developed.

Following discussions through the stakeholder forum which includes the Scottish Environment Protection Agency (SEPA) and Renfrewshire Council, a development criteria has been established to attenuate all development runoff to the undeveloped 'Greenfield' runoff rates.

The principles upon which a detailed surface water management scheme can be developed have been set out in this document, and alongside this, ways of changing the adoption and maintenance approach to SuDS are discussed and a schedule that is in line with the SuDS manual put forward. An ArcGIS database has also been created including detail on future requirements for sub-catchment strategic surface water systems.

The primary principles for the development and the design study process were to create exemplar infrastructure elements and base the design process around the infrastructure, establishing a more integrated approach to the study process that looks at:

- The base line constraints on site
- The exemplar infrastructure
- Developing a plan around the above.

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1 Introduction

1.1 Scope

The scope of the Green Network Integrated Urban Infrastructure project is to produce holistic, design lead approaches to the design studies for the six candidate sites. This will incorporate understanding the existing opportunities and constraints of the site, and to improve the design study process through informed assessment at an early stage to ensure that appropriate decisions are made in developing places where future communities will be able to thrive.

The design study will focus on the requirements of existing and future development and incorporating the required infrastructure, whilst also looking to minimise the impact on the environment, enhancing existing green networks and managing water quantity and quality at both a site and catchment scale.

This will highlight the value of exemplar infrastructure as a base to an exemplar design.

1.2 Project background

Potential changes in climate and the possibility of increased flooding events requires a change in the way our urban spaces and cities are planned and developed. The interaction between our systems, the natural environment and future communities will be assessed more thoroughly and informed decisions made to best suit all aspects of development.

In managing the water environment and raising the profile that water design requires, the Metropolitan Glasgow Strategic Drainage Partnership (MGSDP) was created to evaluate current approaches and develop innovative and sustainable solutions to identified problems. The MGSDP comprises of:

Founding Partners:

- Glasgow City Council
- Scottish Water
- Scottish Environment Protection Agency (SEPA)
- Scottish Enterprise
- Glasgow & Clyde Valley Green Network Partnership
- Other local authorities within MGSDP area:
- South Lanarkshire Council
- West Dunbartonshire Council
- East Dunbartonshire Council
- Renfrewshire Council
- East Renfrewshire Council
- North Lanarkshire Council

Other agencies:

- Scottish Government
- Glasgow and the Clyde Valley strategic development planning authority
- Clyde Gateway Urban Regeneration Company

SEPA's Clyde Draft Area Management Plan 2009 – 2015 proclaims the vision:

'To maintain and improve the quality of the rivers, lochs, estuaries, coastal waters and groundwater areas. To focus on local actions highlighting the opportunities for partnership working to ensure that we all benefit from improvements in the water environment, which will contribute to the goals of the draft River Basin Management Plan [RBMP] that have been produced for both of Scotland's River Basin Districts [RBD]'

The Green Networks Integrated Urban Infrastructure project has been supported by additional partners, which include the Forestry Commission Scotland and Scottish Natural Heritage.

1.3 Johnstone Site

The Johnstone study site is located to the south-west of Glasgow centred at grid reference NGR 241940,661710. It covers approximately 292ha and consists of heavily urbanised land with existing residential housing including semi-detached homes and high rise flats, large commercial buildings including retail, industrial and office premises, and areas of green-space and parkland including an 18hole golf-course. The site boundary and topographic level schematic are shown in **Figures 1.3a and 1.3b, Appendix A** respectively.

Outwith the site boundary, further residential housing estates occupy the northern and eastern boundaries, a large quarry is located to the south beyond which lies predominantly rural and agricultural hilly lands, and similarly outside the western boundary.

Approximately 70% of the housing in the study area is under Renfrewshire Council ownership. Much of the residential housing was built during the late 1960's and early 1970's and consists of low quality terraced housing and flats which are currently in need of refurbishment. However, there are also patchs and ribbons of new housing developments, pre-dominantly privately owned. Two modern primary schools and a large new high school are located within the site boundary and some older now derelict schools still exist which are scheduled for demolition.

Three watercourses dissect the site including the Spateston Burn, Floors Burn and Craigbog Burn. All the burns ultimately flow into the Black Cart River, located outside of the site boundary to the north and which flows in a north-easterly direction towards the River Clyde.

It is considered that approximately 20%[1] of the total housing stock of Johnstone is constrained from redevelopment due to potential flooding and drainage issues and this is a particular problem in socially deprieved areas in need of investment, where frequent historic flooding has occurred from urban watercourses, combined sewers and surface water drainage systems.

Significant infrastructure is currently in place throughout the site including an extensive road network plus bus and rail public transport systems. A railway line runs south-west to north-east along the northern boundary of the study area which can be accessed by the residents of the area at the adjacent Milliken Park and Johnstone stations.

Numerous stand alone green recreational areas exist throughout the site, and the Cochrane Castle golf course occupies approximately 46ha of land in the central to southern regions of the site. Part of the High Craig Quarry site, which is currently operational, encroaches within the south-east boundary of the project site.

The ground elevations of the site generally fall from the steeply sloping hills at the southern periphery of the site boundary, reaching approximately 97m AOD, to the lower elevations of the northern site boundary at approximately 27m AOD.

Large Scottish Power 400kv power lines traverse the western and southern areas of the site potentially limiting development in these areas.

[1] JBA Johnstone Pilot Study 2008

Figure 1.3c – Site Location Plan

1.3.1 Proposed Development

The aspiration of Renfrewshire Council and its partners for the Johnstone site is to regenerate the area and provide a community of residential and recreational areas to meet health and well being targets, using best sustainable development practice, which includes a framework to address the creation, maintenance and management of Sustainable Drainage Systems (SuDS).

The proposed development is anticipated to consist of the construction of a number of new housing locations in areas outlined in the design plan, demolition of some now derelict schools and for the refurbishment of many of the older residential dwellings. Some refurbishment works have already been initiated by Renfrewshire Council with interior refits, exterior re-cladding and new street lighting.

It is intended that there should be an emphasis on creating attractive, worthwhile open spaces as well as core areas for the local communities incorporating community and commercial facilities.

An important aspect of the future development of the study area will be the guidance provided by a strategic water management plan. Renfrewshire Council understands that without an understanding of the flood risk from all sources, the implementation of ad-hoc flood alleviation and/or prevention measures in new developments may be exacerbating flood risk elsewhere.

Following significant flooding in 1994 and frequent local flooding in urban areas of Johnstone, a joint collaboration between Renfrewshire Council and the Urban Water Technology Centre of the University of Abertay has seen parameters set out in *Water Vision for Johnstone - 2006,* for a strategic water management plan for Renfrewshire. The document is based on practice in the Netherlands and sets out statutory objectives, e.g. flood management and watercourse maintenance as well as aspirational

objectives e.g. de-culverting of watercourses, disconnection of surface water from the sewerage system, meeting goals of the Biodiversity Action Plan and improving quality of life for locals.

Water Vision aimed at focusing all stakeholders on the problems and solutions of the wider issues involved in the drainage network of the urban area and consisted of 3 Sections:

- Strategic Water Management Plan primarily for the use of decision and policy makers.
- A Water Vision for Johnstone to inform members of the public about the choices for water in their area.
- A guidance document for urban planners and designers.

A key outcome of *Water Vision* is the use of SuDS, e.g. wetlands, detention ponds, permeable paving and more, designed to attenuate surface water to brownfield or greenfield flow rates. These are to be incorporated from the initial stages of the design study with the intention of contributing to the green space and general amenity areas in urban Renfrewshire as well as providing water treatment and flood attenuation.

1.4 Scope of Report

Moving forwards from the *Technical Baseline Report*, prepared in June 2010, this report sets out the strategic drainage principles that were applied during the ongoing design study process. Several meetings with the design team and stakeholders informed aspects of the drainage principles.

This report has been prepared to provide a Surface Water Management Strategy for the Johnstone site. The report discusses the following areas:

- Surface Water Management Strategy incorporating Future Principles;
- Surface Water Management – Setting a New Agenda; and
- Recommendations.

1.4.1 Drawings and Figures

Included in the Appendices to this report are the following figures:

Figure 1.3a – Site Outline and Watercourses
Figure 1.3b – Topography
Figure 2.1a – Existing Drainage Type
Figure 2.1b – 0.5% AEP + CC Pluvial Flood Extents
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Figure 2.7a – Site SuDS Layout
Figure 2.7b – Site SuDS Layout – Spateston
Figure 2.7c – Site SuDS Layout – Cartside / Floors
Figure 2.7d – Site SuDS Layout – Craigbog
Figure 2.7e – Potentially Contaminative Land

1.5 Approach to the Design Study

Figure 1.5 illustrates the baseline considerations and design elements incorporated into the integrated urban infrastructure design study in the order that was prioritised for this site. The site location and attributes determined the order of priority, the site being a largely brown-field site containing substantial areas of existing development and existing transport infrastructure and utilities traversing the site.

The Digital Terrain Model (DTM) was a core aspect enabling detailed understanding of the current conditions on site. The DTM was utilised to inform the design of infrastructure elements i.e. transport and drainage networks.

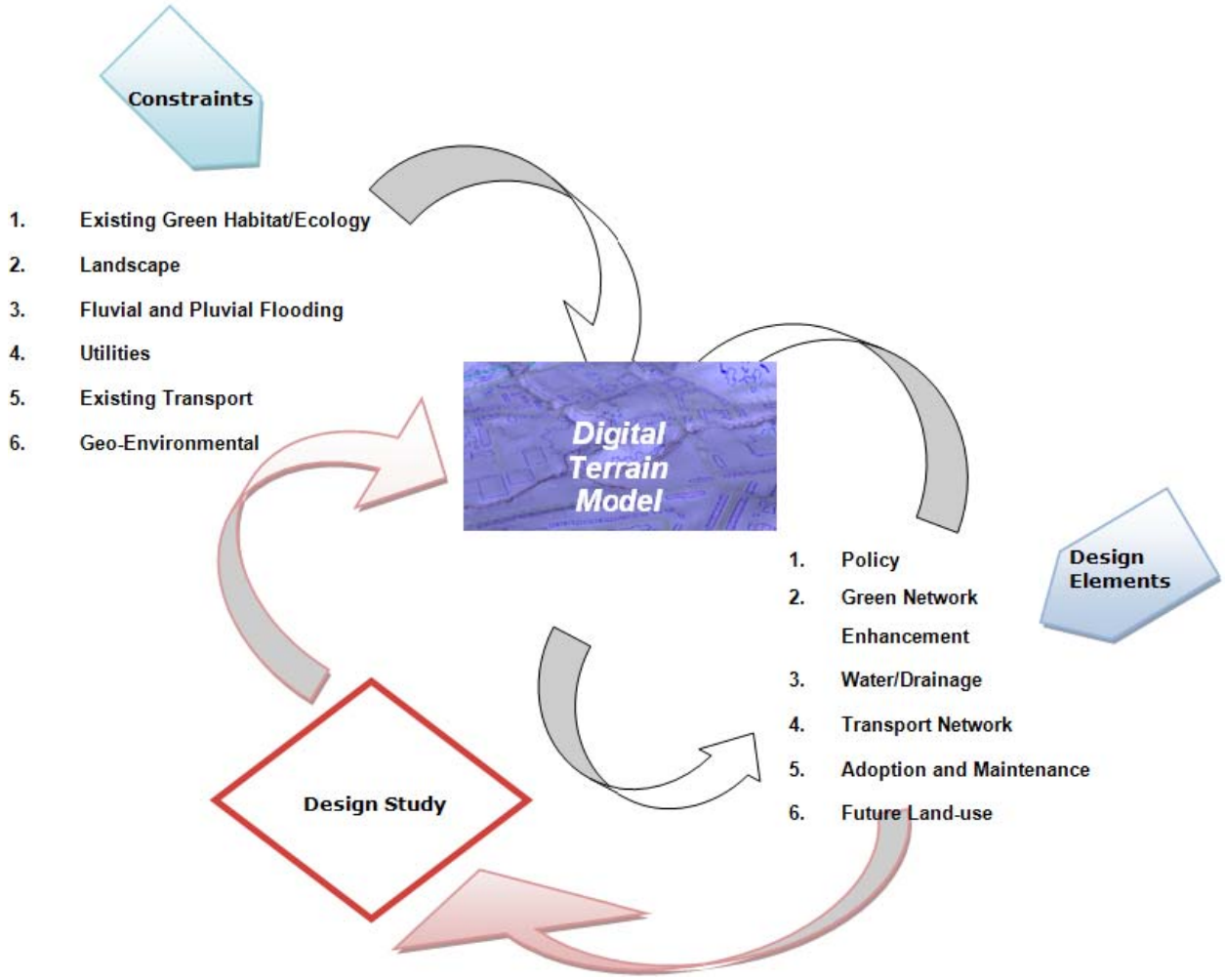


Figure 1.5 - Technical Approach to the Design Study

The design process was informed initially by the technical base lining to get a detailed understanding of the existing constraints to future development and also highlight significant opportunities for innovative and holistic urban design. Key to the success of the design study will be the linkages provided by Scottish National Heritages Green Habitat Network layout as well as the existing area affected by pluvial flooding.

Thereafter, the DTM was used alongside the site constraints and topography to inform the development of the infrastructure design through an iterative process with the design study development. Once equilibrium was achieved a final design study could be completed.

This report sets out the water and drainage aspects of the design.

A significant part of the background and technical development of the SWMP has been included within a Geographical Information System (GIS) database. The Arc-GIS database includes details on the future requirements for sub-catchment strategic surface water systems and surface water constraints for future development areas.

2 Surface Water Management Strategy

2.1 Summary of Flood Risk and Drainage Baseline Results

Base lining of the flood risk and drainage aspects considered all possible sources of flooding and potential mitigation measures to minimise the impact of the development on the hydrological system and manage future flood risk.

The two greatest potential sources of flooding on site are pluvial flooding, and surface water flooding from the combined sewer systems. Due to the local topography of the upper parts of the study area, comprising steep hilly rural catchments, overland flooding in the upper sub-catchment areas is widespread with a number of properties at risk. However, there are also adequate area's in the Johnstone site area at low or no risk in which further development could occur if required. The layout of any future development should consider the potential overland flood routes and open spaces, designed to allow these flows to be appropriately managed.

Key strategies for the site will be the disconnection of storm water in residential areas from the combined sewers, the implementation of regional and site control SuDS systems and the creation of surface water floodplain areas. A schematic of the combined and separate sewer systems for the Johnstone study site is illustrated in **Figure 2.1a**, **Appendix A**.

By developing strategic surface water systems with a holistic approach there are greater opportunities for integrating existing surface water and highway drainage systems to mitigate existing flooding problems. This should also lead to a reduction in the frequency, volumes and rate of spills from the Combined Sewer Overflows (CSO's) in the area.

A pluvial flood outline extent for the 0.5% Annual Exceedance Probability (AEP) event was provided in GIS format by Renfrewshire Council and an integrated modelling study was carried out for the Spateston area incorporating all watercourses, culverts and sewer systems. Pluvial flood extents are shown in **Figure 2.1b, Appendix A**. Hence, the key area of focus is the management of surface water drainage and ensuring a reduction in runoff and future flood risk can occur.

2.1.1 Existing Surface Water Runoff

To assess the surface water drainage requirements the undeveloped greenfield runoff rates were calculated for the individual sub-catchments of the site based on the methodology set out in the Institute of Hydrology Report 124 – *Flood Estimation for Small Catchments*.

In considering the outline surface water management for the development areas, an average impermeable area of 50% has been applied for the existing and proposed development areas.

Table 2.1a – Overall Site Greenfield Runoff Rates

AEP (%)	Flow (l/s/ha)
50	7.81
20	10.14
10	12.18
4	15.51
3.33	16.31
2	18.67
1	22.54
0.5	27.29

Extensive surface water systems are already in place at the site. From previous studies[2] and anecdotal flooding evidence it is assumed that the current combined and surface water systems will not have capacity to accommodate future surface water runoff from additional developments in the area.

A preliminary estimate of the required attenuation storage was calculated ensuring that future runoff, and therefore flood risk downstream, will not be increased in accordance with the requirements of SPP[3]. The treatment volume, V_t for each individual sub-catchments were also calculated in accordance with CIRIA C697 – *The SuDS Manual*.

The treatment and attenuation volumes for the entire development are shown in **Table 2.1b.**

Table 2.1b – Indicative Attenuation and Treatment Volumes

Area (ha)	Attenuation Volume (m^3)	Treatment Volume (m^3)
292 (50% contributing)	68284	31572

Potentially the main constraint on the site is the location of the existing culverts on the watercourses which bisect the site, particularly on the Spateston Burn where rain water during heavy rainfall is periodically unable to enter the culverts quickly enough. De-culverting of part of the burns throughout the site and returning them to their more natural state may be part of the flood mitigation solution. The location of the culverts on the burns can be seen in **Figure 2.1.1**, **Appendix A**.

2.2 Adaptation to Climate Change and Designing for Exceedance

Appropriate measures to adapt to climate change were discussed in the Technical Baseline report. Two key changes in climate were identified:

- 30% increase in winter rainfall
- Increase in extreme weather patterns

Future climate uncertainty – Design for Exceedance

Exceedance of drainage systems during extreme events is inevitable; how the designer chooses to manage it will determine whether there is a risk associated with this type of surface water pluvial flooding. If exceedance is not accommodated in an urban environment, pathways will be formed during extreme events which may flow to receptors which are vulnerable and create unacceptable risks. To prevent this, exceedance pathways must be incorporated into development design. **Figure 2.2** overleaf highlights how drainage and exceedance routes interact during extreme events.

[2] JBA Johnstone Pilot Study 2008
[3] Scottish Planning Policy 2010

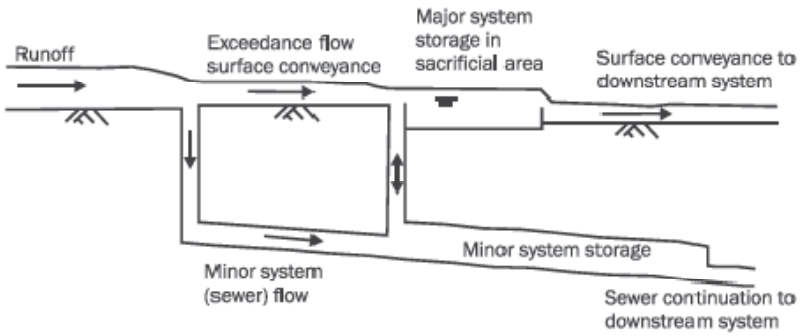


Figure 2.2 – Interaction between minor and major systems during extreme events[4]

2.3 Catchment and Sub-catchment Definitions

As a large exemplar site, the aspiration is to respond to both existing and future development at a hydrological catchment scale, providing more holistic functioning drainage infrastructure and moving away from individual site focused solutions.

Contributions to the hydrological cycle within this catchment have been reviewed and measures for existing and future surface water drainage considered. The delineated hydrological catchments showing their urban and rural components are illustrated in **Figure 2.3a**, **Appendix A**.

Within the Johnstone site, areas have also been distinguished as individual sub-catchments in order to develop appropriate solutions for the future management of surface water runoff from within these areas. The sub-catchments are defined by the urban constraints and topography of the site. A general strategy for surface water management has been developed within each of these sub-catchments which unite to form the overall strategic development strategy.

In developing the SWMP, 14 individual sub-catchments have been defined based on existing topographical constraints and watercourse catchments within the Johnstone site area, see **Figure 2.3b, Appendix A**.

Within each sub-catchment the existing runoff contributions, based on a 50% impermeable area scenario, have been determined for the 0.5% Annual Exceedance Probability (AEP) event plus a 30% allowance for climate change. The runoff rate within each sub-catchment has been considered to be the baseline against which to compare future runoff and to use as a measure of change of flood risk.

Further consideration has been carried out on the proposed developable green-field and brown-field land areas designated for new residential development in the design plan but with a 40% impermeable area applied to these individual sites reflecting the implementation of SuDS features from the outset of the design. Proposed development areas in the design plan are shown in **Figures 2.3c-2.3e**, **Appendix A**.

2.4 Strategy Approach

To assist the future development in meeting the principles in this SWMS, it is proposed that strategic surface water systems be developed and implemented for all of the sub-catchments to avoid a piecemeal approach.

It is anticipated that these strategic systems will receive surface water flows from the development areas and, integrated with the existing developed areas and highway systems, remove any reliance on the combined sewerage system to receive surface water runoff. The strategic drainage systems will comprise mainly of open surface water systems draining to a series of ponds or

[4] CIRIA C635 Designing for Exceedance in Urban Drainage – Good Practice

wooded wetlands to provide attenuation to all increased runoff up to the 0.5% AEP event and will also include allowances for future climate change in line with current guidance.

Due to the licensing requirements of the Water Environment (Controlled Activities) (Scotland) Regulations 2005 (CARs), as identified in the Technical Baseline assessment, there is a legal obligation to appropriately manage future surface water runoff from new development which includes the implementation of SuDS.

This strategy will utilise the conveyance and treatment train set out in the SuDS manual[5] to its maximum capacity:

PREVENTION – SOURCE CONTROL – CONVEYANCE – ATTENUATION / DETENTION

- Prevention – preventing any increase above natural runoff by use of soft landscaping;
- Source control – limiting direct surface water runoff rates at the point or origin through utilising elements that include permeable surfaces, green roofs and water butts within the development;
- Conveyance – providing clearly defined drainage paths which also provide 'holding' points where water will be contained during extreme events, using these areas to create exceedance routes, where water will be anticipated to flow during extreme events which exceed the design of the drainage system clearly directing water to the least vulnerable areas; and
- Attenuation/Detention – wetlands, ponds or detention basins will provide treatment volume storage and the remaining amount of the attenuation which is not being contained within the upper elements of the system.

2.5 Future Drainage Principles

The aspiration of the proposed strategy is to change the current practice of incorporating the minimum requirement to achieve compliance with regulations and introduce a more holistic approach to surface water management. By looking at a more comprehensive suite of SuDS tools and considering these as not only surface water management tools, but also as assets with greater value to the place in which they are built; environmental and urban interactions with potential for incorporating water elements throughout the development creating more diverse urban and natural environments.

Future surface water management should look to provide benefits to the water and natural environment, reduce existing flood risks and provide capacity for adaptation for climate change. Appropriate design can integrate natural aspects and the urban environment to provide additional benefits by allowing surface water systems to be utilised to create attractive spaces. This approach can deliver benefits to all stakeholders from the present day landowners, local authorities, developers and future communities.

Due to the existing surface flooding issues within the site, it is recognised that surface water will need to be managed and drained via SuDS to the receiving watercourses, ensuring the probability of flooding is not increased up to the 0.5% AEP events, including an allowance to adapt to future climate change. Any potential for mitigating existing flooding sources should be investigated.

The principles that have been considered for the future surface water management are set out below and future development should aspire to meet these principles. Where this is not considered practical there should be appropriate justification of why an alternative approach has been considered.

The primary principles for future surface water drainage within the Johnstone study area should:

[5] CIRIA C697 The SuDS Manual

Ensure that surface water is kept separate and managed on the surface

Surface water runoff will be kept on the surface wherever possible; infiltration should only be considered following detailed investigation and designed with appropriate care.

By providing strategic surface water systems which incorporate surface features; e.g. open watercourses, attenuation basins, swales and wetlands, there are a number of benefits to be realised which include:

- environmental benefits including habitat enhancement and creation;
- creating focal points within the design study, incorporate open spaces and blue/green access routes;
- providing a 'buffer' between the existing water environment and urban form;
- incorporate simpler and more sustainable construction methods;
- increased adaptability, ease of modification and adaptability to potential additional climate change;
- reduce long term high cost maintenance requirements, introducing a softer landscape management requirement; and
- raising public awareness of the environment and water environment by keeping water visible.

Due to the existing flooding issues within the site and also within the wider Black Cart Water catchment, it is recognised that surface water will need to be managed and drained via SuDS to ensure that the probability of flooding is actually decreased up to the 0.5% AEP event including an allowance for future climate change.

Decrease flood probability and associated risk from the surface water system

By developing strategic surface water systems and a holistic, catchment wide approach there are greater opportunities for integrating existing surface water and highway drainage systems to mitigate existing flooding problems;

Potential for mitigating existing flooding sources should be investigated and the surface water management strategy applied to the wider hydrological catchment or existing developments where tangible benefits can be realised. Reducing the reliance on flood protection measures to protect existing development would improve the ultimate performance and long term viability of such measures.

Maximise potential for environment enhancement

By implementing strategic surface water systems, an opportunity to provide a buffer between the urban and natural environments can be utilised to provide open spaces for amenity/recreation in addition to potential habitats for wildlife e.g. footpaths, wetlands, attenuation basins and open watercourses.

Ensure in-curtilage space is retained as permeable surfaces to minimise runoff

To reduce overall runoff from within the site and thereby reduce pluvial flooding during extreme rainfall events, it is recommended that the maximum possible area be kept permeable. For example, shared gardens and community areas should cultivated green-space areas and policies implemented to prevent inappropriate paving.

This requires a long term policy to implement and enforce, however, recent changes in Planning Policy in England and Wales have set a precedent for managing 'urban creep' to help protect the water environment and prevent increases in flood risk as a result of unchecked impermeable areas.

Permeable paving should be utilised wherever practical in areas such as community car parking areas and residential streets where no through traffic is expected. Permeable paving benefits surface water management in reducing direct runoff and improved water quality of road runoff.

Incorporate retro-fit SuDS improvements to existing drainage systems

Within the Johnstone development area, many of the existing developments including buildings and road layouts will remain. Existing drainage should be incorporated in to the strategic drainage system and SuDS drainage systems applied to existing, as well as new, roads and developments. This will reduce or remove the dependence on the combined sewer network and provide benefits to the wider community and environment through reduced flood risk from the sewer network and fewer spills to the water environment through combined sewer overflows.

Maximise environmental and aesthetic benefits of the sites watercourses through river restoration and de-culverting

Where the banks of the watercourses have been altered in the past, there may be potential to restore a natural riverbank and enhance the aquatic environment. River restoration techniques have the potential to reduce conveyance of flood waters, restore natural floodplain mechanisms and improve the amenity of the water course through the site. River restoration techniques, including de-culverting sections of watercourses, can be used to restore a natural channel in locations where the existing riverbanks are concrete or masonry walls.

Seek opportunities for enhancing the existing environment

With developments such as the Johnstone site, opportunities will be present to consider aspects of the existing drainage and infrastructure in order to improve the existing situation and enhance the environment. These benefits should be considered to maximise the opportunities that this redevelopment can generate.

Where existing development and roads are been retained, the opportunity exists to incorporate areas which discharge untreated storm water directly to the adjacent burns to be incorporated into the strategic drainage system to provide better water quality and surface water management improvements throughout the site and surrounding area.

2.6 Strategic Approach to SuDS

When a site is developed impermeable surfaces and artificial piped drainage systems are introduced. As a result, natural drainage patterns are disrupted and surface water runoff rates and volumes increase with a resulting increase in downstream flood risk and diffuse pollution entering the water environment.

A proposed Strategic Surface Water System concept has been developed to determine outline requirements, potential locations and required volumes for the treatment and attenuation facilities at a development scale. Flows from the developments, which will have passed through source control, will then flow into the strategic surface water systems to be conveyed, further treated and attenuated prior to discharge at greenfield rates to the receiving watercourses.

2.6.1 Green Roofs

Green roofs can be considered to help prevent increased runoff and should be used where possible as a source control technique within a well designed SuDS network. For the Johnstone site an aspirational target for incorporation of green roofs should be set for the development. However on a plot scale this coverage will be hard to enforce, so the aim is to focus green roof coverage on larger residential blocks commercial and educational buildings.

The benefits of green roofs are widely published. It is recognised that they have a lower benefit-cost ratio than other SuDS elements from a purely water management perspective, but the non-tangible benefits are significantly wider; improving habitats, reducing visual impacts and also having good thermal properties at a building scale. Green roofs can be implemented within the housing typologies to create amenity value, providing open space, private gardens etc.

Photo 1 – Green Roofs on a Modern Development

Green roofs of arbitrary target e.g. 10% within new developments

2.6.2 Rainwater Harvesting, Recycling and Water Butts

Rainwater harvesting and recycling is a useful opportunity for water conservation, for example when hosepipe bans are in place.

Grey water recycling is also a possibility for the larger commercial and flatted areas. Reuse of water and rainwater etc can radically reduce the overall water consumption of a development.

Water butts have a limited scope to provide attenuation as they are often left full. The butts can be modified so that they have a throttled overflow from the butt ensuring that there will be available capacity when there is a storm event.

The main areas where this will be a viable measure is in larger residential flatted developments where a larger scale approach can be adopted. However, wide scale residential application of water butts can be shown to provide significant benefits, through reducing peak runoff rates by ~15% by capturing and slowing extreme convective short duration rainfall events which can present a significant threat of pluvial flooding within urban areas.

Enforcing the use of water butts and rainwater harvesting on a plot scale will be extremely difficult. If the butts are proposed to be incorporated into the attenuation storage for the development then this should be modelled.

2.6.3 Source Control

As part of the development process the developer will still be required to provide onsite source and site controls. There are a number of options available such as swales, lined permeable paving, filter strips etc. It is advised that guidance in CIRIA C697 – *The SuDS Manual* is followed when providing source control at each development site.

When the source control elements are being considered the underlying principles of the SWMS should be incorporated and used to guide the overall design.

The enforcement of long term management of source control elements within private curtilage is currently limited, where possible urban design elements should be kept within the public domain, i.e. provide community parking areas which can comprise of permeable paving and can be adopted within SuDS for Roads guidance.

Community parking will facilitate permeable paving inclusion and maintenance

2.6.4 Drainage/Conveyance Paths

The strategic system should include surface drainage paths where possible, which could include open water courses to receive flows from roof runoff from within development areas. These watercourses can be incorporated within the urban design to provide additional capacity in the event of extreme rainfall events.

Within individual development areas, blue-green corridors can be situated which are designed to be open green space or act as access through the site on a day to day basis but during a storm event will convey flood waters in open swale channels or a series of small basins.

It is important that a maintenance program is implemented to ensure that such corridors do not become blocked with litter and debris.

2.6.5 Exceedance Routes

It is proposed that as a minimum, open channels or water-bodies will be designed to accommodate the predicted flows up to the 0.5% AEP event (equivalent to 200 year return period events) plus climate change. By integrating these watercourses with roads, footpaths, cycleways etc. there is an opportunity to create routes for exceedance flows, those greater than the 0.5% AEP event. Exceedance routes will be utilised during extreme rainfall events that have the potential to temporarily overwhelm individual elements of the drainage system such as road drains.

It is recommended that the strategic drainage system should be able to convey the 0.5% AEP event plus climate change flows as a minimum design requirement. Quantity of flow will be determined and through the detailed design and development of the Surface Water Management Plan (SWMP).

These overland flow routes can in effect be regarded as surface water floodplains. As stated above they need to be managed as a fluvial floodplain would, being kept clear of development or managed in such a way as to benefit the site and avoid flooding of properties.

2.6.6 Storage Areas

The strategic surface water systems should incorporate regional storage areas in the form of storage or detention basins. These will primarily provide treatment of flood waters and attenuation of runoff to ensure that discharges to the surrounding watercourses are not increased as a result of the development. A permanent water body, like ponds or wetlands, would provide a treatment volume area, with the area outside the waterbody i.e. the surface water floodplain, flooding during extreme rainfall events.

> Introduce 'Surface Water Floodplains' as specific terminology, which relates to the areas that are designed to flood during extreme rainfall events. These areas are part of the Strategic Surface Water System, but not part of the SuDS design, which can remove some of the burden associated with adoption, maintenance and primary use.

Depending on the outcomes of the design study for the area, future storage provision can be developed to include natural aspects incorporating open space and environmental habitat enhancement, or incorporated within the urban design as water features to create a waterfront ambience to the future developments.

The permanent treatment volume (VT) held within these storage areas has previously been kept out of the 0.5% AEP floodplain similar to the attenuation volume.

Future storage provisions can be developed to included natural aspects incorporating open space and environmental habitats and enhancement or incorporated within the urban design as water features to create a waterfront ambience to the future developments, depending on the outcomes of the design study for the area.

The above is discussed further in **Appendix B**.

2.7 SuDS Selection

Through assessment of the ground conditions, topography, available land and required design criteria; the management train approach has highlighted a range of possible options appropriate for the site. The types of SuDS have been chosen and the design study developed around the water, habitat and road infrastructure. Once the design study has been developed the SuDS features are sized according to the contributing areas. An iterative process with development of the design study is required to ensure equilibrium between the surrounding development and the required infrastructure.

Measures taken across the entire site to prevent and reduce runoff include:

- Prevention; this is the first aspect of the SuDs management train, the amount and extent of paving throughout the development area should be minimised.
- Reduction; where possible the volume of water connecting to drainage systems should be reduced through infiltration, rainwater recycling or reuse to prevent runoff.
- Source control; should be used as a first level of treatment throughout the sub-catchments using permeable paving and green roofs where practical.

Sub-catchment 1

Apply the principles set out above with regards to prevention and source control measures.

Sub-catchment 1 is located in the upper urban Swintrees burn catchment area and consists of approximately 5ha in area. Both combined sewer systems and separate storm water systems are in place within the sub-catchment boundaries. The sub-catchment consists mainly of medium density residential housing and peripheral green areas. The Spateston Road South thoroughfare partially wraps around the estate with the exception of the eastern extent which consists of a large green area located at the Swintrees and Spateston Burn catchment threshold. No new development is envisaged occurring in the design study, however some housing stock may be refurbished.

Renfrewshire Council records note a problematic historical flooding point located in sub-catchment 1 at Spateston Road South in the western regions of the sub-catchment where runoff from the surrounding hills periodically causes flooding of the road. The flood water subsequently enters both the foul and surface water systems which cannot cope with the additional rural runoff during heavy rainfall events.

The general approach taken in sub-catchment 1 has been to retain as much runoff as possible within the sub-catchment in order to reduce the need for much larger attenuation volumes in the lower sub-catchments where the design study envisages extensive new developments being built. The residential area may be suitable for disconnection from the combined sewerage system and a pond/wooded wetland feature would formally capture and attentuate much of the storm water as well as runoff currently causing problems for the Spateston Road South, see **Photo 2**.

Photo 2: Sub-catchment 1 - Pond/Wooded Wetland

It is considered that multiple smaller ponds/wooded wetlands may be preferable to very large pond/wetland areas which conceivably could attract large flocks of migrating birds and thus materially enhance the risk to aeroplanes flying to/from Glasgow Airport, located 4.3km from the sites eastern perimeters.

It is anticipated that the proposed offline attenuation pond/wooded wetland SuDS feature in sub-catchment 1 will be connected or in *WinDES* modelling terms ‘cascaded’ to a larger pond/wooded wetland area situated downstream in sub-catchment 2. Where possible in sub-catchment 1, flows would be conveyed on the surface from source controls e.g. in swales, to site controls. Swales are much easier to maintain in good condition than the small pipes of the surface water drainage network. Surface water flood routes and temporary floodplain areas, created by appropriate landscaping, would be normally dry and used by the public with the exception of during extreme rainfall events. See **Figure 2.7a to 2.7d, Appendix A** for SuDS layout and sizes. Although sub-catchment 1 is relatively steep in its upper regions, the location of the pond/wooded wetland is relatively planar suiting a SuDS feature which would discharge controlled flows into conveyance structures at green field runoff rates.

Sub-catchment 2

Apply the principles set out above with regards to prevention and source control measures.

Sub-catchment 2 is located lower in the lower Swintrees burn catchment and consists of approximately 11ha in area. Both combined sewer systems and separate storm water systems are in place within the sub-catchment boundaries. The sub-catchment consists of medium density residential housing areas in the upper areas, with St.Anthony’s primary school and the now demolished brownfield site of St.Cuthberts secondary school situated in the lower regions.

It is envisaged that new residential areas will be developed in the upper and lower parts of the sub-catchment including a Community Growth Area (CGA) outside the arbitrary study site boundary to the west and north-west of sub-catchment 2. A schematic of the design study development areas in the Spateston catchment is shown in **Figure 2.3c, Appendix A**. This introduces the opportunity to provide larger more holistic regional controls, see **Photo 3**, and to create SuDS buffer features between any new developments and the Swintrees burn. New development also provides the opportunity to implement source control systems such as permeable paving for underground storm water storage as well surface SuDS systems like swales for road and curtilage drainage. However, it should be noted that part of the lower sub-catchment, notably the Renfrewshire Council zoned 'active recreational open space' in the grounds of the derelict school, may be unsuitable for infiltration SuDS due to the presence of potentially contaminative land, see **Figure 2.7f, Appendix A**.

Photo 3: Sub-catchment 2 - Pond/Wooded Wetland

Connections between permanent water features should be through surface water connections, relying only on pipes systems when the crossing of roadways is required. It is envisaged that the conveyance swales from sub-catchment 1 will link with those in sub-catchment 2 and subsequently lead to the larger pond/wooded wetland area located to the north-west of sub-catchment 2. This can be sized to account for future developments in the overall Swintrees catchment to occur. The pond/wooded wetland site itself is located in an area where future housing plots are unlikely to occur due to the proximity of prominent overhead power lines. The required treatment volume will be captured and held in the pond/wooded wetland feature, prior to discharging to the Swintrees burn at attenuated green field runoff rates.

Sub-catchment 3

The principles set out above with regards to the prevention and source control measures are applied throughout.

Sub-catchment 3 is located in the upper urban Spateston burn catchment and consists of approximately 5.6ha area in total. Both combined sewer systems and separate storm water systems are currently in place within the sub-catchment. The sub-catchment consists of medium density residential housing area and a large green space area located lower in the sub-catchment.

The design study does not envisage any new development of housing stock in the area, though some refurbmishment may occur. As confirmed by Renfrewshire Council, the traditional combined and storm sewer pipe systems in the sub-catchment are under specified are no longer a sustainable solution.

The approach has been taken to attentuate as much runoff as possible in sub-catchments such as sub-catchment 3 which are in the urban upper areas of the Spateston catchment. As the greatest pluvial flooding affects occur in the lower sub-catchments e.g. 5 and 6, the capture and attentuation of flows here with subsequent controlled release back to the Spateston burn will reduce the flooding affects in the downstream catchment as well as reducing the spill frequency and

Photo 4: Sub-catchment 3 – Detention Basin

volume of CSO spills occuring downstream. It may be possible to disconnect some or all of the housing from the existing combined sewerage system areas in the sub-catchment with the storm waters being directed to a detention basin at the lower end of the sub-catchment in a large green field area, see **Photo 4**.

Source controls which could be implemented in the sub-catchment include conveyance swales combined with appropriate temporary floodplain landscaping which would direct and control storm runoff. The retrofitting of permeable paving in the large existing communal car parks of the residential area would be desirable.

The detention basin could have dual recreational / flood attenuation purposes for the surrounding residential area. Its anticipated that the SuDS features be combined as a network of interconnected surface storage areas providing treatment and attenuation of runoff from extreme events, together with a system of exceedance routes created by landscaping and the directing of overland flow towards the detention basin, in essence creating a surface water flood route. The locating of the detention pond in the green area should minimise the surface water burden at the local mini shopping centre located nearby downstream in sub-catchment 5 which experiences periodic surface water flooding and should also reduce flood volumes in other sub-catchments further downstream.

Sub-catchment 4

The principles set out above with regards to the prevention and source control measures are applied throughout.

Sub-catchment 4 is located in the upper urban Spateston burn catchment and consists of approximately 7ha area in total. Both combined sewer systems and separate storm water systems are currently in place in the sub-catchment. The sub-catchment currently consists of medium density residential housing areas and large swathes of managed green space located to the western and southern limits. Again, the approach has been taken to try retain as much runoff as possible in the sub-catchment, located higher up the Spateston catchment. It is envisaged in the design plan that a section of new development could occur to the north of Spateston road in the presently green space area.

A Renfrewshire Council flood prevention scheme was built on the Spateston burn adjacent to the proposed developable green space area. Under storm conditions, a high flow rate occurs in the Spateston burn due to the steepness of the surrounding upland rural catchment which in the past has caused the back up of flows due to the presence of a culvert entry point. This culvert may need to be upsized or removed to accomadate storm flows from the Spateston Burn and to lessen the flood risk to any potential development on the adjacent green site, see **Figure 2.1b, Appendix A** for pluvial flood map.

The residential areas in sub-catchment 4 contributing to the combined sewer networks may be suitable for storm water disconnection and the large expanse of green space to the west lends itself as an ideal location to capture and convey excess surface water to an attenuation pond or wooded wetland located to the south of the sub-catchment, see **Photo 5**.

Photo 5: Sub-catchment 4 - Pond/Wooded Wetland

The swale(s) from the residential areas would need to be culverted under the Spateston road to the football pitch, in current dis-repair, containing the proposed basin. Anecdotal evidence is available from the Urban Water Technology Centre that flooding has occurred on the football pitch in the past. The basin has the potential to be a dual purpose ‘basin-football pitch’. The basin would provide enhanced water quality for rainfall from the upstream catchment and attentuate water during heavy rainfall events helping to alleviate flooding problems occurring further downstream. The collected rainwater in the basin would then be discharged via a control into the Spateston Burn at attenuated greenfield runoff rates.

Space is available to potentially de-culvert or 'day-light' the Spateston burn from the present culvert entry pinch point. The burn becomes culverted for approximately 0.5km from this culvert near Churchill Avenue and continues down to Corseford Avenue before the channel re-opens beyond the main Irvine to Glasgow railway for a further 150m before joining the Black Cart River.

Sub-catchment 5

The principles set out above with regards to the prevention and source control measures are applied throughout.

Sub-catchment 5 is located in the lower urban Spateston burn catchment and consists of approximately 4ha area in total. Both combined sewer systems and separate storm water systems are currently in place in the sub-catchment. The sub-catchment consists of medium density housing and a mini-market shopping centre. It is envisaged that the aging mini-market shopping centre will be extensively re-developed and new residential dwellings created in areas both north and south of the centre.

Sub-catchment 5 experiences extensive fluvial flooding under the 0.5% storm event, see **Figure 2.1b, Appendix A**. It is understood from previous studies[6] in the area that the culverted Spateston burn at the eastern margin of the sub-catchment becomes surcharged under large storm events causing a build up of capacity in the sewerage system which subsequently causes the overtopping of manholes in the sub-catchment.

For sub-catchment 5, a positive flood alleviation influence would be the disconnection of some, or all, of the residential and commercial buildings from the combined sewerage network and for the capture and attenuation of the storm water until the peak storm intensities have sub-sided.

Photo 6: Sub-catchment 5 - Pond/Wooded Wetland

Hence, the required treatment volume could be captured and held at the end of the sub-catchment in the existing green space land adjacent to Hallhill road prior to discharge to a pond/wooded wetland at attenuated greenfield runoff rates into the Spateston Burn, see **Photo 6**. The potential to 'day-light' the culverted Spateston Burn in this area combined with the new attenuation pond/wooded wetland could help alleviate much of the fluvial flooding problems experienced on Beith road, the main arterial route through the Johnstone area.

De-culverting can help with flood alleviation but in conformity with *Water Vision* idealisms it can also bring wider environmental benefits to the sub-catchment. As seen in sub-catchment 4, there are already a variety of vegetation types close to the existing open channel sections of the Spateston burn which provide a diversity of habitat to support many terrestrial species and a continuous riparian corridor created by broadleaved trees, tall herb vegetation and wet grassland providing ideal cover for the movement of many animals and birds which could potentially include species such as otter.

Sub-catchment 6

Sub-catchment 6 is located in the lower urban Spateston burn catchment and consists of approximately 5.5ha area in total. Both combined sewer systems and separate storm water systems are currently in place in the sub-catchment. The sub-catchment consists mainly of medium to high density housing and associated infrastructure. It is envisaged in the design study that no new development would occur in the sub-catchment. As with sub-catchment 5, pluvial flooding is a problem in the area where sewer systems cannot cope with the influx of storm waters under storm conditions.

[6] JBA Johnstone Pilot Study 2008

Hence, it is considered worthwhile to find residential areas suitable for disconnection in the sub-catchment and for the attenuation of the storm water before its controlled discharge to the de-culverted Spateston Burn after the peak event has subsided. Where possible in the sub-catchment, surface water drainage should be kept on the surface and conveyed via swales/exceedance surface water flood routes to the site control, providing further treatment and attenuation. The required treatment volume could be captured and held within a pond/wooded wetland located adjacent to Fordbank primary school, see **Photo 7**. It is considered that a pond/wooded wetland would attenuate and treat storm flows as well as act as an amenity/educational area for the school. Safety fears which may arise due to proximity to school children could be address by erecting fencing and planting barrier vegetation to inhibit full access to the pond/wetland or the building of a walkway around or through the pond/wooded wetland.

Photo 7: Sub-catchment 6 - Pond/Wooded Wetland

It is recognised that this is a tightly constrained sub-catchment and works would involve substantial development and alterations in the estates. However, the works in the long term could significantly alleviate existing flooding issues. The influence of the attenuation capacity of the pond/wooded wetland would have a positive influence on the existing flooding problems downstream in the Tay Place area of sub-catchment 8. The pond/wooded wetland could be piped to a conveyance swale discharging into the Spateston Burn. Similar to sub-catchments 4 and 5, the Spateston Burn is currently culverted under sub-catchment 6 and has the potential to be ‘day-lighted’ bringing multiple environmental benefits.

Sub-catchment 7 and 8

Sub-catchment 7 and 8 are located at the lower end of the Spateston catchment and consists of approximately 7ha and 5.6ha respectively. Both combined sewer systems and separate storm water systems are currently in place in the sub-catchments. The sub-catchments comprise relatively high density residential development including some new ribbon development adjacent to the presently culverted Spateston burn. There are no substantial amenity areas in the sub-catchments, see **Photo 8**.

Photo 8: Sub-catchment 7&8 - Pond/Wooded Wetland

A Combined Sewer Overflow (CSO) is located in the upper area of sub-catchment 7 which is periodically opertaional. It is considered that the CSO spill volumes and frequency of use can be reduced due to the storm water attenuation measures implemented in the upstream sub-catchments, if applied. No substantial green or amenity areas exist in sub-catchments 7 and 8 which could accomadate larger SuDS features like ponds. Hovever, some runoff in the sub-catchments themselves could be attenuated by the retrofitting of SuDS measures such as permeable paving and rain-water harvesting.

The potential for the de-culverting of the Spateston Burn, located at the border between the two sub-catchments, has been significantly reduced in this area due to the proximity of a strip of new housing developments backing onto the culvert path. However, this may still be possible following a detailed investigation of the area and in the long term is considered desirable.

Sub-catchment 9

Sub-catchment 9 is located in the Floors Burn catchment and consists of approximately 29.9ha area in total. Both combined sewer systems and separate storm water systems are currently in place in the sub-catchment. The sub-catchment consists of medium density housing, a large brownfield site, green space areas and Johnstone High School which incorporates a large public recreational green area in its surroundings. The 'Cochrane Castle' 18hole golf course borders sub-catchment 9 to the south. A new residential development is envisaged in the design plan for the presently green space area to the west of the sub-catchment. It is envisaged that sections of new development would occur to the east and north of the sub-catchment, see **Figure 2.3c**, **Appendix A**.

Sub-catchment 9 experiences some periodic surface flooding issues. The sub-catchment is bisected by Beith road. During heavy rainfall, Renfrewshire Council have confirmed that Beith road experiences flooding due to the blockage of drainage pipes with grit washed from the Johnstone High School's blaze football pitches which can close the road to traffic. Another problematic area is found in the Auchengreoch Avenue estate to the east of the sub-catchment which consists of a combined sewerage system which has previously caused surface flooding due to the manholes in the area becoming surcharged due to the lack of sewer capacity in storm events.

Culverting of the Floors Burn begins at Auchengreoch Avenue and continues for approximately 1.4km, passing beneath the grounds of Johnstone High School, traversing into sub-catchment 10 and crossing under Beith road into sub-catchment 11 before emerging as an open watercourse at Shanks Cresent, located just outside the northern Johnstone site boundary.

Many of *Water Visions* provisions for flood management and aspirational objectives can be achieved in this area if measures taken in sub-catchment 9 are combined with measures connected with its adjacent sub-catchments 10 and 11.

- De-culverting of the extensively culverted Floors Burn as well as possible re-direction of the watercourse
- Disconnection of the storm water in residential areas from the combined sewage system
- Creation of new / re-developed residential areas around sections of the de-culverted Floors Burn watercourse
- Potential for the creation of extensive new linked habitats and biodiversity areas
- Potential for the creation of educational areas in close proximity to schools
- Implementation of SuDs features including ponds, wetland, permeable paving and green roofs

A possible re-location of the football pitches at Johnstone High School may need to occur or a pond/wetted woodland site control could have dual recreational/flood alleviation purpose, see **Photo 10** overleaf. Seperate storm waters sewers could be constructed for the new development areas which under storm conditions would be directed to the site control via a system of swales and underground pipes.

The pluvial flooding extent map, see **Figure 2.3c, Appendix A**, shows there is considerable overland flows in the region of the Johnstone High playing pitches and on Beith road where the capacity of the Floors Burn culvert is overwhelmed in storm conditions. These flows could be formally channel into the appropriately sized online pond/wooded wetland.

A possible re-direction of the currently culverted Floors Burn in sub-catchment 9 could occur with a new linkage created with sub-catchment 11. The rationale behind this is that it would help alleviate the culvert under the Beith road from becoming blocked with runoff material from the football pitches and would enable a significant new design feature to occur in the re-developable lands of sub-catchment 11 where a lack of features has been flagged as a problem in the area.

Photo 10: Sub-catchment 9 - Pond/Wooded Wetland

Sub-catchment 10

Sub-catchment 10 is located in the Floors Burn catchment and consists of approximately 28.5ha area in total. Both combined sewer systems and separate storm water systems are currently in place in the sub-catchment. The sub-catchment consists of a mix of medium density newer private development to the west and older mainly council owned dwellings to the east of the sub-catchment. A petrol station fronts onto Beith road and 2 large green areas are located within the sub-catchment. New residential development areas are envisaged in the design plan to the north and west of the sub-catchment.

Photo 11: Sub-catchment 10 - Pond/Wooded Wetland

An existing large privately build development to the west of the sub-catchment contains a separate strom water system discharging to the Floors Burn culvert leading from sub-catchment 9. Storm water flows to a proposed new pond/wooded wetland, see **Photo 11**, located in the green area to the north-west of the catchment could emanate from new storm water sewers and the possible disconnection of storm water from houses in the existing residential areas.

The influence of the attenuation capacity of the pond/wooded wetland should have a positive influence on the existing pluvial flooding problems in the catchment and similarly downstream in sub-catchment 11. Where possible water should be kept on the surface in the form of swales and exceedance

routes to the site control. Due to space issues in sub-catchment 1, the swales may possibly be kept to the western boundary of the sub-catchment, adjacent to the Cochrane Castle golfcourse.

Sub-catchment 11

Sub-catchment 11 is located in the Corseford catchment and consists of approximately 10.6ha area in total. Both combined sewer systems and separate storm water systems are currently in place in the sub-catchment. The sub-catchment consists of poor quality housing principally consisting of terraces of flatted four in a block properties dating from the 1930's and a large brownfield site. The sub-catchment is constrained by a railway line embankment running to the north. A large victorian 'Thomas Shanks' public park is located in the eastern regions of the sub-catchment which contains well maintained open space, mature trees and sport facilities. It is envisaged in the design plan that in addition to the construction of new residential development areas, the layout of the existing plots may be re-modelled, both at a housing scale and a larger area scale to integrate the region more with the surrounding sub-catchments, aided by the creation of improved more user friendly links.

Renfrewshire council have reported that on numerous occasions flooding has occurred at the road gully outside No 100 Greenend Avenue which, is situated at a low spot in the sub-catchment. Council employees have reported foul sewage backed up into the gully chamber pot, even when flooding has not occurred. CCTV did not identify any operational problems. It is thought that there is a lack of capacity in the downstream sewers from Greenend Avenue. No properties have been identified as 'at risk' of internal flooding.

Most of the current pluvial flooding occurs at the re-developable brownfield site to the south and in Thomas Shanks Public Park. The approach has been taken to continue to de-culvert the Floors Burn from the upstream sub-catchment 9 with the possible re-routing of the Floors Burn to run adjacent to Beith road, creating an identifiable and attractive feature around which re-alignment of the housing stock could occur.

For sub-catchment 11, the required treatment volume can be captured in two locations, to the east of the current brownfield site aadjacent to Dundonald Avenue and to the north-west of St.Davids Primary School in Thomas Shanks Park. These would discharge at attenuated greenfield runoff rates back to the Floors Burn and an area of surface water floodplain would be provided around the permanent pond features to aid attenuation of surface water runoff in storm conditions.

Photo 12: Sub-catchment 11 - Pond/Wooded Wetland

Wider environmental improvements can be realised through the complete redevelopment of the sub-catchment area and the disconnection of extensive areas contributing the combined sewer system, thereby improving on the existing flood risk and diffuse pollution from the combined sewer system.

A similar approach is taken to retain runoff within the new development area by utilising the storage volume available with permeable paving and also within the conveyance system using open swales for road and curtilage drainage as space is currently available. These swale features are combined as a network of surface storage areas with the drainage exeedance routes providing treatment and attenuation of runoff from extreme events in essence, creating a surface water flood route. These surface water routes would normally be dry and may be areas of open green-space or other areas with public access, or otherwise utilised by the public for the majority of the time with the exception of during extreme rainfall events.

Sub-catchment 12

Sub- catchment 12 is located in the Craigbog Burn catchment and consists of approximately 17.5ha area in total. Both combined sewer systems and separate storm water systems are currently in place in the sub-catchment which consists principally of medium to high density housing and occasional green areas. No new development is envisaged in the design plan for sub-catchment 12.

Despite no new scheduled development, it is envisaged that retrofit SuDS measures could be implemented in the sub-catchment due to available space with the overall aim of reducing the frequency of operation of a CSO located downstream in sub-catchment 14 at 'The Crikey' green area.

Disconnection of the storm water from the existing residential areas in sub-catchment 12 may be possible with the flows following an elongated swale structure running throughout the sub-catchment in the green areas adjacent to the 'Sycamore Avenue' and ending in a pond/wetted woodland situated in 'The Crikey'.

Photo 13: Sub-catchment 12 – Swale Feature

Sub-catchment 13

Sub-catchment 13 is located in the Craigbog Burn catchment and consists of approximately 9.9ha area in total. Both combined sewer systems and separate storm water systems are currently in place in the sub-catchment. The sub-catchment consists principally of medium density housing. No new development is envisaged in the design plan for the existing residential areas.

To help alleviate the volumes of flows currently experienced in the sewerage system, especially in sub-catchment 14, disconnection of the storm water from the residential areas may be possible with the flows leading to a large pond/wetland in 'The Crickey' green space area.

Sub-catchment 14

Sub-catchment 14 is located in the Craigbog Burn catchment and consists of approximately 23.6ha area in total. Both combined sewer systems and separate storm water systems are currently in place in the sub-catchment. The sub-catchment consists principally of medium density housing with a large green space area to the north-west. It is envisaged in the design study that some new housing re-development could occur in an existing residential area of 'Ash Place' and 'Heather Place'.

A recent storage tank has been built by Scottish Water in 'The Crikey' green area emphasing the high volume of flows the culvert is experiencing under storm conditions and which is causing flooding problems.

Again, disconnection of the storm water from the residential areas of sub-catchment 14 may be possible with the flows leading to a large pond/wetland in 'The Crickey' green space area.

Photo 14: Sub-catchment 14 - Pond/Wooded Wetland

The design study has been developed around these proposals and the SuDS modelled based on the contributing area, see **Appendix B** for details. A detailed feasibility study has not been carried out on swale widths and de-culverted channels widths in their proposed locations. **Table 2.3** sets out the required treatment and attenuation volumes for the individual sub-catchments based on a 50% impermeable area.

Table 2.3 – Summary of SuDs Scheme

Sub-catchment	Developed Area (ha)	Treatment Volume (m^3)	Attenuation Volume (m^3)	Type of Detention
1	2.34	825.55	1660	Pond / Wetland
2	5.55	1958.04	5920	Pond/Wetland
3	2.78	980.78	1970	Detention basin
4	3.52	1241.86	2850	Pond / Wetland
5	2.044	721.12	1570	Pond / Wetland
6	2.74	965.40	2130	Pond / Wetland
7	3.5	1234.80	2575	Pond / Wetland
8	2.79	984.31	1960	Pond / Wetland

9	14.95	5274.36	11900	Pond / Wetland
10	14.3	5045.04	10800	Pond / Wetland
11	5.3	4720.46	3900	Pond / Wetland
12,13,14	21.6	7620.48	15300	Pond / Wetland
Total	82	31572.21	62535	

Further details of the modelling of the Strategic Surface Water Systems is presented in **Appendix B.**

Table 2.4 sets out the required treatment and attenuation volumes for the interim proposed developable areas i.e the developable areas outlined in the design plan, see **Appendix A**, **Figures 2.3c-2.3e**, based on a 40% impermeable area scenario.

Table 2.4 – Summary of Interim SuDs Scheme

Sub-catchment	Developed Area (ha)	Treatment Volume (m^3)	Attenuation Volume (m^3)	Type of Detention
1	n/a	n/a	n/a	n/a
2	2.02	713	1350	Pond/Wetland
3	n/a	n/a	n/a	n/a
4	0.2	112	230	Pond / Wetland
5	0.72	254	499	Pond / Wetland
6	n/a	n/a	n/a	n/a
7	n/a	n/a	n/a	n/a
8	n/a	n/a	n/a	n/a
9	1.08	381	712	Pond / Wetland
10	1.47	518	969	Pond / Wetland
11a	0.74	261	476	Pond / Wetland
11b	1.11	390	713	Pond / Wetland
14	0.39	35	51	Pond / Wetland
Total	82	2664	5000	

2.8 Proposed Development

Collective Architecture and AECOM's approach to the design study has been to add value to the site through creative and exemplar design of the infrastructure systems and the development of the design study to support this. Collective Architecture has put forward a design study that encompasses the water environment, natural hydrological process and green spaces and natural aspects of the six candidate sites. The design is influenced by understanding the hydrological cycle, the basis for implementing SuDS and considering how the urban infrastructure can be best placed with the development to provide a holistic approach to design.

The principles set out above are the basis upon which the design study was developed.

Minimise developed surfaces and Maximise permeable surfaces to:

- **Minimise effect on natural hydrological cycles**
- **Minimise required mitigation measures**
  - **Reduce attenuation and treatment volume requirements**
- **Optimise developable land**

3 Surface Water Management – Setting a New Agenda

A risk based approach to creating better living and working places

Set out in the Technical Baseline report, are the current policies for adoption and maintenance of SuDS features. Throughout this project the opportunity has been taken to assess how these policies might be changed in the future to improve the integration of SuDS into new developments. The focus of the project also allowed us to consider how best to integrate the SWMS and SuDS into the development and overcome safety issues associated with large bodies of permanent water.

One of the challenges to overcome with SuDS features in developments is how isolated they become once they are fenced off or placed at the back of development areas, becoming cut off from the public and increasing the perception of the hazard. Throughout this process we have considered how water features can create a 'sense of place' within a development or create blue/green corridors through the site which provide both access and conveyance of flood water through the site.

3.1 Setting a New Agenda

With large bodies of permanent or temporary water there are inherently health and safety challenges to be overcome. Sewers for Scotland 2nd edition states stringent safety requirements which have been adopted by Scottish Water and local authorities in the past when designing ponds and detention basins. The following is a list of the main safety features:

- Signs and safety equipment should be provided;
- Vertical drops over 1.2m should be fenced;
- Aquatic benches should be planted with appropriate species to achieve a high density barrier, which will dissuade people from trying to get access to the open water;
- Signs denoting any infrequent and temporary flooding areas, warning against swimming should also be provided; and
- Barrier fencing must be provided at all detention ponds. All access gates must be lockable with a minimum fence height of 1.1m.

Whilst many of these aspects are good design attributes, they create a series of design standards which result in standard designs. These requirements are normally applied often without thought to the individuality of the site and the surrounding development.

Our aim for this exemplar site is to push the boundaries for existing policies and look at the design of the individual SuDS components. Our aim is set out in a quote taken from the newly released designing streets document:

'…..design should derive from an intelligent response to location, rather than the rigid application of standards, regardless of context. Designing Streets does not, thus, support a standards based methodology for street design but instead requires a design-led approach. This demands taking into account site specific requirements and involves early engagement with all relevant parties. Designing Streets marks the Scottish Government's commitment to move away from processes which tend to result in streets with a poor sense of place and to change the emphasis of policy requirements to raise the quality of design in urban and rural development.'[7]

The above clearly emphasises that each individual design element should be looked at on its own merits with the risk and benefits assessed and an appropriate solution found for the specific situation.

Health and safety is a key area of debate in recent times with the UK as a whole being more and more safety conscious. There have been numerous cases brought forward where an individual has sued a land owner for lack of safety cover on their land. The following are quotes from the judgements reached in previous cases relating to public safety:

[7] A policy guide for Scotland – Designing Streets

'If the danger is obvious, the visitor is able to appreciate it, he is not under any kind of pressure and he is free to do what is necessary for his own safety, then no warning is required. So, for example, it is unnecessary to warn an adult of sound mind that it is dangerous to go near the edge of an obvious cliff'. Exceptions – where there is no informed choice, where the individual lacks capacity – eg a child[8]

'Clear from case law that the duty imposed upon an occupier does not extend to providing protection against obvious and natural features of the landscape. Therefore there was no duty to provide fencing, warning signs, or notices[9]'

'It is a fallacy to say that because drowning is a serious matter that there is therefore a serious risk of drowning.'[10]

Where the surface water management system being incorporated into a development has bodies of permanent water it will be necessary to provide safety cover in places. However, to completely fence off all water bodies from public access would go against the design aim for this project. Including water infrastructure into the development and using these areas as public space will entail breaking with the standard requirements set out above. To ensure the benefits of adding this amenity to the development out way the risks, careful design measures must be put in place such as:

Where there is obvious risk i.e. permanent deep water close to developments, ensure fencing is provided;

Recognise that people want access to water, therefore, provide access to the water at specific locations and ensure a large shallow bay is designed to minimise the risk of an incident occurring;

Provide educational boards for the public to appreciate the wetland/ponds for their dual purpose of water quality treatment and as an amenity value;

Photograph 4: Public access to water features

To set a new agenda with regards to SuDS safety requirements, sound reasons and design should be put forward to enhance the way the public view these features and how they can be used for dual purpose adding value to an area as well as providing a service.

[8] Cotton v. Derbyshire Dales D.C.(June 10, 1994, CA, unreported). From Darby v National Trust

[9] Struthers-Wright v Nevis Range Development Co PLC [2006] CSOH 68 4 May 2006

[10] Tomlinson v Congleton, HL 2003

3.2 Adoption and Maintenance schedule

Adoption or 'Vesting' and maintenance has been a challenging subject since 2004 when SPP7 set out that the 0.5% AEP event should be used to control development in a sustainable manner. Whilst Scottish Water have a regulatory duty for drainage up to the 3.33% AEP event, there has become a 'void' in the ability for developers to have appropriate design vested and maintained within the public sector.

This issue has been recognised and there is now a significant change developing through the use of Section 7 agreements between Scottish Water and Local Authorities to provide an opportunity to develop and build appropriate surface water management systems and have these vested in public authorities. However, this issue is always likely to present a constraint to how integrated the urban infrastructure can become.

Therefore, for this exemplar site we have considered how the proposed SuDS elements should logically be adopted and maintained. The general principles set out below are based on considering the skills that exist within Local Authorities and Scottish Water, shared responsibility between these organisations and a recognition that a single surface water drainage system is the most suitable for the future.

- The strategic surface water drainage will attenuate and treat runoff from highways and curtilage alike;
- All systems conveying water from source to storage below ground designed to the 3.33% AEP event plus climate change are vested and maintained by Scottish Water;
- All surface water runoff in exceedance of the 3.33% up to the 0.5% AEP plus climate change will be adopted and managed by the local authorities. These could be in the form of exceedance routes running in line with the Scottish Water systems;
- Wet storage areas will have a permanent water body holding the treatment volume for the site, the vesting and maintainence of which can be agreed between Scottish Water and the local authority;
- Outwith this will be the 0.5% AEP storm event plus climate change 'surface water floodplain'. This will only under extreme conditions be used and will be maintained and adopted by the local councils as managed open space; and
- Inlets and outlets to the permanent water body will be vested and maintained by Scottish Water.

The principles set out above were formed through several workshops and several discussions between SEPA, Scottish Water, Collective Architecture and AECOM. Included in these discussions was external expertise from Chris Jeffries and Rebecca Wade from Abertay University and Robert Huxford of the Urban Design Group.

It was perceived that the maintenance and adoption challenges were prohibiting SuDS projects from reaching their full potential. To overcome this and ensure the schemes proposed for the six candidate sites site could be made a reality the current policies were reviewed. It was thought the below ground infrastructure was best vested by Scottish Water due to their specialism in that area. Other open areas such as swales or filter strips would be adopted and maintained by the local authorities. For the large SuDS components a different approach was taken as specified above where the permanent water body (vt) could be vested by Scottish Water. This permanent water body could be managed and maintained by Scottish Water. For flood events the land outwith the treatment volume would be treated as surface water floodplain and adopted by the local authority. **Table 3.2** sets out further information on how the adoption of individual SuDS elements could be shared.

We have set out a proposal for developing Strategic Surface Water Systems which provide a holistic catchment response to surface water management for future developments. Within these systems the Sustainable Drainage Systems are designed to perform specific objectives in terms of treatment and attenuation to a specific level of performance. Beyond these levels, surface water floodplains provide the additional land areas to manage flooding to the required planning criteria.

The introduction of surface water floodplain terminology changes the perception of these spaces to allow them to be seen as opportunities for good urban design as open space with amenity, being removed from the adoption and maintenance burden of SuDS.

Table 3.2 – Adoption Schedule

SuDS	Description	Management Train Suitability						Adoption/Vesting Schedule	
		Prevention	Conveyance	Pre-treatment	Source Control	Site Control	Regional Control	Out/Inlet Structure	General
Water Butts, site layout and Management	Good housekeeping and good design practice	♠	⊕		♠			LA / Landowner	LA
Pervious Pavements	Allow inflow of rainwater into underlying construction/soil	♠			♠	⊕		SW / LA (where required)	LA / Landowner
Filter Drain	Linear drains/trenches filled with a permeable material, often with a perforated pipe in the base of the trench		♠		♠	⊕		SW / LA (where required)	LA / Landowner
Filter Strips	Vegetated strips of gently sloping ground designed to drain water evenly from impermeable areas and filter out silt and other particulates			♠	♠			SW / LA	LA
Swales	Shallow vegetated channels that conduct and/or retain water. The vegetation filters particulates.		♠		♠	♠		SW / LA	LA
Ponds	Depressions used for storing and treating water. They have permanent pool and bank side emergent and aquatic vegetation					♠	♠	SW	LA / SW
Wetlands	As ponds, but the runoff flows slowly but continuously through aquatic vegetation that attenuates and filters flow.		⊕			♠	♠	SW	LA
Detention Basins	Dry depressions designed to store water for a specified detention time					♠	♠	SW	LA
Soakaways	Sub-surface structures that store and dispose of water via infiltration				♠			LA / Landowner	SW / LA
Infiltration trenches	As filter drains, but allowing infiltration through trench base and sides		⊕		♠	♠		LA	SW / LA
Green roofs	Vegetated roofs that reduce runoff volume and rate	♠		♠	♠			LA / Landowner	LA / Landowner
Pipes, subsurface storage	Conduits and their accessories as conveyance measures and/or storage. Water quality can be targeted using sedimentation and filter measures.		♠			♠		SW up to 3.33% AEP	SW up to 3.33% AEP
Exceedance routes	Any manmade route created for the diversion of pluvial flood waters.		♠					LA / Landowner	LA / Landowner

Key Symbols: ♠ - High/Primary process ⊕ - some opportunities subject to design, LA – Local Authorities, SW – Scottish Water

Any agreement on adoptions will require detailed proposals to be presented to the Local Authority and Scottish Water in advance in order to assess and approve any proposals prior to an agreement on adoption being made.

Table 3.3 – Maintenance Schedule

SuDS	Adoption/Vesting Schedule		Maintenance Schedule		
	Out/Inlet Structure	General	Inlet/outlets/Structures	Sediment/blockages andgeneral maintenance	Monitoring
Water Butts, site layout and Management	LA / Landowner	LA / Landowner	Annually/ when there is poor performance	Annually/ when there is poor performance	Annually/ when there is poor performance
Pervious Pavements	SW / LA (where required)	LA / Landowner	3 times annually	3 times annually or as required	Annually
Filter Drain	SW / LA (where required)	LA / Landowner	Half yearly	Monthly	Half yearly
Filter Strips	SW / La	LA	N/A	Monthly	Half yearly
Swales	SW / LA	LA	Monthly	Monthly	Half yearly
Ponds	SW	LA (SW maintains the permanent VT)	Monthly	1-5 years in forebay, 10 years to main quadrant	Monthly/half yearly
Wetlands	SW	LA	Monthly/ as required	Sediment removal every 25years / monthly removal of rubbish	Monthly/half yearly
Detention Basins	SW	LA	Monthly/after large storms	Monthly	Half yearly
Soakaways	SW / LA / Landowner	SW	Annually	Monthly within the first year then annually	Annually
Infiltration trenches	SW / LA	LA / Landowner	Half yearly	Monthly	Half yearly
Green roofs	LA/Landowner	LA/Landowner	Annually/ after a severe storm	6 monthly or as required	Annually / after a severe storm
Pipes, subsurface storage	SW up to 3.33% AEP	SW up to 3.33% AEP	Annually	Annually	Annually
Exceedance routes	LA / Landowner	LA / Landowner	Monthly	Monthly	N/A

The maintenance schedule can be tailored to site specific requirements, where factors can influence an increase or decrease in frequencies, also experience with the constructed system will provide a higher understanding of the performance of the system which can allow the maintenance schedule to be revised.

4 Recommendations

The Technical Baseline report highlighted the current conditions on site, the SWMS sets out how the design should be implemented to gain a zero impact scenario, i.e. no increase in flows to the Spateston, Floors and Craigbog burns, and appropriate management of surface water through strategic application of SuDS;

The design should be design lead **not** standards based;

In-curtilage areas should be kept as permeable land;

Treatment of current drainage from existing Johnstone development discharging directly to the burns will improve water quality and reduce the incremental contribution to flood risk from the watercourse downstream of the site. Incorporating existing drainage into the strategic surface water management system should be considered;

Surface water should be kept separate and managed on the surface where possible;

River restoration techniques should be applied to reaches of all the burns;

Follow full SuDS management train to maintain exemplar approach;

Maximise potential for environmental enhancement and benefit;

Aim for a 10% coverage of green roofs throughout the site, aimed to cover a majority of the flatted and commercial properties;

Promote prevention as the first line of defence, rainwater harvesting, and grey water recycling should be promoted throughout the site;

Community parking for developments should be utilised where possible to enable pervious paving to be used and maintained by the local authorities;

Treatment volume should be kept out with the 3.33% AEP floodplain and attenuation for runoff should be kept out with the 0.5% AEP floodplain, in essence creating a buffer between the urban and natural environment;

Conveyance networks should maximise treatment and minimise the need for large attenuation areas at the bottom of the sub-catchments;

Minimise impermeable surfaces to maximise developable land;

Establish a working maintenance and adoption schedule prior to development;

Drainage exceedance and conveyance networks can be for public access/use for the majority of the time;

Provide drainage exceedance routes throughout the site;

Communication with Network Rail needed for proposals adjacent to the railway line.

Ensure the water features enhance the surrounding environment;

Promote good safe practice by the side of water features to minimise the health and safety risk posed; and

Education about the use of the wetlands and detention areas should be provided throughout the site to highlight their multipurpose functions.

5 References

SPP - Scottish Planning Policy 2010

JBA Consulting – Interreg IIIB NWE Project 'Urban Water' Johnstone Pilot Study Final Report, August 2008

CIRIA C635 - Designing for Exceedance in Urban Drainage – Good Practice

CIRIA C697 - The SuDS Manual

CIRIA C644 - Building Greener

Urban Water Technology Centre of the University of Aberday, Dundee - 'Water Vision for Johnstone working Together', June 2007

A policy guide for Scotland – Designing Streets

Renfrewshire Local Development Plan – *Development Plan Scheme*, March 2010

Cotton v. Derbyshire Dales D.C. (June 10, 1994, CA, unreported). From Darby v National Trust

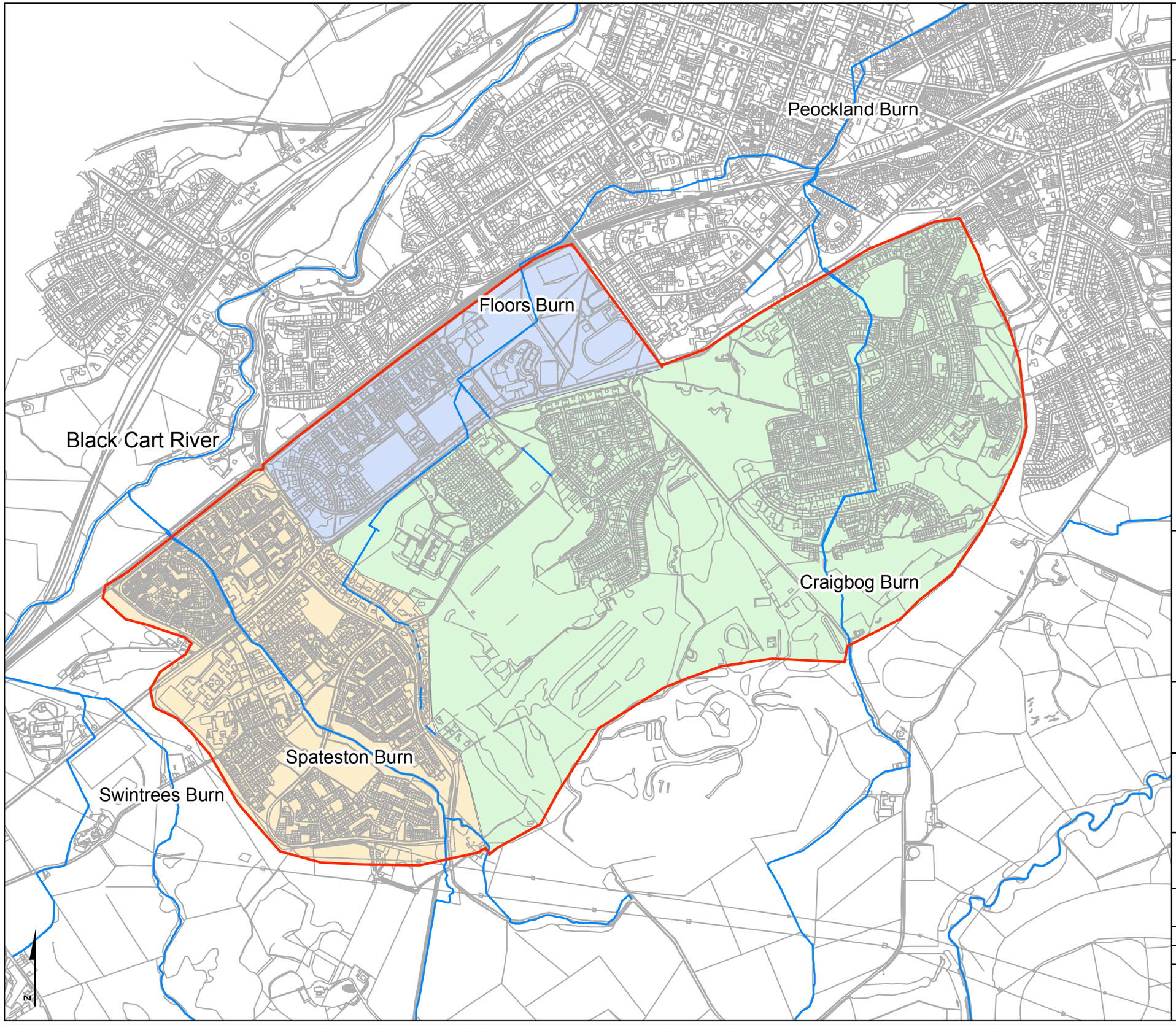
Struthers-Wright v Nevis Range Development Co PLC [2006] CSOH 68 4 May 2006

Tomlinson v Congleton, HL 2003

Airport Operators Association & General Aviation Awareness Council in Advice Note 6 – Potential Bird Strikes from Sustainable Urban Drainage Schemes 2006

Appendix A – Figures

Figure 1.3a – Site Outline and Watercourses
Figure 1.3b – Topography
Figure 2.1a – Existing Drainage Type
Figure 2.1b – 0.5% AEP + CC Pluvial Flood Extents
Figure 2.1.1 – Culvert Locations
Figure 2.3a – Site Hydrological Catchments
Figure 2.3b – Individual Sub-Catchments
Figure 2.3c – Design Study_Development Sites_Spateston
Figure 2.3d – Design Study_Development Sites_Aughengreoch
Figure 2.3e – Design Study_Development Site_Craigbog
Figure 2.7a – Site SuDS Layout
Figure 2.7b – Site SuDS Layout – Spateston
Figure 2.7c – Site SuDS Layout – Cartside
Figure 2.7d – Site SuDS Layout – Craigbog
Figure 2.7e – Potentially Contaminative Land



Legend

- Site Boundary
- Cartside
- Spateston
- Craigbog

Client	Renfrewshire Council
Project	Green Networks Integrated Urban Infrastructure - 6 Candidate Sites
Site	Johnstone
Title	Site Outline & Watercourses
Ref	Figure 1.3a

Scale	NTS	Drawn by	BOC	Rev.
Date	Aug'10	Chk'd by	PR	-

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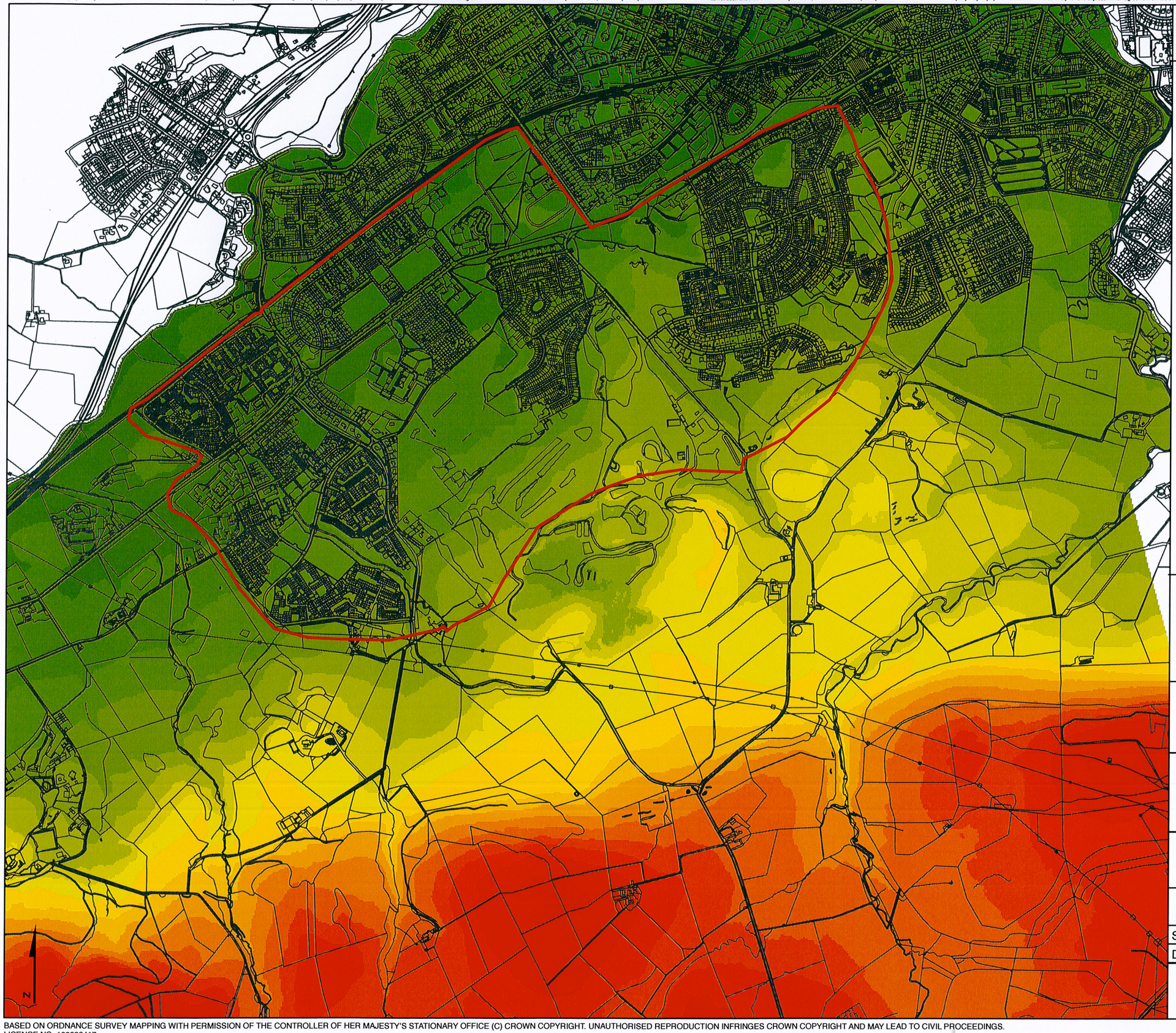

Legend

Site Boundary

Elevation in mAOD

- 3.4 - 17
- 18 - 28
- 29 - 37
- 38 - 47
- 48 - 59
- 60 - 71
- 72 - 84
- 85 - 95
- 96 - 110
- 120 - 120
- 130 - 130
- 140 - 140
- 150 - 160
- 170 - 170
- 180 - 180
- 190 - 190
- 200 - 190
- 200 - 200
- 210 - 210
- 220 - 230

Client	Renfrewshire Council
Project	Green Networks Integrated Urban Infrastructure - 6 Candidate Sites
Site	Johnstone
Title	Topography
Ref	Figure 1.3b

Scale	NTS	Drawn by	BOC	Rev.
Date	Aug'10	Chk'd by	PR	-

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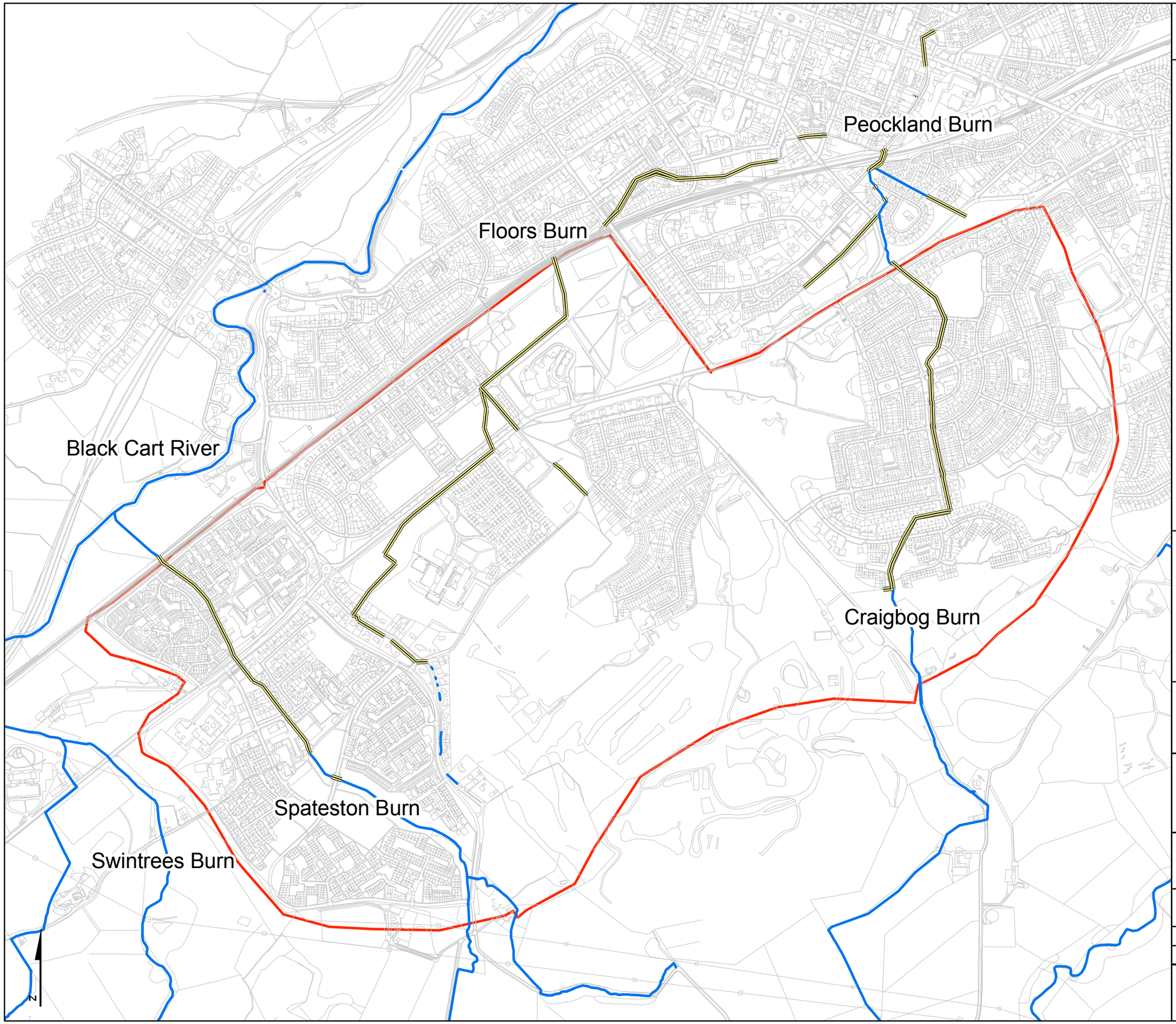

Legend

- Site Boundary
- Culvert
- Watercourse

Client	Renfrewshire Council
Project	Green Networks Integrated Urban Infrastructure - 6 Candidate Sites
Site	Johnstone
Title	Culvert Locations
Ref	Figure 2.1.1

Scale	NTS	Drawn by	BOC	Rev.
Date	Oct '10	Chk'd by	PR	-

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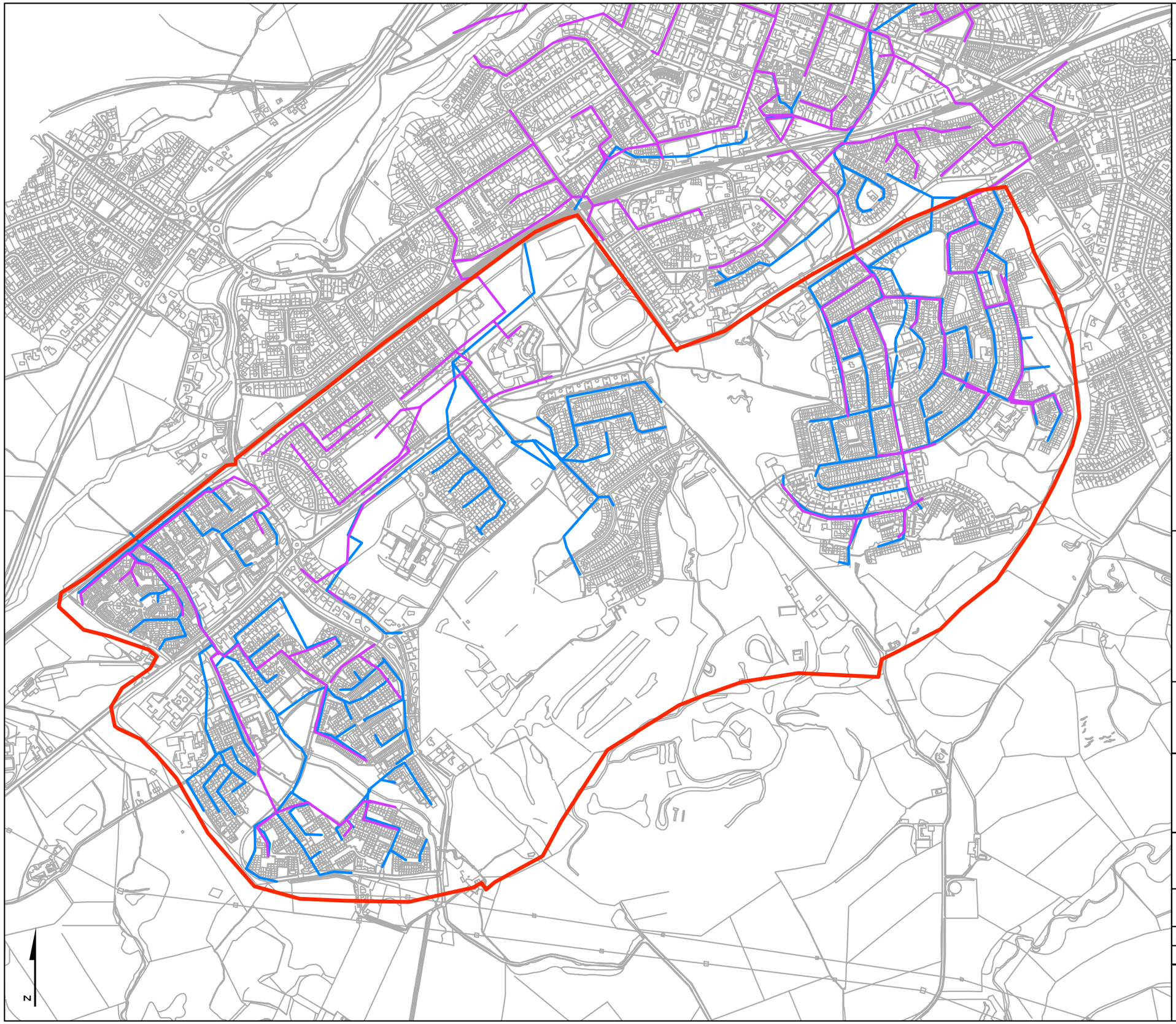

Legend

Site Boundary

Combined Sewer System

Seperate Sewer System

Client	Renfrewshire Council
Project	Green Networks Integrated Urban Infrastructure - 6 Candidate Sites
Site	Johnstone
Title	Existing Drainage Type
Ref	Figure 2.1a

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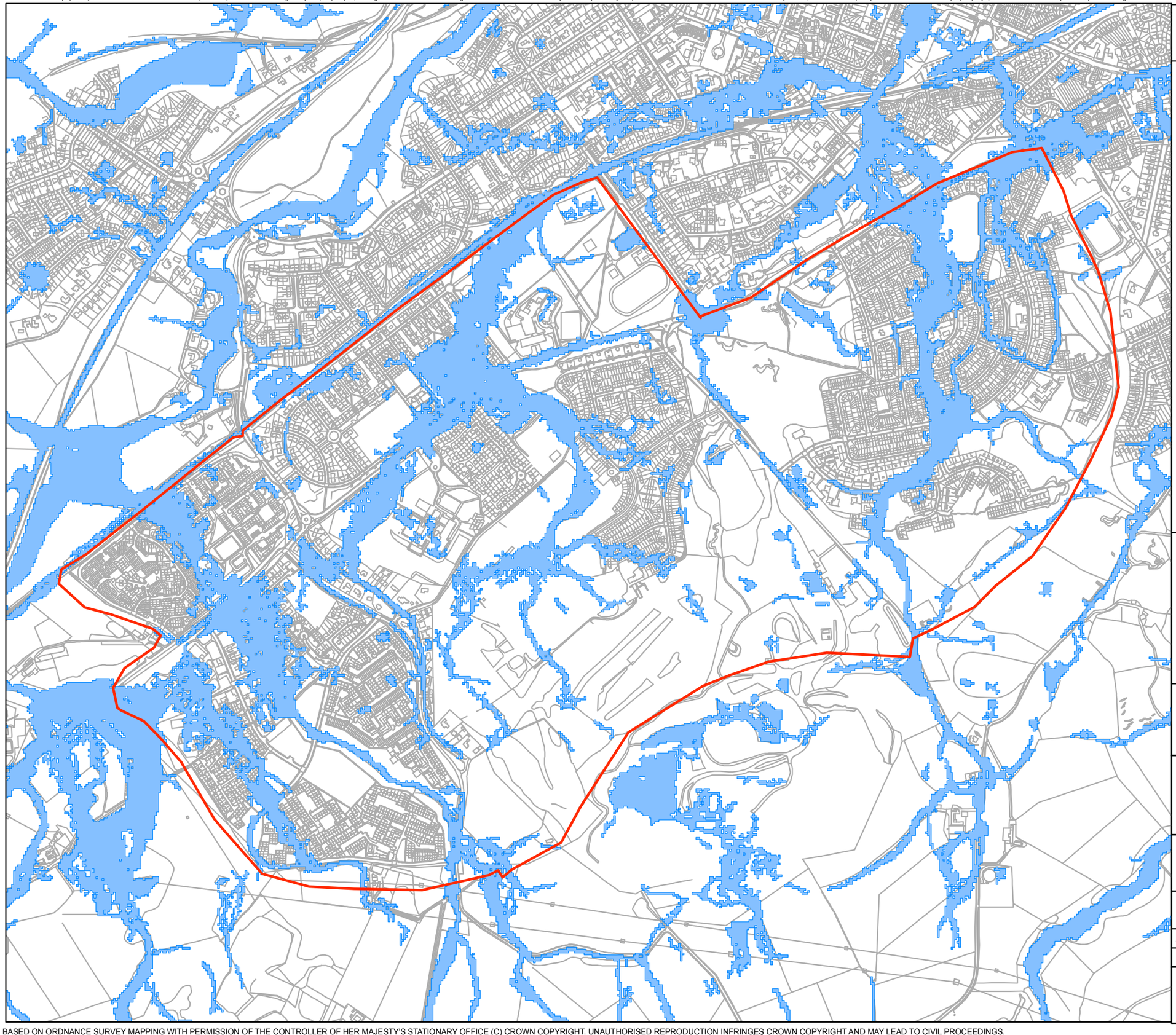

Legend

Site Boundary

Pluvial Flooding

Client	Renfrewshire Council
Project	Green Networks Integrated Urban Infrastructure - 6 Candidate Sites
Site	Johnstone
Title	Pluvial Flooding
Ref	Figure 2.1b

Scale	NTS	Drawn by	BOC	Rev.
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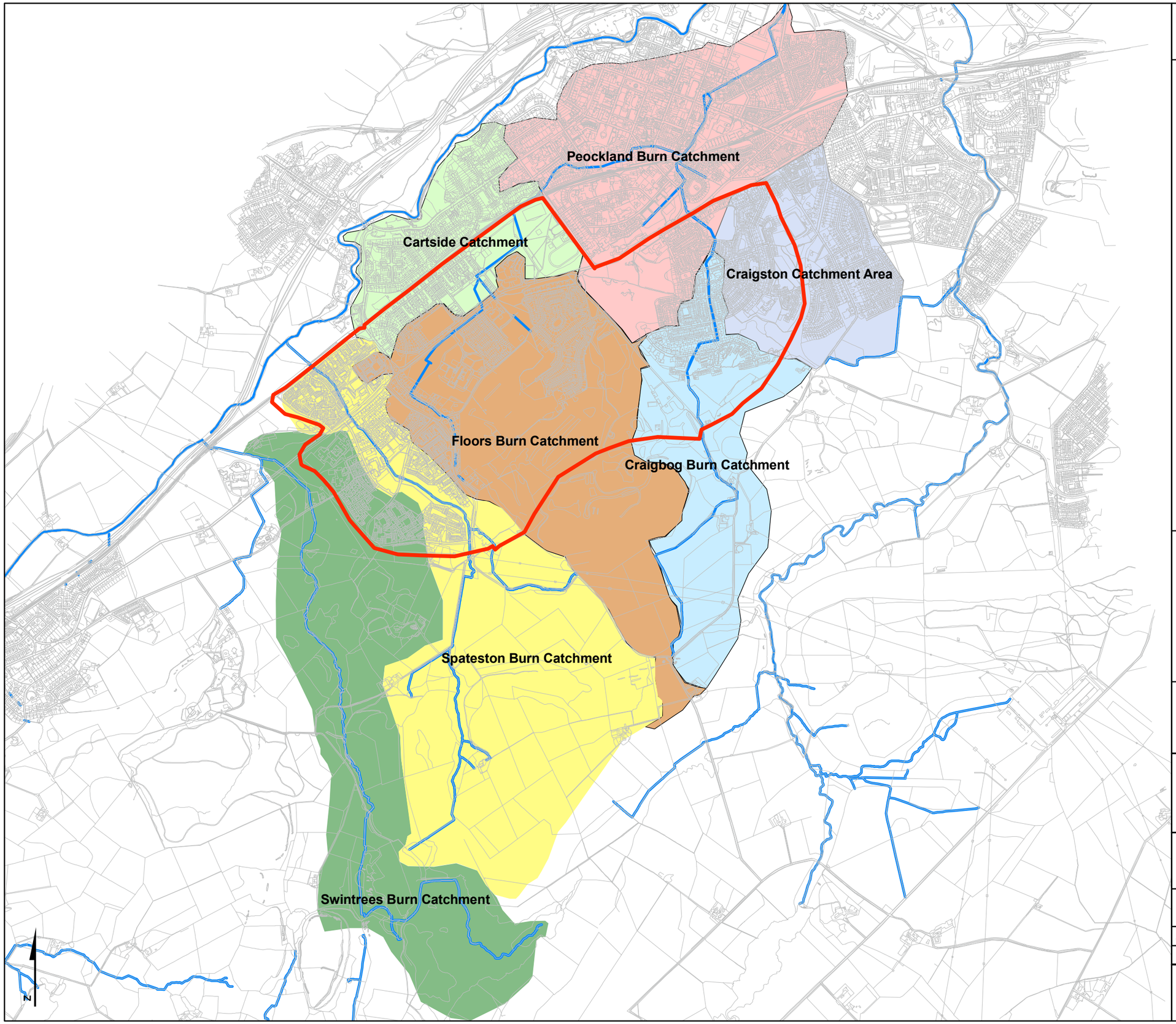

Legend

Site Boundary

Client	Renfrewshire Council			
Project	Green Networks Integrated Urban Infrastructure - 6 Candidate Sites			
Site	Johnstone			
Title	Site Hydrolgical Catchments			
Ref	Figure 2.3a			
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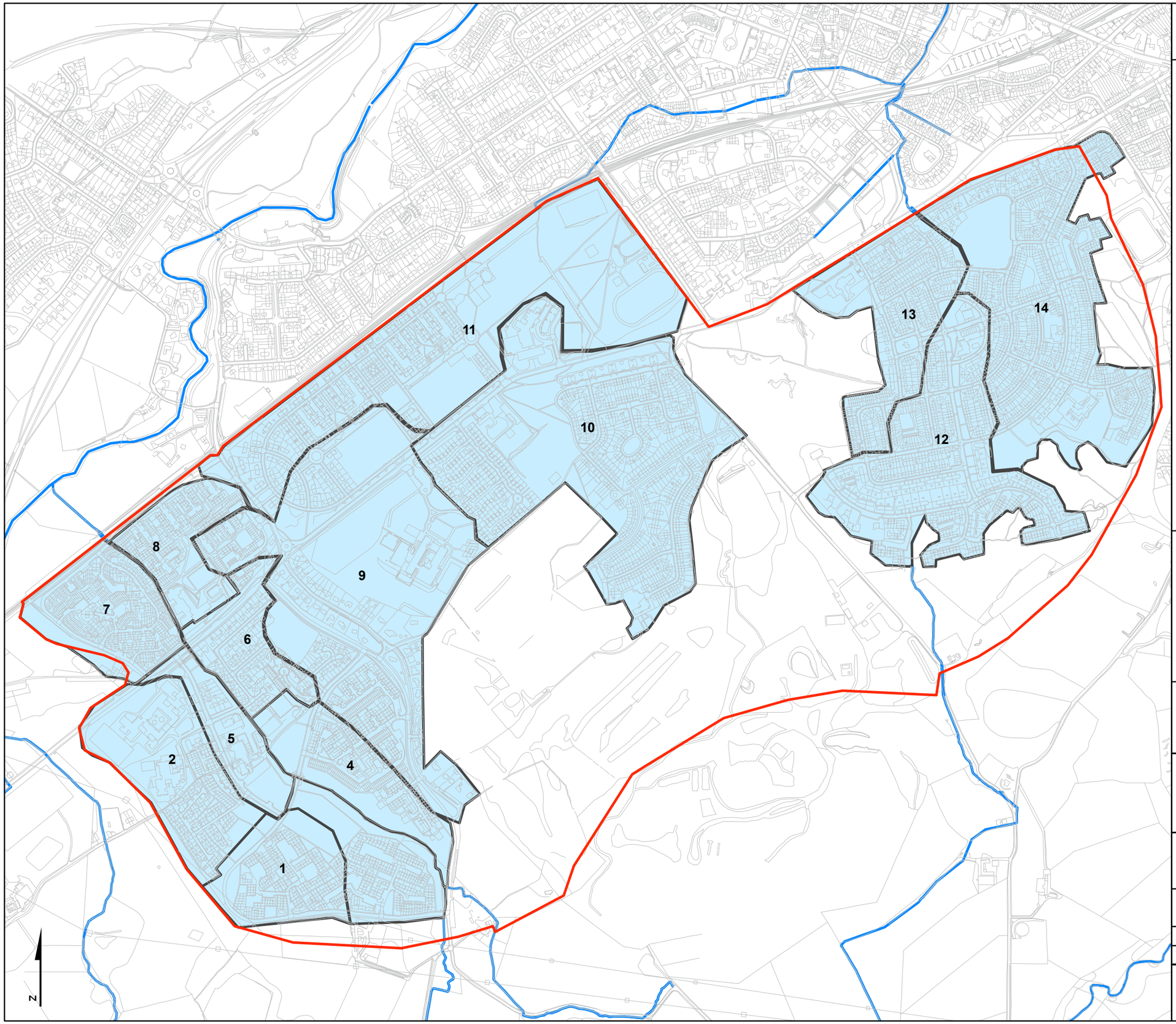

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Site Boundary

Sub-Catchment

Client	Renfrewshire Council
Project	Green Networks Integrated Urban Infrastructure - 6 Candidate Sites
Site	Johnstone
Title	Sub-Catchments
Ref	Figure 2.3b

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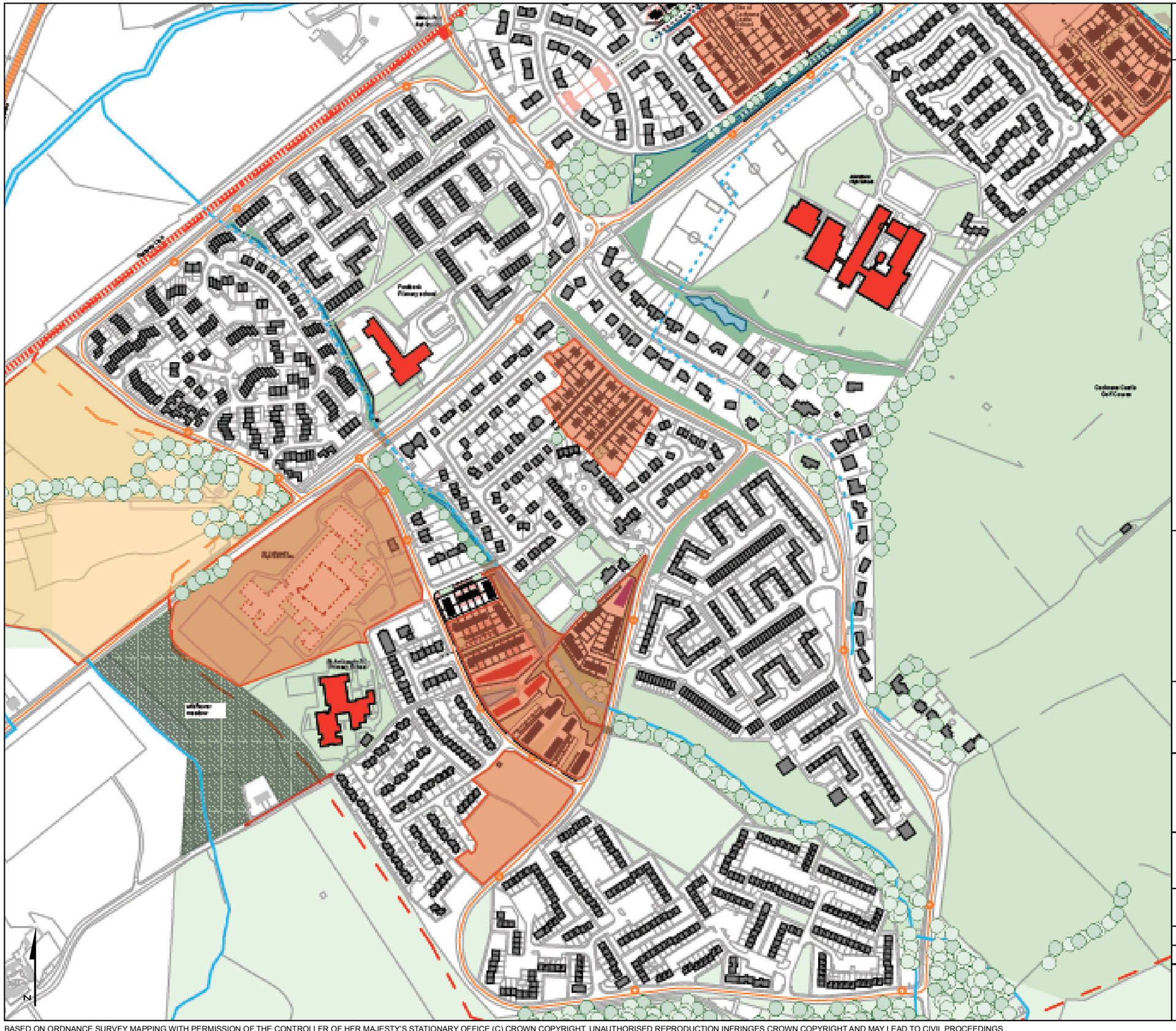

Legend

Site Boundary

Development Area

Community Growth Area

Client	Renfrewshire Council				
Project	Green Networks Integrated Urban Infrastructure - 6 Candidate Sites				
Site	Johnstone				
Title	Design Study - Development Sites Spateston				
Ref	Figure 2.3c				
Scale	NTS	Drawn by	BOC	Rev.	-
Date	Aug '10	Chk'd by	PR		

AECOM COLLECTIVE ARCHITECTURE

Legend

Site Boundary

Development Area

Client	Renfrewshire Council
Project	Green Networks Integrated Urban Infrastructure - 6 Candidate Sites
Site	Johnstone
Title	Design study_Development Site Aughengreoch
Ref	Figure 2.3d

Scale	NTS	Drawn by	BOC	Rev.
Date	Aug '10	Chk'd by	PR	-

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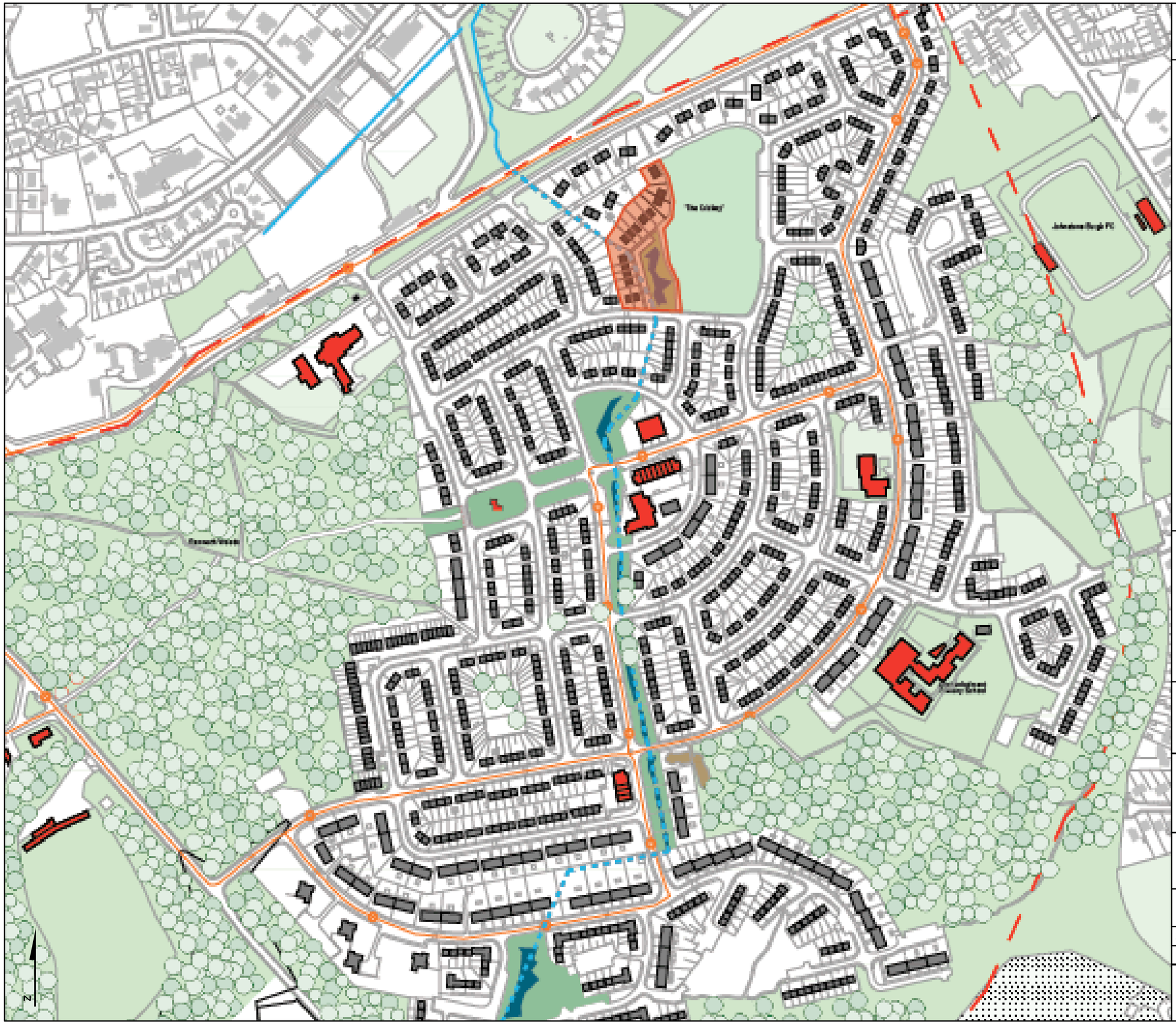

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Site Boundary

Development Area

Client	Renfrewshire Council
Project	Green Networks Integrated Urban Infrastructure - 6 Candidate Sites
Site	Johnstone
Title	Design Study_Development Site Craigbog
Ref	Figure 2.3e

Scale	NTS	Drawn by	BOC	Rev.
Date	Aug '10	Chk'd by	PR	-

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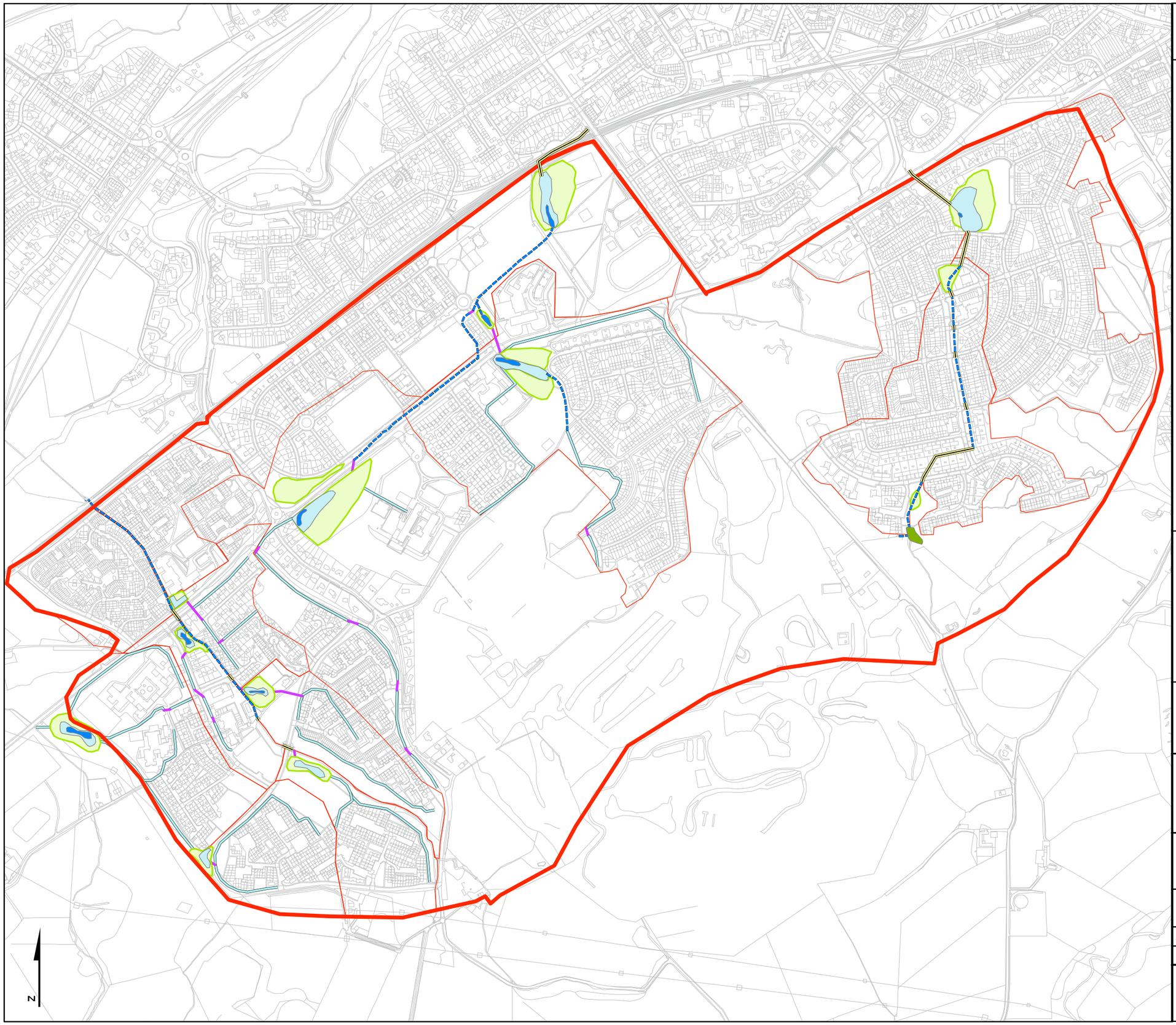

Legend

- Site Boundary
- Sub-Cathment
- Pond/Wooded Wetland - Total Sub-catchment (50% impermeable)
- Pond/Wooded Wetland - Design Study Development Area (40% impermeable)
- Surface Water Exceedance Route / Temporary Floodplain
- Surface Water Exceedance Route / Temporary Floodplain - Option 2
- De-culverted Watercourse
- Swale
- Existing Culvert
- Proposed Culvert

Client	Renfrewshire Council
Project	Green Networks Integrated Urban Infrastructure - 6 Candidate Sites
Site	Johnstone South West
Title	Site SuDS Layout
Ref	Figure 2.7a

Scale	NTS	Drawn by	BOC	Rev. -
Date	Nov'10	Chk'd by	PR	

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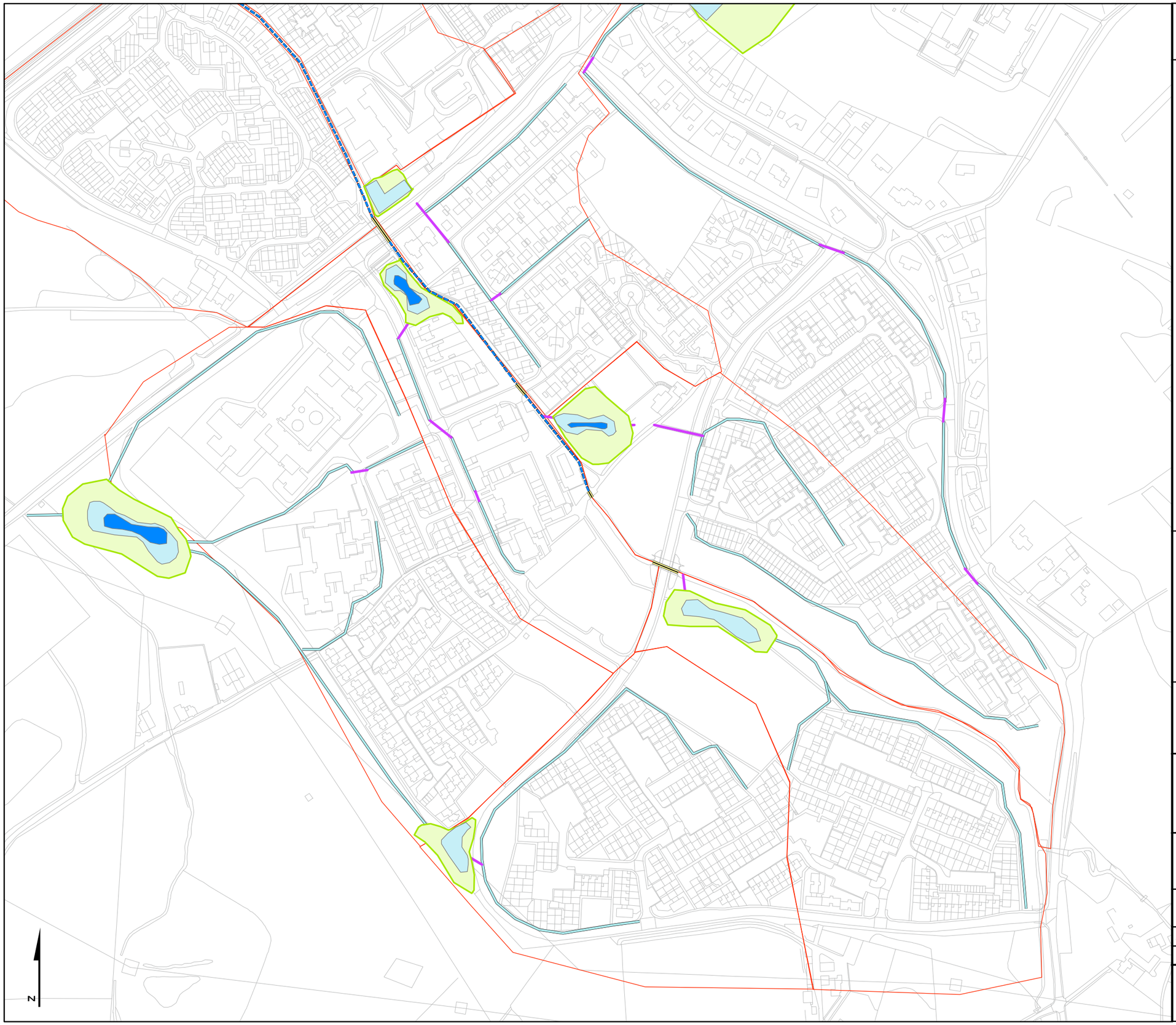

Legend

- Site Boundary
- Sub-Cathment
- Pond/Wooded Wetland - Total Sub-catchment (50% impermeable)
- Pond/Wooded Wetland - Design Study Development Area (40% impermeable)
- Surface Water Exceedance Route / Temporary Floodplain
- Surface Water Exceedance Route / Temporary Floodplain - Option 2
- De-culverted Watercourse
- Swale
- Existing Culvert
- Proposed Culvert

Client	Renfrewshire Council
Project	Green Networks Integrated Urban Infrastructure - 6 Candidate Sites
Site	Johnstone South West
Title	SuDS Layout - Spateston
Ref	Figure 2.7b

Scale	NTS	Drawn by	BOC	Rev.
Date	Nov'10	Chk'd by	PR	-

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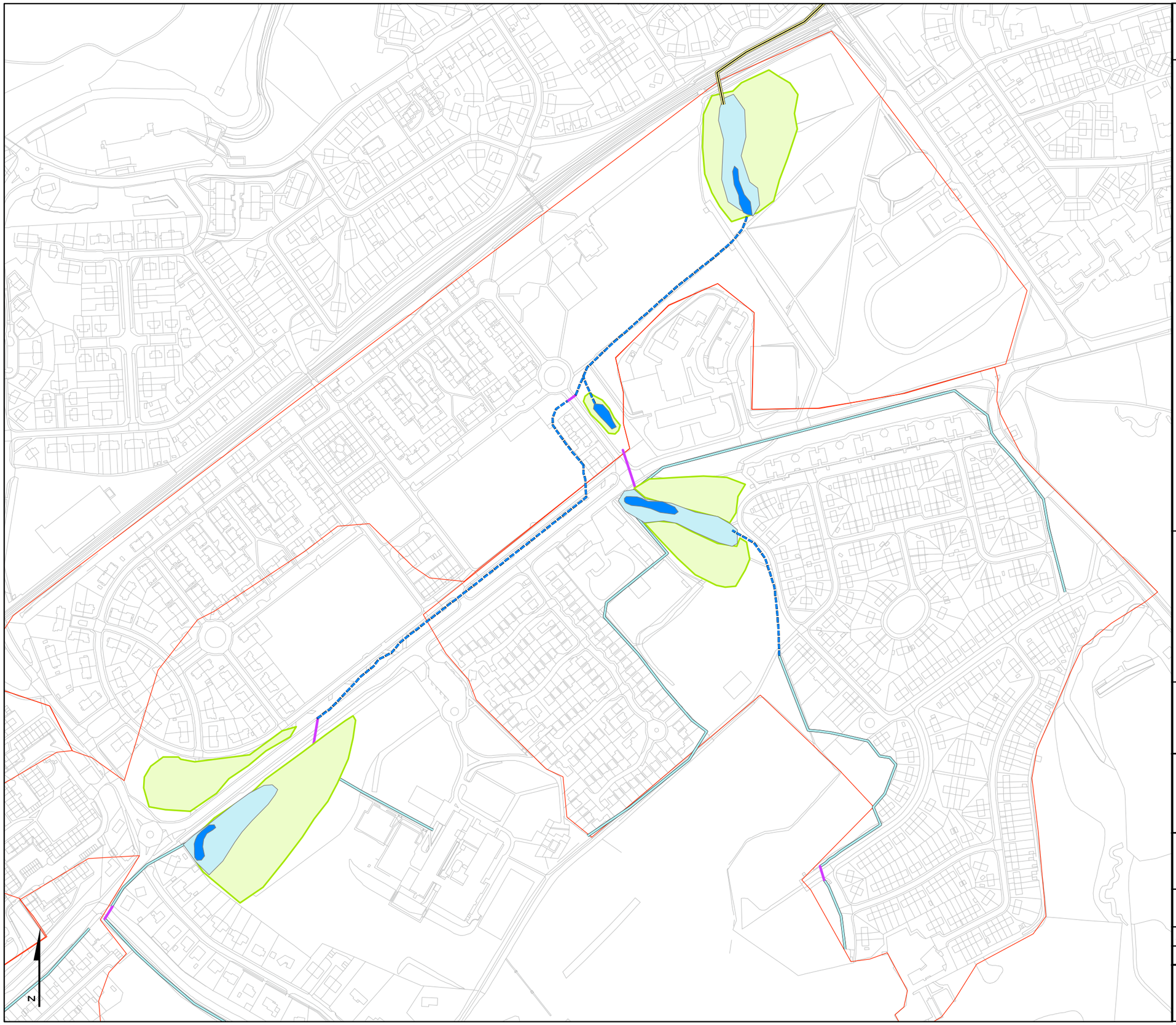

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- Site Boundary
- Sub-Cathment
- Pond/Wooded Wetland - Total Sub-catchment (50% impermeable)
- Pond/Wooded Wetland - Design Study Development Area (40% impermeable)
- Surface Water Exceedance Route / Temporary Floodplain
- Surface Water Exceedance Route / Temporary Floodplain - Option 2
- De-culverted Watercourse
- Swale
- Existing Culvert
- Proposed Culvert

Client	Renfrewshire Council
Project	Green Networks Integrated Urban Infrastructure - 6 Candidate Sites
Site	Johnstone South West
Title	SuDS Layout - Cartside
Ref	Figure 2.7c

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Date	Nov'10	Chk'd by	PR	-

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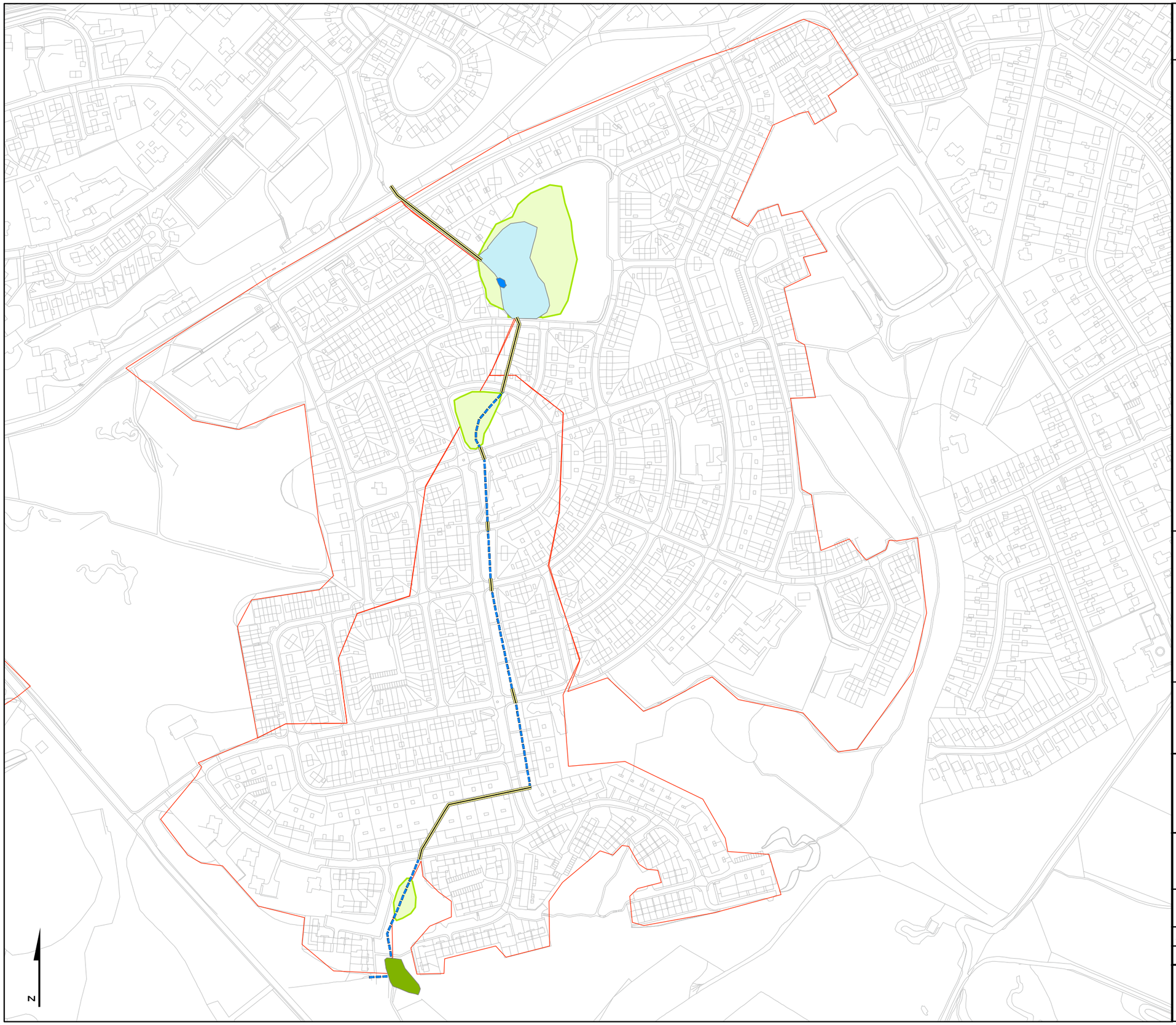

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- Site Boundary
- Sub-Cathment
- Pond/Wooded Wetland - Total Sub-catchment (50% impermeable)
- Pond/Wooded Wetland - Design Study Development Area (40% impermeable)
- Surface Water Exceedance Route / Temporary Floodplain
- Surface Water Exceedance Route / Temporary Floodplain - Option 2
- De-culverted Watercourse
- Swale
- Existing Culvert
- Proposed Culvert

Client	Renfrewshire Council
Project	Green Networks Integrated Urban Infrastructure - 6 Candidate Sites
Site	Johnstone South West
Title	SuDS Layout - Craigbog
Ref	Figure 2.7d

Scale	NTS	Drawn by	BOC	Rev.
Date	Nov'10	Chk'd by	PR	-

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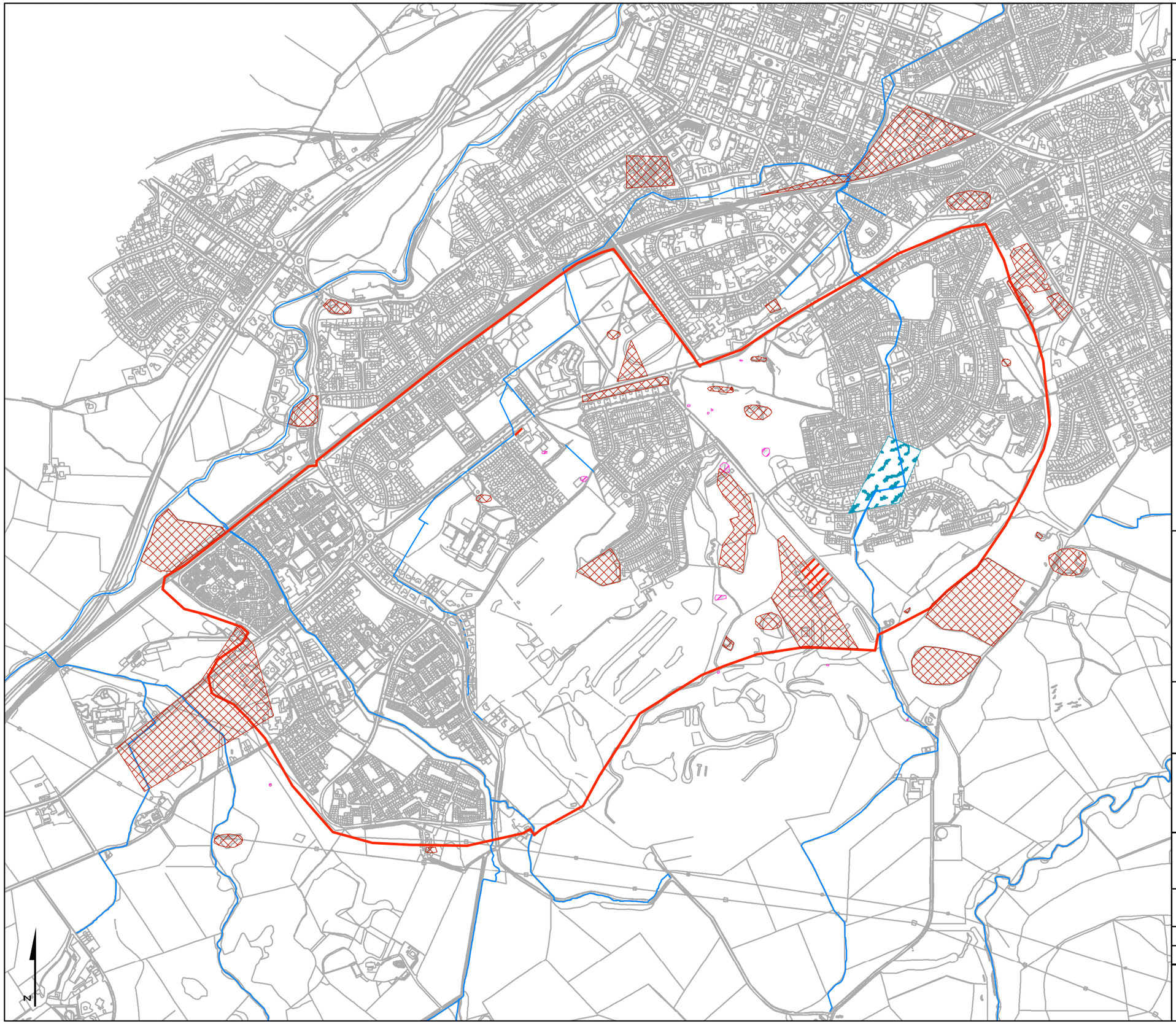

Legend

- Site Boundary
- Potentially Contaminative Land Use
- Potential for Shallow Mine Workings
- Potential for Contaminative Land Use and Landfill Gas
- Indicative extents of low to moderate soakaway potential (Alluvium)

Client	Renfrewshire Council
Project	Green Networks Integrated Urban Infrastructure - 6 Candidate Sites
Site	Johnstone
Title	Potentially Contaminative Land
Ref	Figure 2.7e

Scale	NTS	Drawn by	BOC	Rev.
Date	Aug'10	Chk'd by	PR	-

AECOM COLLECTIVE ARCHITECTURE

Appendix B – Surface Water Modelling

B.1 Approach

The runoff from the site is proposed to incorporate Sustainable urban Drainage Systems (SuDS) to provide natural treatment and attenuation of runoff from the development.

To assess the impact of the development on the surface water runoff from the site, initial consultation has been undertaken with SEPA and Renfrewshire to determine the required level of attenuation.

B.1.1 Sustainable Drainage Systems (SuDS)

The opportunity to incorporate SuDS within the development has been identified and, where appropriate, the use of SuDS has been adopted in the surface water management plan. To help achieve optimal use of SuDS features, a management train approach is used to identify the most advantageous solution according to site location, character and operational requirements. This procedure is presented in **Table B.1**.

Table B.1 Management Train Procedure

Management Train Stage	Considered in the design of	SuDS Selection
1. Prevention	Building layout.	The SuDS selection process included in CIRIA guide C697 has been used to help identify the most appropriate SuDS techniques for the different management train levels.
2. Source Control	Building and sub catchment layout.	
3. Site Control	Sub catchment/ Catchment layout.	
4. Regional Control	Catchment layout.	

SuDS techniques that have been considered and adopted within the overall scheme design have been selected from proven techniques and solutions that include the following:

- Permeable paving;
- Green roofs;
- Bio retention;
- Filtration techniques;
- Grassed filter trips;
- Swales;
- Infiltration devices;
- Filter drains;
- Infiltration basin;
- Extended detention ponds;
- Wet ponds;
- Storm water wetlands; and
- On / off line storage.

In order to produce a successful detailed SuDS solution, the amenity value of proposals and the quality and quantity of the surface water discharge need to be considered for each management train stage. This has been achieved by using the guidance

set out in CIRIA report C697; *The SUDS manual,* which uses a scoring system to evaluate the main aspects of surface water discharge by considering the following issues:

- Hydrological;
- Land use;
- Physical site features;
- Community and environment; and
- Economic and maintenance.

B.1.2 SuDS Selection

By assessing the topography, ground conditions, available land and required design criteria, the management train approach has identified that a range of options are applicable to the site.

Section B.4 discusses the SuDS selection for the identified sub-catchments in more detail.

B.2 Criteria

B.2.1 Attenuation

The SWMP has been developed assuming that the runoff from the site will not be increased following development. Therefore, the discharge rates from the post developed site will be controlled to match those from the undeveloped site for all events up to and including the 0.5% Annual Exceedance Probability (AEP) events, equivalent to the 1 in 200 year events, including an allowance for future climate change.

B.2.2 Required Treatment Volume

The design treatment volume (V_t) is designed to capture 75 – 90% of the storms in a year. This ensures the smaller volumes of runoff are stored within the treatment systems and appropriately treated. The smaller volumes of runoff are those in which pollution is most concentrated as the initial runoff from hard surfaces washes pollutants into the surface water collection system.

The calculations of V_t are based on formulae and guidance published in CIRIA report C697 - *The SUDS Manual.*

For the wet ponds a permanent volume of one times the Vt is stored for treatment, for the wetlands a permanent volume of four times the Vt is provided, and for detention basins Vt is drained over a minimum of 24 hours for any given storm.

B.2.3 Climate Change

UKCIP09 predictions were used for the Johnstone catchment area at the 67th percentile, being highlighted as very unlikely to be exceeded up to the 2080's. A series of 25km grid squares cover the area these give a specific climate change increase for the area covering the Johnstone site of 30% increase in winter precipitation, **see Section 2.2.**

B.3 Methodology

The proposed SuDS for the site have been developed by working through the following stages associated with developing a strategy and outline concept:

Calculation of 'Greenfield' or undeveloped runoff rates;

Determination of a strategy to incorporate the selected elements of SuDS;

Determination of treatment requirements for the site;

Identification of sub-catchments and phasing requirements;

Modelling of individual elements within sub-catchments; and

'Cascading' elements together to provide a complete analysis of whole development site.

B.3.1 Existing Site Runoff

The existing site runoff has been estimated using the guidance from the Institute of Hydrology Report 124 (IoH124). The calculation is based upon the following factors:

B.3.1.1 Area

Catchment Area (ha), the area of the site has been set to 1ha to determine runoff rates per unit area for comparison with each sub-catchment.

B.3.1.2 SAAR
Average annual rainfall (1941-1970) from the Flood Studies Report (FSR) Figure II.3.1 or equivalent, which is 1465mm for this location.

B.3.1.3 Soil
Soil index of the catchment from FSR Figure I.4.18 or Wallingford Procedure Volume 3. Soil Types 1 to 5 have Soil Index Values of 0.15, 0.3, 0.4, 0.45 and 0.5 respectively. For the Johnstone site, the soil is recorded as 100% Type 4, with a Soil Index Value of 0.45; this is described as a low permeable soil.

B.3.1.4 Urban
Value for how developed the existing site is. Greenfield site will have a value of 0; fully developed site 100% impermeable will have a value of 1.

B.3.1.5 Region Number
Region number of the catchment based on FSR Figure I.2.4, which is 2 for this site.

B.3.1.5 Rainfall
Design rainfall for the site has been derived from the Flood Estimation Handbook (FEH) catchment data for the site. The Standard Annual Average Rainfall (SAAR) for the site is 1465mm from the FEH catchment data.

B.3.1.6 Topography
The site topography used within the development of the Surface Water Management Plan (SWMP) has been obtained from LIDAR data provided by Renfrewshire Council.

B.4 Modelling

The site was divided into plots defined by the infrastructure and landform of the existing site. There are a total of 14 sub-catchments, the area of impermeable land calculated for each individual sub-catchment.

B.4.1 Approach
The modelling of the SWMP has been undertaken using the estimated roofed and paved areas, with the values for the roofed and paved areas for the proposed development are estimated from the finalised design study. The contributing areas were assessed by sampling areas of the site and it was found that the ratio of contributing area to green space for a majority of the site was 50:50.

Taking the above assumptions into account the **Table B.2** shows the expected impermeable coverage in the development plot areas.

Table B.2 – Sub-catchment Impervious Areas

Sub-catchment	Total Plot Area (ha)	Contributing Area (ha)
1	4.68	2.34
2	11.1	5.55
3	5.56	2.78
4	7.04	3.52
5	4.09	2.04
6	5.47	2.74
7	7	3.5
8	5.58	2.79
9	29.9	14.95
10	28.6	14.3
11	10.6	5.3

12,13,14	43.2	21.6
Total	82	41

The drainage strategy has been developed through hydrological modelling of the site using Micro Drainage's WinDes software. WinDes is recognised as leading software for carrying out analysis and design of drainage systems.

B.4.2 Discharge Controls

Each element has been controlled to maximise the local attenuation and treatment and then overflow to the next constituent component in the system. The controls at the end of the system have been designed to ensure that there will be no flooding within the site for rainfall events up to and including the future 0.5% event plus climate change and that the discharge rates do not exceed current Greenfield runoff rates.

B.4.3 Simulations

The model of the proposed system has been analysed with a range of rainfall events. The events include those with the annual probability that is of particular interest, i.e. 0.5% and 3.33%, and for a range of durations from 15 minutes up to 10080 minutes, or 7 days. This is checked to ensure that the critical duration event is included within the analysis.

B.5 Results

B.5.1 Existing Site Runoff

The runoff from the overall existing site has been calculated using the methodology outlined in Section B.3.1 and the results are summarised in **Table B.3** below:

Table B.3 Undeveloped 'Greenfield' Site Runoff (in l/s/ha)

AEP (%)	S.C 1	S.C 2	S.C 3	S.C 4	S.C 5	S.C 6	S.C 7	S.C 8	S.C 9	S.C 10	S.C 11	S.C 12
50	18	43	22	27	16	21	27	22	117	112	41	169
20	24	56	28	36	21	28	35	28	152	145	54	219
10	28	68	34	43	25	33	43	34	182	174	65	263
3.3	36	86	43	55	32	42	54	43	232	222	82	335
2	38	91	45	57	33	45	57	46	244	233	86	352
1	44	104	52	66	38	51	65	52	279	267	99	403
0.5	49	116	58	73	43	57	73	58	312	298	111	451

S.C = Sub-catchment

B.5.2 Treatment Volume, V_t

The design treatment volume, Vt, has been calculated from the following formula and for detention basins will be drained from the structure over a 24 hour period[11]:

$$V_t(m^3/ha) = 9 \times D \times \left(\frac{SOIL}{2} + \left(1 - \frac{SOIL}{2}\right) \times I\right)$$

For the Johnstone site:

D = M5-60, is the statistical 5 year 60 minute rainfall event, and is predicted to be 16mm

[11] CIRIA 697 '*The SUDS manual*'

SOIL = 0.425

I, impervious area = 1.0, assuming that the development area draining to the SuDS is 100% impermeable.

Table B.4 summarises the results: The V_t for the total sub-catchment has been calculated along with the required permanent pond treatment volume required.

Table B.4 – Required Treatment Volume for proposed SuDS development

Plot	Max.Treatment Volume (m^3)	Type of Detention
1	825.55	Pond / Detention
2	1958.04	Pond / Wetland
3	980.78	Detention Basin
4	1241.86	Pond / Wetland
5	721.12	Pond / Wetland
6	965.40	Pond / Wetland
7	1234.80	Pond / Wetland
8	984.31	Pond / Wetland
9	5274.36	Pond / Wetland
10	5045.04	Pond / Wetland
11	4720.46	Pond / Wetland
12,13,14	7620.48	Pond / Wetland
Total	31572.21	

B.5.3 SuDS Performance

The proposed scheme has been modelled within the WinDes MicroDrainage software.

The results summarise the areas draining to SuDS from the catchment and the limiting criteria applicable to the catchment. The predicted maximum discharge from the sub-catchment, the Greenfield runoff rates and the required maximum storage are also included.

Table B.5 SuDS option for the site

Sub-catchment 1

Criteria		Modelled Discharge (l/s)	Equivalent Greenfield Runoff Rate (l/s)	Meets Criteria
Maximum Discharge	0.5% (200 year)	61.7	64	Yes
Attenuation	Maximum Stored Volume (0.5%)	1660m^3		

Sub-catchment 2

Criteria		Modelled Discharge (l/s)	Equivalent Greenfield Runoff Rate (l/s)	Meets Criteria
Maximum Discharge	0.5% (200 year)	151	151	Yes
Attenuation	Maximum Stored Volume (0.5%)	5920m^3		

Sub-catchment 3

Criteria		Modelled Discharge (l/s)	Equivalent Greenfield Runoff Rate (l/s)	Meets Criteria
Maximum Discharge	0.5% (200 year)	75.3	76	Yes
Attenuation	Maximum Stored Volume (0.5%)	1970m^3		

Sub-catchment 4

Criteria		Modelled Discharge (l/s)	Equivalent Greenfield Runoff Rate (l/s)	Meets Criteria
Maximum Discharge	0.5% (200 year)	96	96	Yes
Attenuation	Maximum Stored Volume (0.5%)	2850m^3		

Sub-catchment 5

Criteria		Modelled Discharge (l/s)	Equivalent Greenfield Runoff Rate (l/s)	Meets Criteria
Maximum Discharge	0.5% (200 year)	56	56	Yes
Attenuation	Maximum Stored Volume (0.5%)	1570m^3		

Sub-catchment 6

Criteria		Modelled Discharge (l/s)	Equivalent Greenfield Runoff Rate (l/s)	Meets Criteria
Maximum Discharge	0.5% (200 year)	75.7	75	Yes
Attenuation	Maximum Stored Volume (0.5%)	2130m^3		

Sub-catchment 7

Criteria		Modelled Discharge (l/s)	Equivalent Greenfield Runoff Rate (l/s)	Meets Criteria
Maximum Discharge	0.5% (200 year)	95.4	96	Yes
Attenuation	Maximum Stored Volume (0.5%)	2575m^3		

Sub-catchment 8

Criteria		Modelled Discharge (l/s)	Equivalent Greenfield Runoff Rate (l/s)	Meets Criteria
Maximum Discharge	0.5% (200 year)	76	76	Yes
Attenuation	Maximum Stored Volume (0.5%)	1960m^3		

Sub-catchment 9

Criteria		Modelled Discharge (l/s)	Equivalent Greenfield Runoff Rate (l/s)	Meets Criteria
Maximum Discharge	0.5% (200 year)	404.3	408	Yes
Attenuation	Maximum Stored Volume (0.5%)	11900m^3		

Sub-catchment 10

Criteria		Modelled Discharge (l/s)	Equivalent Greenfield Runoff Rate (l/s)	Meets Criteria
Maximum Discharge	0.5% (200 year)	387.5	390	Yes
Attenuation	Maximum Stored Volume (0.5%)	10800m^3		

Sub-catchment 11

Criteria		Modelled Discharge (l/s)	Equivalent Greenfield Runoff Rate (l/s)	Meets Criteria
Maximum Discharge	0.5% (200 year)	360	365	Yes
Attenuation	Maximum Stored Volume (0.5%)	9649m^3		

Sub-catchment 12,13,14

Criteria		Modelled Discharge (l/s)	Equivalent Greenfield Runoff Rate (l/s)	Meets Criteria
Maximum Discharge	0.5% (200 year)		589	Yes
Attenuation	Maximum Stored Volume (0.5%)	15300 m^3		

The SuDS options are illustrated in **Figure 2.9, Appendix A**, and the outputs quantified in **Table B.5**. The site controls used in this option are a combination of wetland ponds and detention areas. All water will be discharged at Greenfield rates to the nearest watercourse after treatment.