REC
Resource & Environmental Consultants Ltd

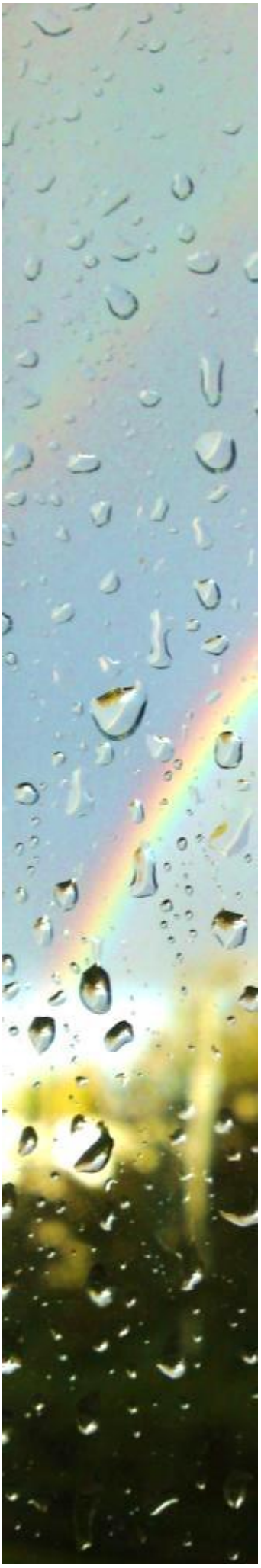
FLOOD RISK ASSESSMENT & OUTLINE DRAINAGE IMPACT ASSESSMENT

Proposed Simplified Planning Zone
Hillington Business Park
Glasgow
G52 4JU

REC Report: 45354FRp1r4
Issued: April 2014

Prepared for:

MEPC



REC Flood Risk

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QUALITY ASSURANCE

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EXECUTIVE SUMMARY

Site Address	Hillington Business Park, Glasgow, G52 4JU
Grid Reference	E251919, N665438
Site Area	198.62 hectares (ha)
Current Site Use	The site currently comprises the Hillington Business Park site. The business park provides offices and industrial units to over 270 organisations within the manufacturing, distribution, technology and service sectors.
Proposed Site Use	REC Ltd understands that it has been proposed that the Hillington Business Park will be covered by a Simplified Planning Zone (SPZ). The SPZ will simplify planning control by removing the need for a planning application for development within the defined parameters. SPZs are designed to aid in the urban regeneration by de-regulating the planning process in specific areas. The SPZ scheme will grant planning permission for a defined range of development without the need for individual planning permissions.
Hydrological Setting	The closest watercourse to the site is Mill Burn Culvert which is located underneath the site and flows in a northwards direction towards the M8. White Cart Water is located approximately 2.4 km west of the site. This flows north where it converges with Black Cart Water to form the River Cart, located approximately 2.7 km north-west of the site. The River Cart continues to flow north and discharges into the River Clyde, located approximately 1 km north-east of the site. Stanley Reservoir and Thornley Dam are located approximately 5 km south-west of the site. Glenburn and Harelaw Reservoirs are located approximately 6 km south-west and south of the site respectively.
Sources of Flooding and Risk Analysis	**River** Risk of river water flooding following a 1 in 200 year event – **Moderate to High** **Surface Water/Pluvial Flooding** Risk of surface water flooding following a 1 in 200 year event – **Moderate to High** **Groundwater** The potential risk of groundwater flooding – **Moderate** **Sewers** The potential risk of sewer flooding – **Moderate to High** **Canals, Reservoirs and Artificial Watercourses** The potential risk from these additional sources – **Low**

1.0 INTRODUCTION

1.1 Background

Resource and Environmental Consultants Ltd (REC) have been commissioned by MEPC to undertake a Flood Risk Assessment (FRA) for the Proposed Simplified Planning Zone (SPZ) for the Hillington Business Park, Glasgow.

As the report is required to remove the need for a planning application for development within the defined parameters, the report will be written in relation to flood risk guidance contained within the Scottish Planning Policy (SPP).

1.2 Objectives

This Flood Risk Assessment follows guidance set out in the Scottish Planning Policy (SPP). The Scottish Planning Policy (SPP) states that a Flood Risk Assessment is required for any residential development comprising more than five dwellings or an area greater than 250m^2 for industrial or commercial developments.

The objectives of the FRA and Outline DIA are to:

- Undertake a review of the Scottish Environment Protection Agency (SEPA) Indicative Flood Mapping;
- Review the Scottish National Flood Risk Assessment (NFRA) information;
- Review of available development proposals and comparison with the existing land use;
- Undertake an initial assessment of the flood risk and identify areas that need further investigation; and,
- Recommendations as to protection and mitigation measures (if required).

1.3 Sources of Information

Background information was sought from the following sources:

- Scottish Planning Policy (SPP);
- Scottish Environment Protection Agency (SEPA) Indicative Flood Mapping;
- Scottish Environment Protection Agency (SEPA) Vulnerable Area Mapping;
- Scottish National Flood Risk Assessment (NFRA);
- Scottish Water Sewer Plans;
- River Clyde Flood Management Strategy;
- Glasgow City Council's City Plan 2 Policy ENV 5 – Flood Prevention and Land Drainage;
- Renfrewshire Strategic Flood Risk Assessment (2011) (SFRA);
- URS Hillington Park Flood Study Report (2007);
- Farrer Consulting and Scottish Water Renfrewshire Flooding Investigations (2007);
- JBA Hillington Industrial Estate Existing Flood Risk Report (2007);
- Sewers for Scotland – 2nd Edition;
- Flood Estimation Handbook (FEH) CD-ROM;

- SEPA's Guidance Document for Regulators and Developers for Drainage Impact Assessments;
- Ordnance Survey Landranger Map; and,
- British Geological Survey Solid and Drift Geological Map.

1.4 Limitations of the Study

Reliance has been placed on factual and anecdotal data obtained from the sources identified. REC Ltd cannot be held responsible for the scope of work, or any omissions, misrepresentation, errors or inaccuracies with the supplied information. The initial Flood Risk Assessment information is not necessarily exhaustive and further information relevant to the site may be available. New information, revised practices or changes in legislation may necessitate the re-interpretation of the report, in whole or in part.

2.0 SITE SETTING

2.1 Site Details

Site Address	Hillington Business Park, Glasgow, G52 4JU
National Grid Reference	E251919, N665438
Site Area	198.62 ha

2.2 Site Description

2.2.1 Current Layout

The site currently comprises the Hillington Business Park site. The business park provides offices and industrial units to over 270 organisations within the manufacturing, distribution, technology and service sectors.

The site is approximately rectangular in shape and comprises approximately 146 commercial/industrial units of varying size. The site is bound by the M8 to the north of the site and a railway line to the south. The A736 dissects the site from north to south creating two distinct areas; a densely populated area to the west of the A736 and a less dense area to the east. There are areas of undeveloped land located to the north, which were the former Rolls Royce works where buildings have recently been demolished, to the east and within the industrial units to the west. The business park also has an extensive road network comprising the A736, Mossland Road to the north and Queen Elizabeth Avenue to the south. There is a large number of smaller access roads servicing the industrial units within the site.

A topographic survey of the undeveloped northern western area only (M8 boundary to Stephenson Street and from the western boundary to the junction with the A736) has been provided. The survey indicates that there is a steep embankment located along the northern boundary with elevations at approximately 9.5 mAOD at the embankment crest before reducing to 6.97 mAOD – 8 mAOD at the base.

From here, the land appears to slope gently in a southerly direction towards Stephenson Street. From east to west, the land appears to undulate slightly as a result of the undeveloped nature of the area. A low point is identified approximately 130 m west of the A736 at 6.42 mAOD with a high point identified just north of the junction of Kelvin Avenue and Mossland Road at 8.20 mAOD.

A Site Location Map and Aerial Photograph are presented as Figure 1 in Appendix I.

2.2.2 Surrounding Hydrology

The site is located relatively close to several major watercourses. The closest watercourse to the site is Mill Burn Culvert which is located underneath the site and flows in a northwards direction towards the M8. White Cart Water is located approximately 2.4 km west of the site. This flows north where it converges with Black Cart Water to form the River Cart, located approximately 2.7 km north-west of the site. The River Cart continues to flow north and discharges into the River Clyde, located approximately 1 km north-east of the site. Stanley Reservoir and Thornley Dam are located approximately 5 km south-west of the site. Glenburn and Harelaw Reservoirs are located approximately 6 km south-west and south of the site respectively.

A Map of the Surrounding Hydrology is presented as Figure 2 in Appendix I.

2.2.3 Surrounding Area

The surrounding area is described in the table below:

Direction	Description
North	M8 with Victory Gardens residential area beyond
East	M8 & Cardonald Park with Shieldhall and West Drumoyne residential areas beyond
South	Penilee and Cardonald residential areas
West	Undeveloped agricultural land and North Arkleston Cemetery

2.3 Future Site Use

Information provided by Terence O'Rourke Ltd states that it is has been proposed that the Hillington Business Park will be covered by a Simplified Planning Zone (SPZ). The SPZ will simplify planning control by removing the need for a planning application for development within the defined parameters. SPZs are designed to aid in the urban regeneration by de-regulating the planning process in specific areas. The SPZ scheme will grant planning permission for a defined range of development without the need for individual planning permissions.

The Hillington Business Park has planning consent for an additional 6 hectares of employment land which aims to increase the level of employment land at the park in the region of 10 – 15%.

3.0 SOURCES OF FLOODING

3.1 Flooding from Rivers

3.1.1 SEPA Flood Maps

The Scottish Environment Protection Agency's (SEPA) Indicative Flood Map indicates that the site is located outside of a SEPA defined functional floodplain. This is defined as land with less than a 0.5% (1 in 200) chance of river flooding in any given year. However, the SEPA Flood Maps do not assess or map flood risk/hazards associated with watercourses such as the Mill Burn Culvert, located underneath the site, as their catchment sizes are below the 3km^2 threshold.

Reports provided by JBA indicates that there are areas adjacent to the Mill Burn Culvert which are located within the 1 in 200 year flood envelope therefore, these areas are considered to be within the floodplain of Mill Burn culvert.

The SEPA Flood Risk Map is presented as Figure 3 in Appendix I.

3.1.2 Glasgow City Council's Strategic Flood Risk Assessment

Glasgow City Council have not yet published a Strategic Flood Risk Assessment. The Glasgow area has however, been assessed by the River Clyde Flood Strategy Commission for production of the River Clyde Flood Management Strategy. The site is located outside of the area identified as the River Clyde Corridor therefore there was no specific reference to the Hillington area within this report. The River Clyde Flood Management Strategy should however, be read in conjunction with Glasgow City Council's City Plan 2 Policy ENV 5 – Flood Prevention and Land Drainage. The key elements of this policy relating to any future development as part of the SPZ are presented below:

- New development does not have an adverse impact on the water environment, does not increase the probability of flooding elsewhere and does not interfere with the storage capacity of the functional floodplain;
- New developments should contribute to minimising flood risk and avoid increasing the risk to people and property from any other source; and,
- Developers should also assess the impact of discharging surface water from any proposed development to a watercourse through a Drainage Impact Assessment.

3.1.3 Renfrewshire Strategic Flood Risk Assessment

The wider Renfrewshire area has been assessed as part of the Renfrewshire Strategic Flood Risk Assessment. The Strategic Flood Risk Assessment was completed by Renfrewshire Council in 2011. There was no specific reference to the subject site within the SFRA but additional information about flood risk within the Renfrewshire area has been identified with the salient findings presented below:

- Flooding is a high priority primarily due to the historic flood events and predicted future flood risk;
- The principle watercourses that flow through or around the Renfrewshire area are the River Clyde, River Cart and the River Gryffe;
- 94% of ground floor properties are at risk of pluvial flooding. This is usually associated with summer thunderstorms or high intensity rainfall within longer duration events;

- Flood events in Renfrewshire are typically characterised by a complex interaction between intense rainfall events, watercourses exceeding peak flow capacities, surface water run-off, lack of sewerage capacity and the tidal influence of the River Clyde;
- The events of 2006 relate to a lack of capacity into the sewerage system and local watercourses which is exacerbated by overland flow;
- SuDS requirement is an integral part of all development wherever site conditions and size permit;
- Intense rainfall will typically result in debris being washed overland resulting in blockage to existing culverts and gullies which will also add to a surcharge or no entry flow to the drainage system resulting in pluvial flooding;
- Sustainable flood risk management will be an integral component in achieving the objectives put forward in the Renfrewshire Local Development Plan; and,
- It is essential that the risk of flooding is minimised over the lifetime of the development plan in all instances. It is important to recognise that flood risk can never be fully mitigated and there will always be a residual risk of flooding.

3.1.4 Scottish National Flood Risk Assessment (NFRA)

The Scottish National Flood Risk Assessment provides an indication of areas potentially vulnerable from flooding. The data considers the probability of flooding and the potential impacts on human health, economic activity and the environment.

The Hillington area and the subject site are located within a SEPA defined Potentially Vulnerable Area (PVA: 11/13).

The PVA identifies the site as being within a moderate to high risk zone of fluvial and pluvial flooding.

The NFRA Vulnerable Area Map is presented as Figure 4 in Appendix I.

3.2 Flooding from Groundwater

The BGS Geological Map for Glasgow shows the following formations are present beneath the site:

Geological Unit	Classification	Description
Drift - north	River Terrace Deposits	Undifferentiated gravel, sand and silt
Drift – south west & south east corners	Raised Tidal Flat Deposits	Gravel, sand and silt
Drift – central southern and central western boundaries	Devensian Till	Diamicton
Solid – north west corner and western boundaries	Lower Limestone	Sedimentary Rock Cycles – Clackmannan Group
Solid - east	Limestone Coal Formation	Sedimentary Rock Cycles – Clackmannan Group
Solid – central band	Hosie Limestone	Limestone

SEPA have stated that Scotland is generally considered as being of very low to low susceptibility to groundwater flooding.

The Scottish NFRA indicates that due to the underlying geology the risk of groundwater flooding in this catchment is moderate.

3.3 Flooding from Reservoirs, Canals and other Artificial Watercourses

Mill Burn Culvert which is located underneath the site and flows in a northwards direction towards the M8. Stanley Reservoir and Thornley Dam are located approximately 5 km south-west of the site. Glenburn and Harelaw Reservoirs are located approximately 6 km south-west and south of the site respectively.

3.4 Pluvial Flood Risk

Pluvial Flooding is defined as flooding caused by rainwater generated overland flow before run-off enters a watercourse or sewer. In such events sewerage and drainage systems and surface watercourses may be overwhelmed.

The Scottish NFRA has created a database which considers the Potential Vulnerable Areas to flooding. This database indicates that approximately 41% of flooding within this area is attributed to surface water flooding.

Whilst the site currently comprises extensive areas of hardstanding and development, the undeveloped grassland area in the north of the site in addition to many of the highways infrastructure located within the site are considered to be at risk of surface water ponding.

The topographic survey indicates that there are a number of depressions located within the M8 frontage area which are likely subject to surface water accumulation in addition to the steep embankment bordering the M8. It is therefore considered that any surface water flows will preferentially be directed towards these depressions.

Furthermore, the SEPA Flood Maps and JBA report indicates that several roads are at high risk of surface water flooding. More specifically, these include:

- Napier Road;
- Kelvin Avenue;
- Ballantine Avenue;
- Hillington Road;
- Mossland Road;
- Cunningham Road;
- Dalziel Road; and,
- Montrose Avenue.

With the following roads considered as being at a moderate or low risk of surface water flooding:

- Mossland Drive;
- Seaforth Road;
- Ainslie Road; and,

- Hepburn Road.

Pluvial flooding depths from the JBA report are presented within Figure 5 in Appendix I.

The URS Hillington Park Flood Study Report (2007) indicates that for a 1 in 200 year event, flood waters along Dalziel Road could reach 1.033m, 0.7m along Hillington Road between Deanside Road and Ainslie Road and up to 0.932m along Ballantyne Avenue. The report also indicates that flood depths on the undeveloped land to the north of Napier Road accumulates flood waters of between 0.672m to 0.823m associated with a topographic depression therefore any overland flow generated on the commercial land to the south is directed towards this depression.

Similarly, the JBA Hillington Industrial Estate Existing Flood Risk Report indicates that during a 1 in 200 year event, a significant number of manholes in the surface water system will surcharge and once the water escapes, it will slowly begin to pond, largely within the road network, therefore resulting in an increased risk of pluvial flooding during events of this magnitude.

The JBA Map of surcharging manholes is presented within Figure 6 in Appendix I.

The Scottish NFRA database did not indicate any historical flood events had occurred at the site. Glasgow City Council's Flood Risk Management Team were contacted regarding any history of pluvial flooding at the Hillington Business Park however, at the time of writing, a response had not been received.

REC Ltd contacted Renfrewshire Council's Flood Risk Management Team was also contacted regarding pluvial flooding at the Hillington Business Park and the following events have been identified:

- 30th November 2006 a flooding event at the junction of Zetland and Mansfield Road;
- 3rd December 2006 a flooding event on Deanside and Hillington Road;
- 10th December 2006 a flooding event on Queen Elizabeth Avenue; and,
- 12th January 2007 a flooding event on Mansfield Road and Queen Elizabeth Avenue.

Based upon available information REC Ltd considers the site is therefore considered to be at a moderate to high risk of pluvial flooding.

The SEPA Pluvial Flood Risk Map is presented as Figure 7 in Appendix I.

3.5 Flooding from Sewers and Surface Water Drainage

A review of Scottish Water sewer plans indicates that there is a complex sewer system underlying the Hillington Business Park comprising, combined sewers, surface water sewers and combined sewer overflows (CSOs). Due to the size of the site, a detailed description of the sewers is not possible but the site has been split into 5 distinct zones:

- A736 – Hillington Road;
- Mossland Road;
- Queen Elizabeth Avenue;
- Smaller industrial access roads in the eastern sector; and,
- Smaller industrial access road in the western sector.

3.5.1 Hillington Road (A736)

Located within the southern sector of the A736 is a 225mm diameter vitrified clay combined sewer, this flows north where is upsizes to 450x300 vitrified clay combined sewer and services the industrial units to the east. The central sector of the A736 is absent of sewer systems. Located in the northern sector is a 225mm diameter vitrified clay combined sewer which flows north and upsizes to a 300mm diameter vitrified clay combined sewer. This flows west onto Kelvin Avenue and ultimately upsizes to a 525mm diameter vitrified clay combined sewer.

There are no dedicated surface water sewers located along this route.

3.5.2 Mossland Road

There are no sewers located in the eastern sector of Mossland Road prior to the junction with Kelvin Avenue. Located in the western sector there is a 450mm diameter vitrified clay combined sewer which flows west and upsizes to a 600mm diameter concrete combined sewer which continues to flow west to a sewer structure.

There is also a 15" CSO laid in the 1930s located in the western sector of the site. This continues to flow west and then south along Penlee Road.

3.5.3 Queen Elizabeth Avenue

There is a 225mm diameter vitrified clay combined sewer which services the eastern sector of Queen Elizabeth Avenue. This sewer branches off and services the smaller access roads of Lister Road and Barrie Road. There is a 300mm diameter vitrified clay combined sewer which flows north east onto Cameron Street where it upsizes to a 450mm diameter concrete combined sewer.

There is a surface water sewer located within the eastern sector of Cameron Street and flows east. The size of this sewer is unknown.

3.5.4 Access roads in the eastern sector

The southern sector of this area is serviced solely by combined sewers of varying size.

There is one 375mm diameter surface water sewer located along Deanside Road in the northern sector.

3.5.5 Access roads in the western sector

The western sector of the site has an extensive system of combined sewers in addition to surface water sewers.

The combined sewers located in this area both flow east and comprise two separate systems:

- The 225mm diameter vitrified clay combined sewer located along Montrose Avenue. This then flows north and upsizes into the 450mm diameter vitrified clay combined sewer located along Mossland Road; and,
- The combined sewers servicing the units close to the western boundary also flow east and discharge into the 375mm diameter vitrified clay combined sewer located along Abercom Avenue and ultimately discharge into the 600mm diameter concrete combined

sewer located within the western sector of Mossland Road.

All of the surface water sewers flow in a northerly direction where they appear to discharge into the 15" clay CSO located along Mossland Road. There is also a 12" clay CSO located along Montrose Avenue which flows north and discharges into the 15" clay CSO located along Mossland Road.

The Scottish Water sewer plans also indicate that there is a 900mm diameter culverted watercourse located along Montrose Avenue. This flows north where it upsizes to a 1200mm diameter culvert and flows northeast underneath the M8.

Renfrewshire Council's Flood Risk Management Team was also contacted regarding sewer flooding at the Hillington Business Park and the following events have been identified:

- 30th November 2006 a flooding event at the junction of Zetland and Mansfield Road;
- 3rd December 2006 a flooding event on Deanside and Hillington Road;
- 10th December 2006 a flloding event on Queen Elizabeth Avenue; and,
- 12th January 2007 a flooding event on Mansfield Road and Queen Elizabeth Avenue.

The flood events of 2006/2007 are attributed to a combination of the following sources; road drainage, combined sewer flooding, pluvial flooding and flooding from Mill Burn.

Farrer Consulting and Scottish Water Renfrewshire Flooding Investigations (2007) report highlighted that these events followed significant rainfall which varied between 44.1mm and 62.7mm between 10th December 2006 and 13th December 2006. The report states that the cumulative total rainfall over the four day period was 152.5mm which is believed to have a return period of 142 years. The report concluded that whilst excessive rainfall and surcharging sewers is believed to have occurred at various locations, in many cases a single source of flooding cannot be attributed to the event. A combination of mechanisms including over ground surface flow, watercourse surcharge, road profile and sewer surcharging were all factors.

The Farrer Consulting and Scottish Water report recommends the following measures are implemented at the above sites in order to reduce to future risk:

- Survey the downstream sewers;
- Confirm sewer sections are re-lined;
- Ensure road gullies are regularly emptied; and,
- Check the connectivity and conditions of the road gullies.

The URS Hillington Park Flood Study Report indicates that the modelled drainage network performance during a 1 in 200 year event results in most channels reaching 100% full flow capacity with the exception of channels located along Queen Elizabeth Avenue and the south of Claverhouse and Watt Road.

A response from Scottish Water is awaited by the planners regarding any sewer connection constraints and the potential need for the developer to assess the impact of the proposals on the adopted sewer network and any potential need to upgrade the network or provide Scottish Water defined storage to reduce flows to the adopted sewer network. Any development within the SPZ will be subject to such pending potential constraints.

The Scottish Water sewer plan is presented as Figure 8 in Appendix I.

4.0 FLOOD RISK ASSESSMENT

4.1 Flooding from Rivers

The Scottish Environment Protection Agency's (SEPA) Indicative Flood Map indicates that the site is located outside of a SEPA defined functional floodplain. This is defined as land with less than a 0.5% (1 in 200) chance of river flooding in any given year. However, the SEPA Fluvial Mapping does not assess or map flood risk/hazards associated with watercourses such as the Mill Burn Culvert, located underneath the site, as their catchment sizes are below the 3km^2 threshold.

Due to the highly modified nature of Mill Burn Culvert, this is has been assessed as an artificial watercourse as detailed within Section 4.4.

Based on the significant water depths and the located of areas of the site within the 1 in 200 year flood envelope associated with Mill Burn culvert, the SPZ is considered as being at a moderate to high risk of fluvial flooding.

4.2 Flooding from Groundwater

Groundwater flooding usually occurs during intense, long duration rainfall events when infiltrating rainwater into the ground raises the water table level and consequently exceeds the ground level. It is common in low lying areas overlain by permeable soils and geology.

This type of flooding happens in response to a combination of already high groundwater levels (usually during mid- or late-winter) and intense or unusually lengthy storm events; often lasting much longer than flooding caused by a fluvial and tidal sources.

The Scottish NFRA states that the groundwater risk associated with this catchment is considered to be moderate. This is likely associated with the underlying solid limestone geology and the permeable sands and gravels covering the majority of the site.

The groundwater risk associated with limestone geology is a result of high pore water content which cannot be drained due to the small pore diameters which are characteristic of this geology. It is known that following a recharge, a critical saturation can be reached which is immediately followed by a rapid rise in groundwater levels which may intercept the land surface. Areas most at risk will be deep foundations, basements and underground infrastructure. The location of the emergence points cannot be accurately located but groundwater can often emerge over a large or diffuse area, but can also emerge at single points. Due to the complexity of groundwater flooding incidents, the potential depth of flooding attributed to this flood source is unknown.

4.3 Flooding from Sewers

The lack of sewer capacity at the site is known to be the cause of multiple flood events which have been exacerbated by overland flow. The flood events of 2006/2007 are attributed to a combination of the following sources; road drainage, combined sewer flooding, pluvial flooding and flooding from the Mill Burn culvert.

The URS Hillington Park Flood Study Report indicates that the modelled drainage network performance during a 1 in 200 year event results in most channels reaching 100% full flow capacity with the exception of channels located along Queen Elizabeth Avenue and the south of Claverhouse and Watt Road. Furthermore, the JBA Hillington Industrial Estate Existing Flood Risk Report indicates that flood depths on the M8 frontage area, to the north of Napier Road, accumulates flood water of between 0.672m and 0.823m associated with

Mill Burn surcharging during a 1 in 200 year event. This risk can be mitigated through the use of techniques described in Section 5.4.

JBA Hillington Industrial Estate Existing Flood Risk Report (2007) modelled various critical storm durations in order to determine which creates the largest flood volume. The results indicate that for the 1 in 200 year event, the critical storm duration is 230 minutes. The JBA report indicates that during a 1 in 200 year event a significant number of manholes surcharge resulting in 14, 462m^3 of water to escape from the sewerage system through a total of 67 manholes. The JFlow results show that once the water escapes from the system, it begins to move around and pond largely within the road network.

Should further development arise as a result of the SPZ, it will be considered necessary that the capacity of these sewers is determined, along with consultation with Scottish Water, so not to increase the current pressures on the current system under extreme events.

A response from Scottish Water is awaited by the planners regarding any sewer connection constraints and the potential need for the developer to assess the impact of the proposals on the adopted sewer network and any potential need to upgrade the network or provide Scottish Water defined storage to reduce flows to the adopted sewer network. Any development within the SPZ will be subject to such pending potential constraints.

The risk of flooding from culverted watercourses and sewers is therefore considered to be moderate to high.

Asset data for Mill Burn Culvert, as supplied by Renfrewshire Council, is presented as Figure 9 in Appendix I.

It is recommended that a detailed hydraulic modelling study for a culvert blockage scenario is undertaken to ascertain the extent of flooding in this scenario.

4.4 Flooding from Reservoirs, Canals & Other Artificial Watercourse

Due to the highly modified nature of Mill Burn Culvert, this is has been assessed as an artificial watercourse. Reports provided by JBA indicate that the areas associated with the Mill Burn Culvert are considered as being at a significant risk during a 1 in 200 year flood event. Furthermore, the report indicates that flood depths on the M8 frontage area, to the north of Napier Road, accumulates flood water of between 0.672m and 0.823m associated with Mill Burn surcharging during a 1 in 200 year event. The Greenfield run-off rates from this area are limited by a 300mmØ land drain located within this area which results in a pluvial ponding area equating to 2350m^3. This volume of storage will have to be compensated for land raising in this area to ensure that this storage capacity is to be maintained. Furthermore, in order to mitigate any risk of flooding, a 400mm freeboard allowance will be included as a mitigation measure.

Stanley Reservoir and Thornley Dam are located approximately 5km south west of the site. Glenburn and Harelaw Reservoirs are located approximately 6km south west and south of the site respectively.

Reservoirs hold large volumes of water which are above ground level. Although unlikely, failure of infrastructure such as dams, reservoirs and canals result in the rapid release of the large volumes of water. The Flood Risk Management (Scotland) Act 2009 transfers the responsibility for reservoirs to SEPA to ensure a streamlined approach to flood risk management.

An review of topographic data indicates that if infrastructure failure were to occur, the water

released from the structure will flow north and northwest as these areas are topographically lower than the reservoirs. If water were to flow north, it would drain into White Cart Water and Black Cart Water to the northwest. The flood waters as a result of infrastructure failure are therefore considered unlikely to affect the site given the presence of intercepting watercourses.

4.5 Historical Flood Events

Glasgow City Council's Flood Risk Management Team were contacted in order to determine if the site has been subject to historical flood events. At the time of writing, a response from the Council had not been received.

Renfrewshire Council's Flood Risk Management Team was also contacted regarding pluvial flooding at the Hillington Business Park and the following events have been identified:

- 30th November 2006 a flooding event at the junction of Zetland and Mansfield Road;
- 3rd December 2006 a flooding event on Deenside and Hillington Road;
- 10th December 2006 a flooding event on Queen Elizabeth Avenue; and,
- 12th January 2007 a flooding event on Mansfield Road and Queen Elizabeth Avenue.

The Scottish NFRA databases and anecdotal web searches were also undertaken to determine if the site had been subject to previous flooding events. The Scottish NFRA does not have any recorded events within the Hillington Business Park area. Anecdotal web searches had one recorded flooding incident at the MEPC Innovation Centre on 11th May 2009. This event however, is attributed to a major leak from a hot water tank located within the roof space of the building.

The River Clyde Flood Management Strategy has indicated that a serious tidal flooding event occurred in Renfrew in 1991 as a result of high tides coinciding with high river flows. There is no evidence to suggest the site was subject to this event.

4.6 Flood Zone Classification

The Scottish Environment Protection Agency's (SEPA) Indicative Flood Map indicates that the site is located outside of a SEPA defined functional floodplain. This is defined as land with less than a 0.5% (1 in 200) chance of river flooding in any given year. However, the SEPA Fluvial Mapping does not assess or map flood risk/hazards associated with watercourses such as the Mill Burn Culvert, located underneath the site, as their catchment sizes are below the 3km^2 threshold. Reports provided by JBA indicate that the areas associated with the Mill Burn Culvert are considered as being at a significant risk during a 1 in 200 year flood event therefore, these areas are located within the floodplain of Mill Burn.

4.7 Access and Egress

Dry access and egress may become compromised during a 1 in 200 year rainfall event. The JBA Hillington Industrial Estate Existing Flood Risk Report JFlow modelling indicates that the average depth of flooding is 130mm with an average kerb height of 150mm therefore, it is likely that flood waters will remain largely within the road channels.

Dry access and egress may also, become compromised if groundwater flooding were to occur but in comparison to fluvial and/or tidal flooding, groundwater flooding is generally a gradual process with low water velocities. Consequently, during an episode of groundwater flooding there will likely be time to relocate expensive vehicles, equipment and people away

from the site.

4.8 Flood Warning and Evacuation Plans

The site is not located within an area where Flood Warnings or Alerts are issued for the West Central area.

4.9 Surface Water Drainage

As stated within paragraph 209 of the Scottish Planning Policy:

"The Water Environment (Controlled Activities) (Scotland) Regulations 2005 require that all surface water from new developments is treated by a Sustainable Drainage System (SuDS) before it is discharged into the water environment, except for a single dwelling or where the discharge will be to coastal waters".

The Water Environment (Controlled Activities) (Scotland) Regulations 2005 also make SuDS a legal requirement for new development. Surface water run-off, including roof water, from all development should be fully or partially drained by SuDS in line with SPP and Planning Advice Note 79 – Water and Drainage with the SuDS systems being designed in accordance with the CIRIA SuDS Manual (C697).

SEPA Guidance Note 2 (Planning Advice in Sustainable Drainage Systems (SuDS)) states that industrial developments require three levels of treatment for hard standing areas and two levels of treatment for roads. An exception is run-off from roofs which require only one level of treatment.

The Hillington Business Park is already a developed site with extensive areas of hardstanding for industrial/commercial uses. The site also has planning consent for an additional 6 hectares of employment land which aims to increase the level of employment land at the park in the region of 10 – 15%. The SPZ scheme will grant planning permission for a defined range of development without the need for individual planning permissions. The calculations below assess the impact that increased development and associated hardstanding will have on the existing runoff of a site.

The Modified Rational Method has been used to calculate the runoff from the impermeable surfaces of the existing site using rainfall data from the FEH CD-ROM and appropriate catchment details. The calculations are in accordance with SEPA's Guidance Document for Regulators and Developers for Drainage Impact Assessments.

A summary of the calculation of the existing runoff rate is tabulated below, with the full calculations provided in Appendix II of this report.

Flow rates for 198.62 hectare site with 58% impermeable area (existing site):

Return Period	Area (Ha)	Peak Flow Rate (l/s)
1 in 2 year	115.08ha impermeable area	1592.6
1 in 50 year		3533.2
1 in 200 year		4837.5

The SPZ Planning Scheme has been provided to REC Ltd which details the gross floor space to be included within each land use class. For the majority of the classes, the floor space is considered to cover ground floor only with the exception of Class 4 (Business) and Class 2 (Financial, Professional and Other Services) which are considered to cover two

floors with Class 7 (Hotels) considered to cover three floors. The development area identified with the SPZ Planning Scheme has therefore been pro-rata to accommodate for this. As no information has been provided regarding the increase in associated impermeable area i.e. access roads, car parking facilities, forecourts etc. an additional 10% allowance has been included to account for this.

In accordance with Sewers for Scotland – 2nd Edition, an additional 10% has been included within all rainfall calculations with run-off rates determined for the critical storm duration (i.e. 230 minutes) as indicated from information provided by the Renfrewshire Council's Flood Officer.

A summary of run-off rates as a result of construction within the SPZ is tabulated below with the full calculations provided within Appendix II of this report.

Flow rates for 198.62 hectare site with 67% impermeable area:

Return Period	Area (Ha)	Peak Flow Rate (l/s)
1 in 2 year	132.80ha impermeable area	1837.8
1 in 50 year		4077.3
1 in 200 year		5582.3

The SPZ Planning Scheme indicates that under the SPZ, there will be approximately 74.47 ha total development within Zone A, 6.63 ha total development within Zone B with Zone C safeguarded from development. Based on this information, by restricting run-off from future development to Greenfield run-off rates, additional attenuation will be required. This will have to analysed as part of a more detailed DIA once the exact development plans are known.

These figures are indicative only and assumes that all surface water from the site leaves via either a single or multiple outlets to a receiving watercourse or sewer network. The calculations do no account for existing SuDS techniques or other attenuation and flow controls within the drainage system. A survey of the existing drainage systems was conducted for the purposes of the ICM model and was the basis for the JBA Existing Flood Risk Report and latterly the URS report on the M8 frontage area of the SPZ. Further information will be required on the cumulative and individual impact of the SPZ proposals on flood risk which are to be submitted, via condition compliance to the FRA and Outline DIA.

Any current Greenfield areas which are to be considered for development will have to maintain current Greenfield run-off rates taking into account any change in existing and proposed receiving networks in design of any mitigation measures.

Any further development within the SPZ must give consideration to the disposal of surface water in accordance with SPP. A hierarchical approach should be taken to the design of the surface water drainage system with priority given to:

- Infiltration via soakaway or other infiltration device;
- Watercourse; and,
- Sewer.

Given the presence of solid limestone geology and the risk of groundwater flooding as a result of rapidly rising groundwater levels, infiltration is not considered an option for the site due to possibility of periods of shallow or emergent groundwater. Furthermore, given the

industrial uses within the site, consideration needs to be given to the possibility of mobile contaminants. In accordance with CIRIA C697 guidance, surface water discharge must not result in the pollution of the water environment and given the industrial land uses for the site, the risk of contamination is considered to be high. Infiltration techniques would therefore not be recommended for this area.

The closest watercourse to the site is the Mill Burn culvert underneath the site along Montrose Avenue. Discharge of surface water is likely to be to a combination of the combined sewer network and the Mill Burn culvert dependent on the proximity of any individual element of the SPZ scheme to the culvert and is to be confirmed by Scottish Water. It is considered necessary that the capacity of these sewers is determined, along with consultation with Scottish Water, so not to increase the pressures on the current system under extreme events.

This Flood Risk Assessment should be supplemented by a detailed Drainage Impact Assessment (DIA) which will ascertain more detailed calculations to establish surface water flows leaving the site and a survey of the existing drainage system. The calculations and conclusions stated above are indicative only.

It is therefore recommended that a DIA is conducted in support of the SPZ including consultation with Glasgow City Council, Renfrewshire Council and Flood Managers post SPZ designation through the provision of compliance to the FRA and Outline DIA.

5.0 DEVELOPABLE AREAS

5.1 Developable Free Areas

From the information provided, it can be concluded that the junction of Scott Road and Dalziel Road should remain development free. This area is considered to be at a significant risk of pluvial flooding and according to the URS Hillington Park Flood Study Report, flood depths along this route could reach 1.033m in depth during a 1 in 200 year event.

5.2 Developable Areas at Risk

There are several areas located within the Hillington Park which may be developed but will required mitigation measures in order to minimise the risk to the proposed use. These areas are considered at risk from a combination of road drainage, combined sewer flooding, pluvial flooding and flooding from Mill Burn culvert and are as follows;

- Napier Road;
- Kelvin Avenue;
- Montrose Avenue;
- Mossland Road;
- Cunningham Road;
- Buccleuch Avenue;
- Seaforth Road;
- Ainslie Road;
- Deanside Road;
- Hillington Road (at the junction of Deanside Road and Ainslie Road);
- Hepburn Road;
- Ballantine Avenue;
- Zetland Road; and,
- Mansfield Road.

The above areas have been deemed developable but at continued risk of flooding from the information provided by Renfrewshire Council, URS Hillington Park Flood Study Report, Farrer Consulting and Scottish Water Renfrewshire Flooding Investigations and the JBA Hillington Industrial Estate Existing Flood Risk Report.

5.3 Developable Areas at Minimal Risk

The remainder of the SPZ is considered as being developable with minimal risk of flooding, providing that the development complies with the approved SPZ FRA and DIA. Development will be required to maintain Greenfield run-off rates, provide compensatory pluvial flood storage capacity and demonstrate the post-development flood risk to a 1 in 200 year event whilst not increasing flood risk elsewhere.

A zoned map highlighting the above mentioned areas is presented as Figure 10 in Appendix I.

5.4 Mitigation Measures

The areas highlighted within Section 5.2 are considered suitable for development providing that appropriate consideration to mitigation measures are incorporated into the building design.

For any development which is to take place within areas considered at risk, the Finished Floor Levels (FFLs) should be set at a minimum to reduce water ingress if flooding were to occur. For developments considered at risk of flooding, FFLs should be set at a minimum of the 1 in 200 year plus 600mm freeboard allowance level.

For any areas where a suitable freeboard allowance cannot be incorporated into the building design, land raising with the provision of SuDS techniques (where appropriate) and the provision of compensatory capacity to ensure the natural storage volume of the area is maintained is recommend. Suitable calculations will have to be conducted for these areas to ensure that suitable compensatory capacity is provided.

Furthermore, within future highways design, the SPZ can be developed to ensure flood water retention in the highway channels to full kerb height, as is the situation in other areas of the Hillington Business Park. This would ensure retention of waters within controlled areas and reducing the risk to proposed buildings.

The risk of sewer surcharging may also be reduced by following the recommendations made within the Farrer Consulting and Scottish Water report that the following measures can be implemented at the above sites in order to reduce to future risk:

- Survey the downstream sewers;
- Confirm sewer sections are re-lined;
- Ensure road gullies are regularly emptied; and,
- Check the connectivity and conditions of the road gullies.

All of the above stated flood management measures are subject to further detail to support individual proposals and should all be compliant with the requirements of the approved SPZ FRA and Outline DIA.

6.0 CONCLUSIONS

Conclusions

Resource and Environmental Consultants Ltd (REC) have been commissioned by MEPC to undertake a Flood Risk Assessment (FRA) for the Hillington Business Park. This Flood Risk Assessment follows guidance set out in the Scottish Planning Policy (SPP).

The report is required for the application for the Proposed Simplified Planning Zone (SPZ) for the Hillington Business Park, Glasgow. The SPZ removes the need for a planning application for development within the defined parameters.

The Scottish Environment Protection Agency's (SEPA) Indicative River and Coastal Flood Map indicates that the site is located outside of a SEPA defined functional floodplain. This is defined as land with less than a 0.5% (1 in 200) chance of river flooding in any given year. However, the SEPA Fluvial Mapping does not assess or map flood risk/hazards associated with watercourses such as the Mill Burn Culvert, located underneath the site, as their catchment sizes are below the 3km^2 threshold.

Reports provided by JBA indicate that the area associated with the Mill Burn Culvert are considered as being at a significant risk during a 1 in 200 year flood event therefore, areas of the site are considered to be at risk of fluvial flooding.

The primary flood risk to the site is considered to be from pluvial/combined sewer sources with secondary flooding from the Mill Burn Culvert, groundwater and road drainage.

The site is therefore considered to be at a medium/high risk of pluvial flooding with previous flooding incidences being recorded for the site.

There is considered to be a medium/high risk associated with a culverted watercourse along Montrose Avenue.

There is considered to be a medium/high risk associated with the sewerage system located within the vicinity.

There is considered to be a moderate risk associated with groundwater with the underlying solid limestone geology and the permeable sands and gravels covering the majority of the site.

It can be concluded that the junction of Scott Road and Dalziel Road should remain development free. This area is considered to be at a significant risk of pluvial flooding with flood depths along this route could reach 1.033m in depth during a 1 in 200 year event.

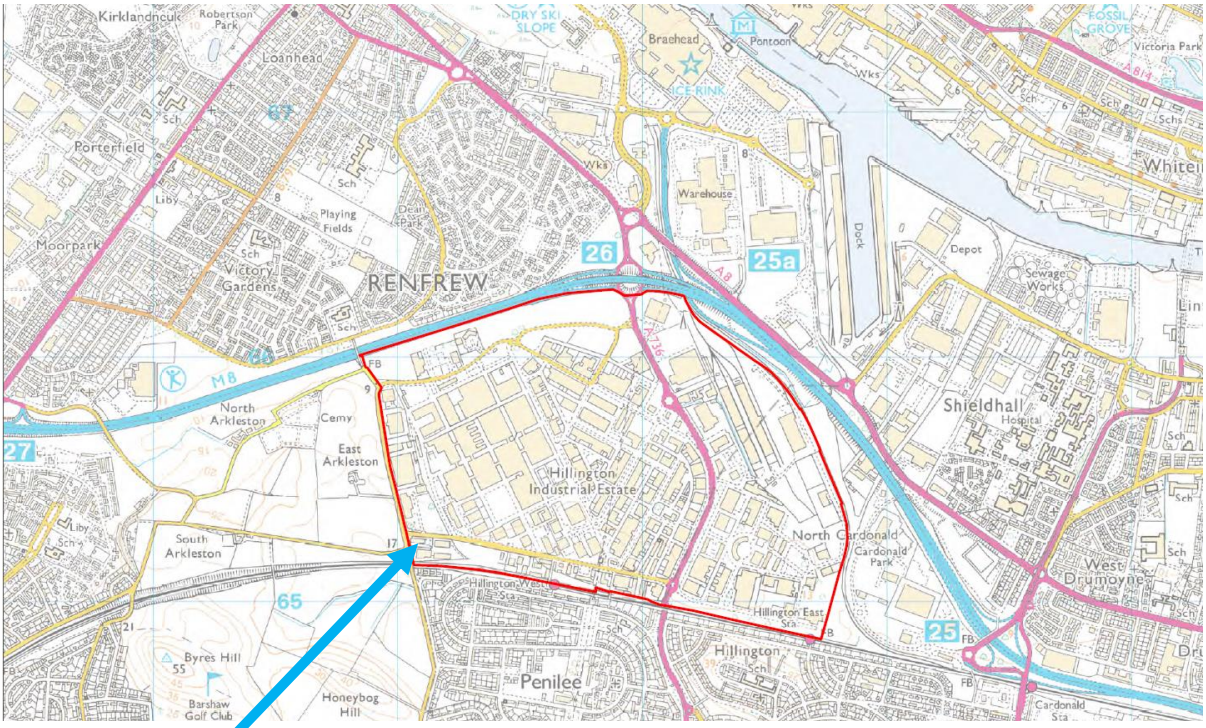
There are several areas within the park which are considered as being developable but at risk. These areas should include suitable mitigation measures in order to minimise this risk.

The majority of the park is considered as being developable with minimal risk of flooding.

END OF REPORT

APPENDIX I

FIGURES



Site Location

Figure 1

Site Location & Aerial Photograph

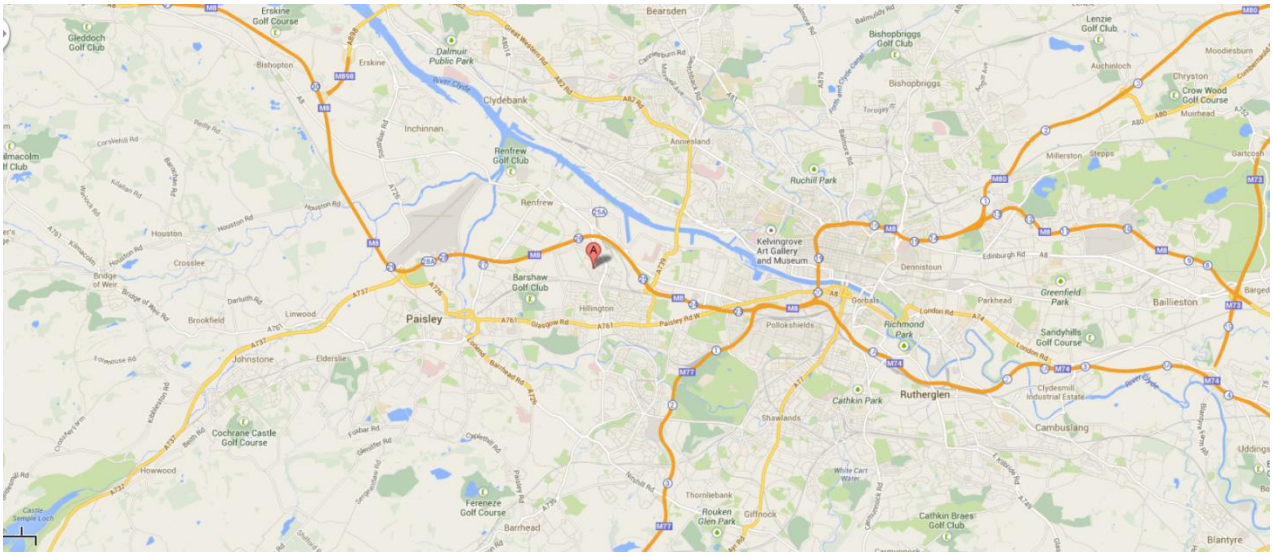


Figure 2

Map of Surrounding Hydrology

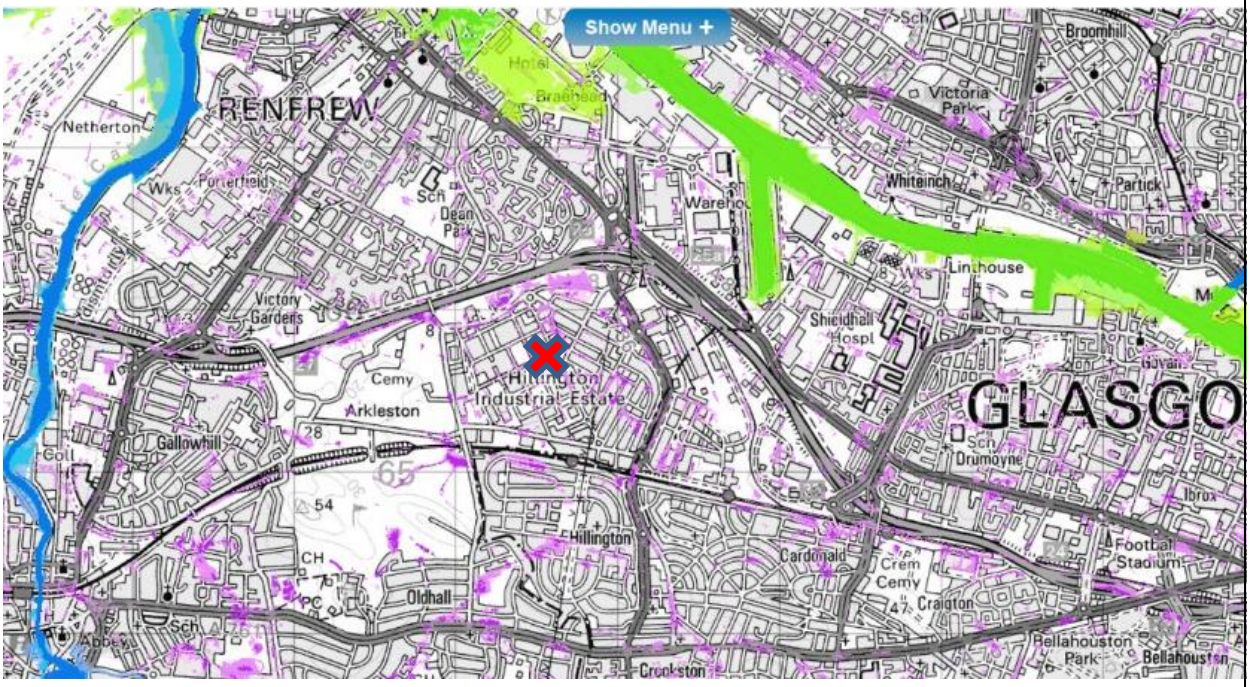


Figure 3

SEPA Indicative River and Coastal Flood Map

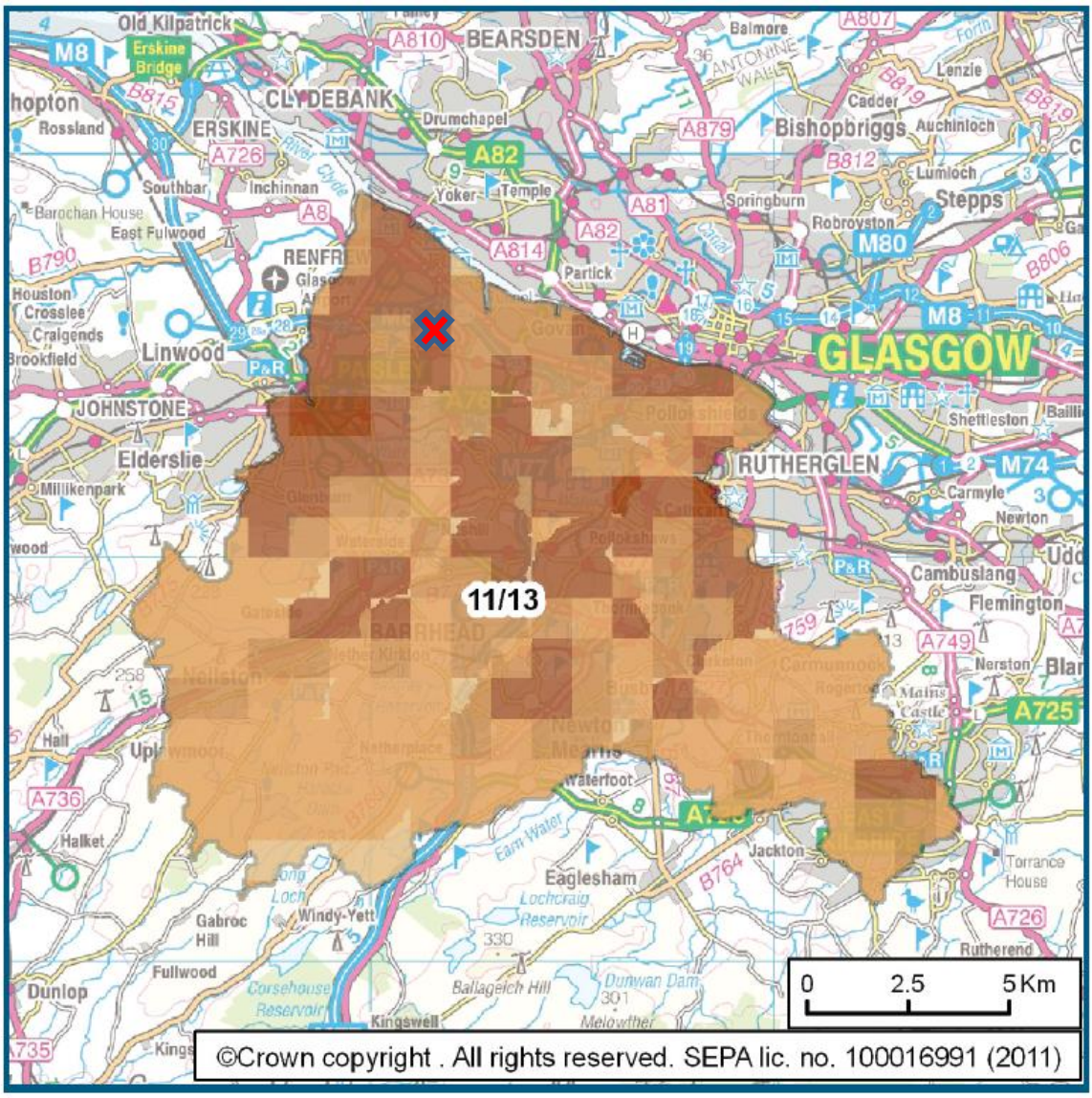
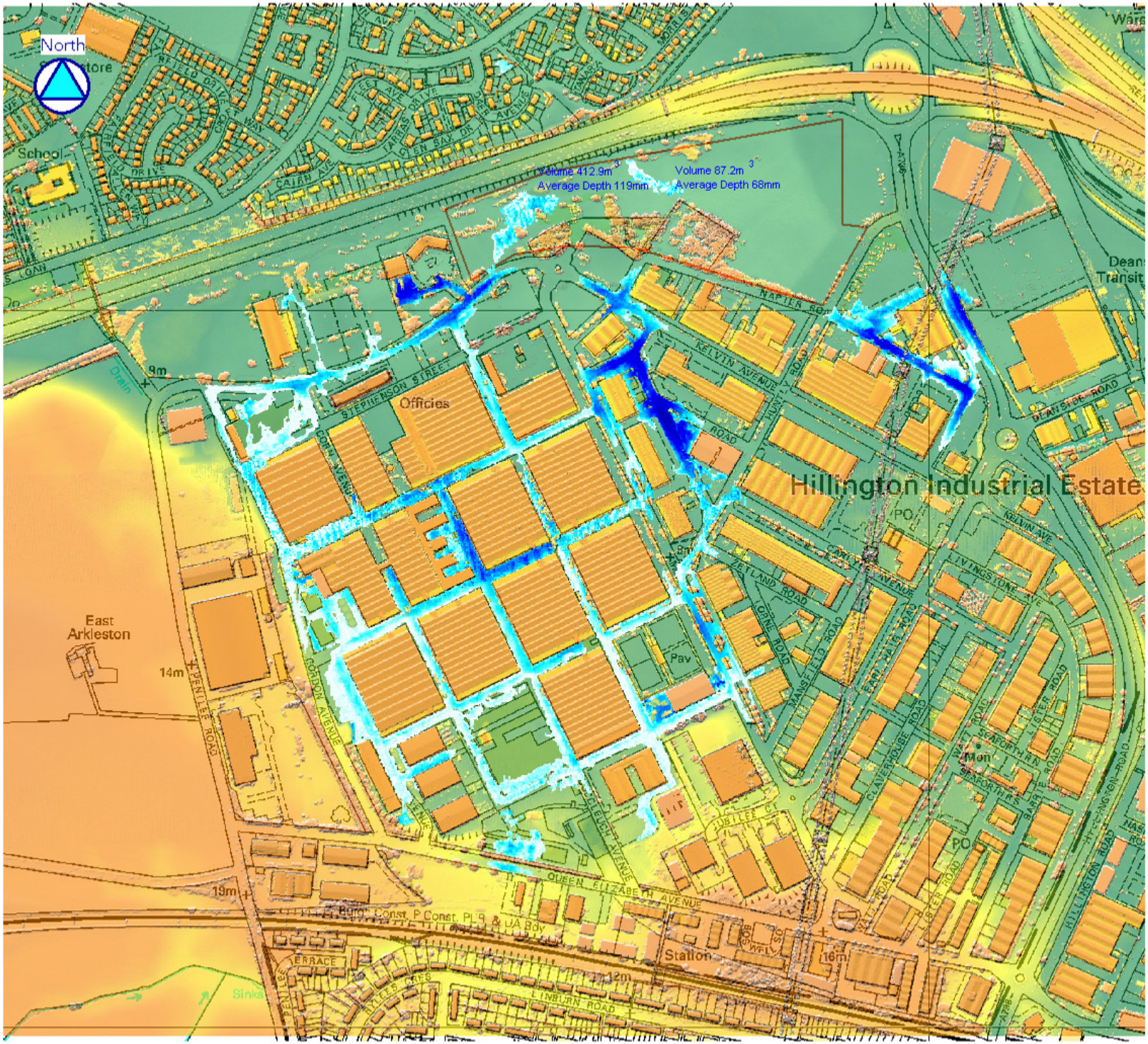
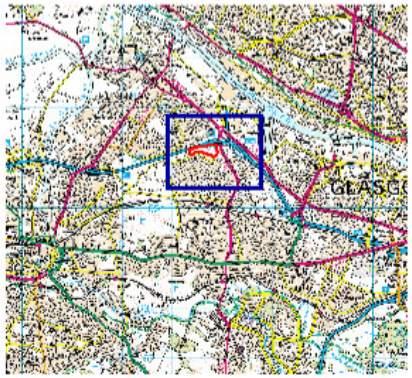


Figure 4

Scottish Environment Protection Agency's Potential Vulnerable Area Map



KEYPLAN



LEGEND

Development Site

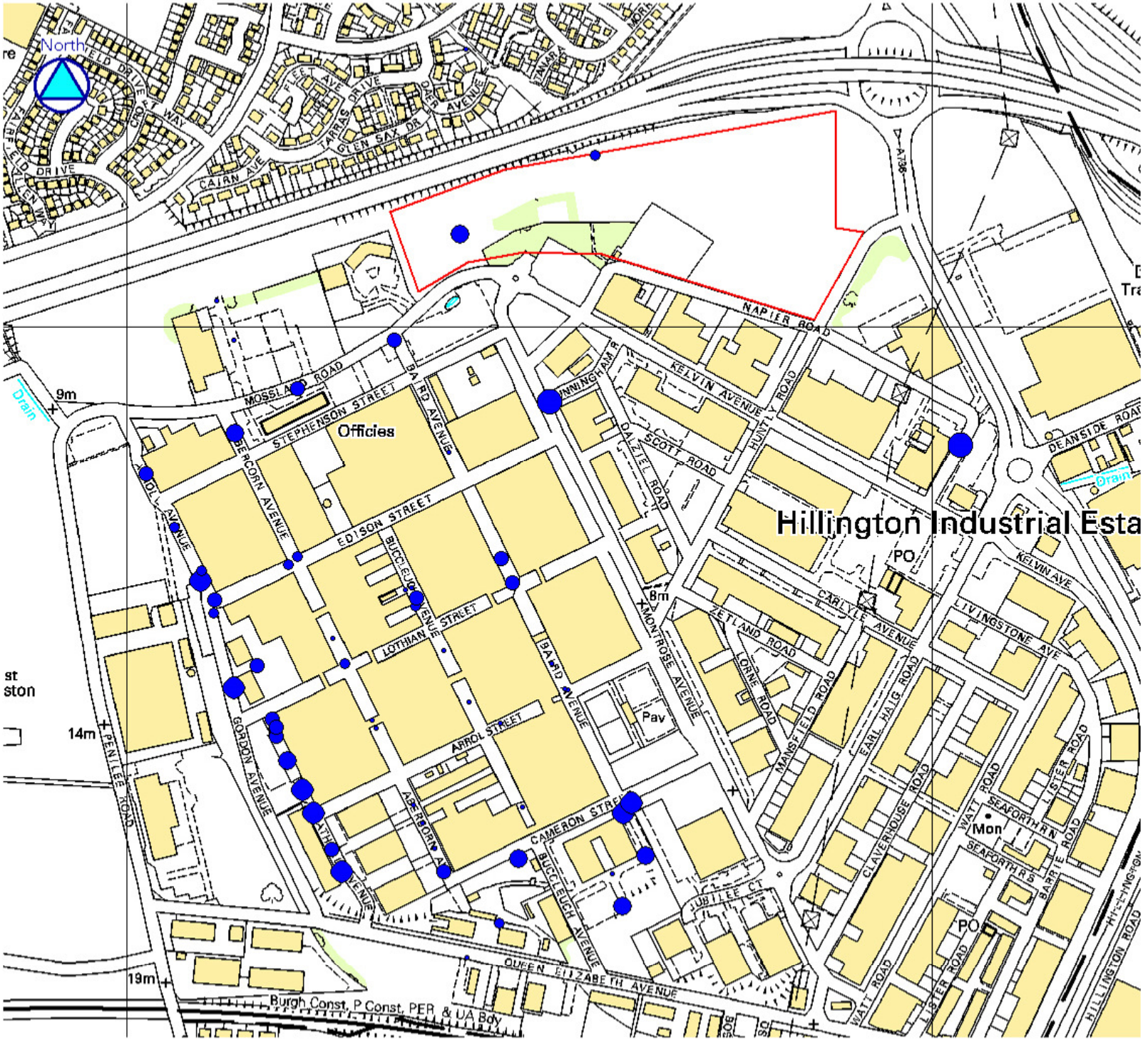
Flood Depth

1.0000
0.5000
0.1500
Depth (m)

jba CONSULTING

FIGURE 2

200 YEAR FLOOD EXTENTS
WITH LIDAR UNDERNEATH



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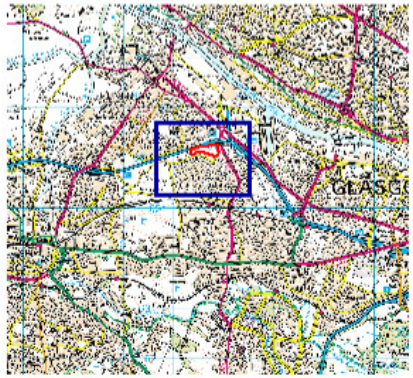


LEGEND

Development Site

Flood Volumes at Manholes

1,000 to 3,150		(2)
500 to 1,000		(7)
250 to	500	(6)
100 to	250	(13)
50 to	100	(9)
1 to	50	(22)
all others		(589)

jba CONSULTING

FIGURE 1

SURCHARGING MANHOLES

Figure 7

SEPA Pluvial Flood Risk Map

Plotted by:
DALZIEKE

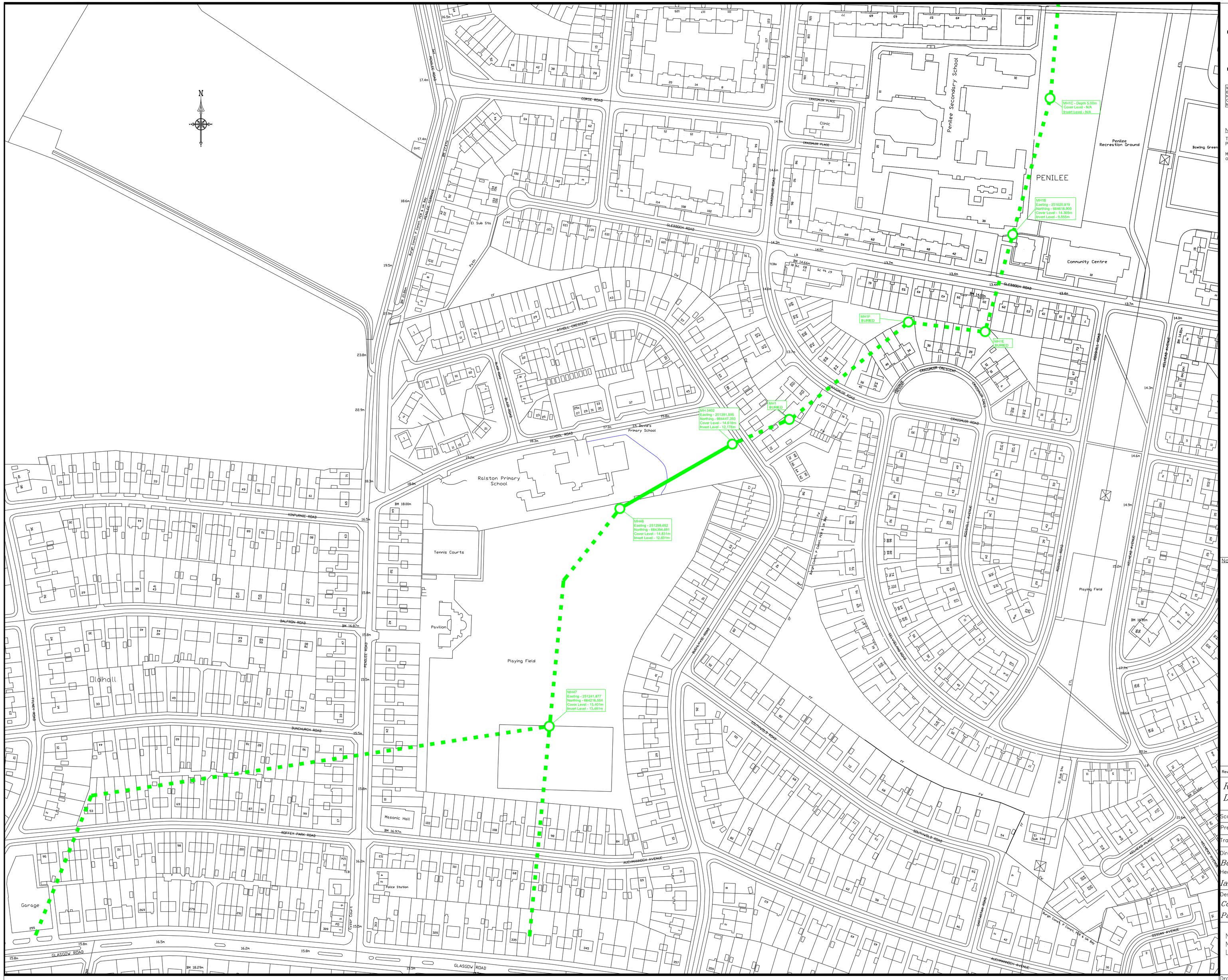
N

Hillington Park

SCALE: 1:2000

Date Plotted: 12/12/2013

Scottish Water
Business serving Scotland
Castle House,
6 Castle Drive,
Dunfermline,
KY11 8GG
Tel No: 0845 601 8855



LEGEND

- Pipe run not surveyed/cleaned
- Manhole
- Pipe run surveyed/cleaned

MH29
Easting - 251254.798
Northing - 666580.569
Cover Level - 6.538m
Invert Level - 4.288m

Information Block indicating position Level and invert level of manhole. All values are to National Grid.

NOTES:

This drawing is to be read in conjunction with Drawings PPA/CE111F/R03-05, 06, 07 & 08.

Manholes without information blocks are either buried or on British Rail owned land and are inaccessible

Notes:

Rev:	Date:	Revision	Checked Date:	Appvd Date:

Renfrewshire Council
Department of Planning and Transport

Scale	: 1:1000	Date	: 23/06/05
Prepared by	: DBC	Checked by	: WF
Traced by	: ACADLT	Approved by	: SC

Director of Planning and Transport:
Bob Darracott: DipTP, Mphil, M.R.T.P.I.
Head of Roads:
Iain Hamilton: B.Sc., C.Eng., M.I.C.E., F.I.H.T.
Design Office:
Council Offices (South Block) Cotton Street, Paisley, PA1 1ST.

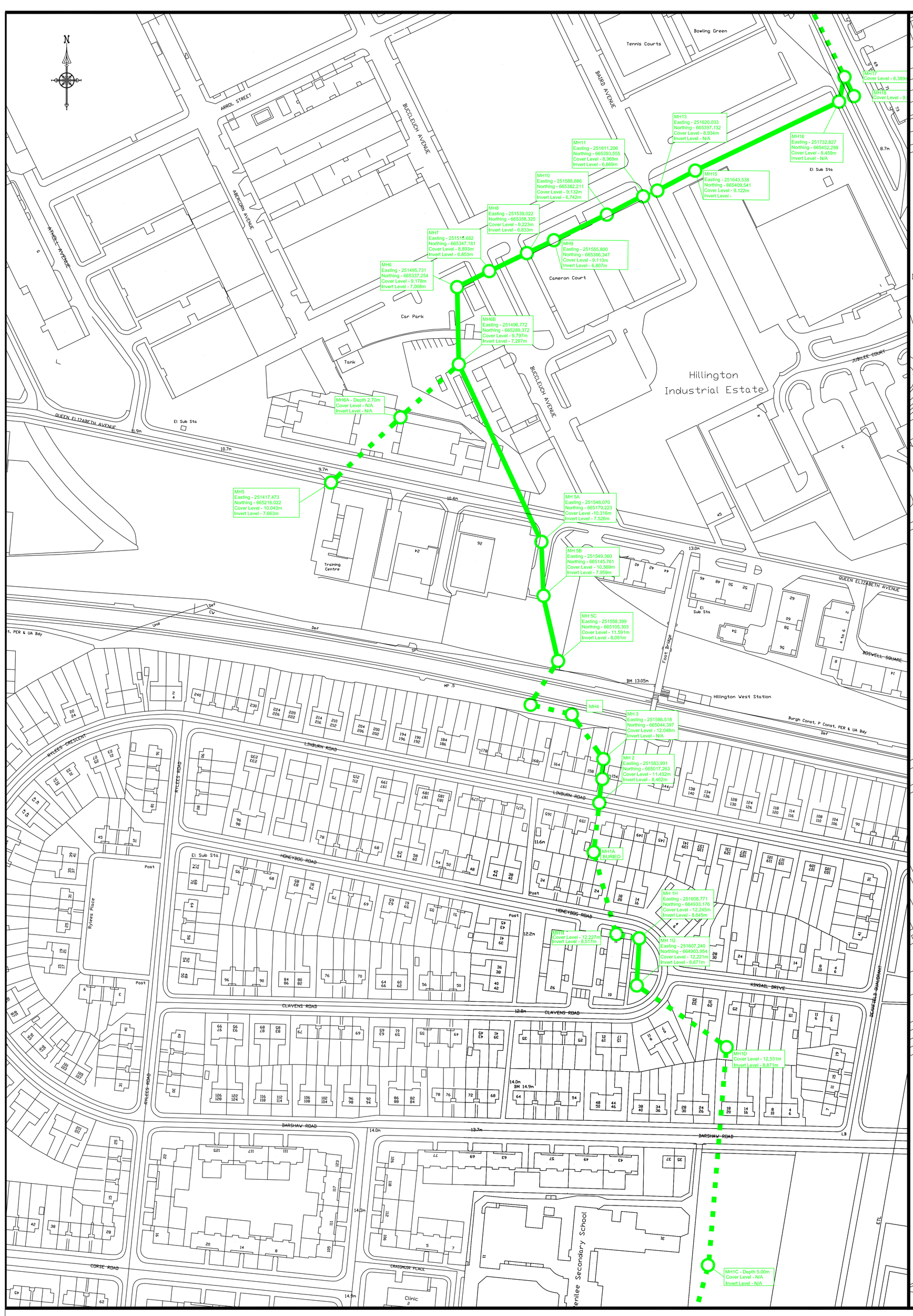
NORTH RENFREW FLOOD PREVENTION SCHEME MILLBURN - MANHOLE/RIVER BED SURVEY LOCATION PLAN No 1 OF 4

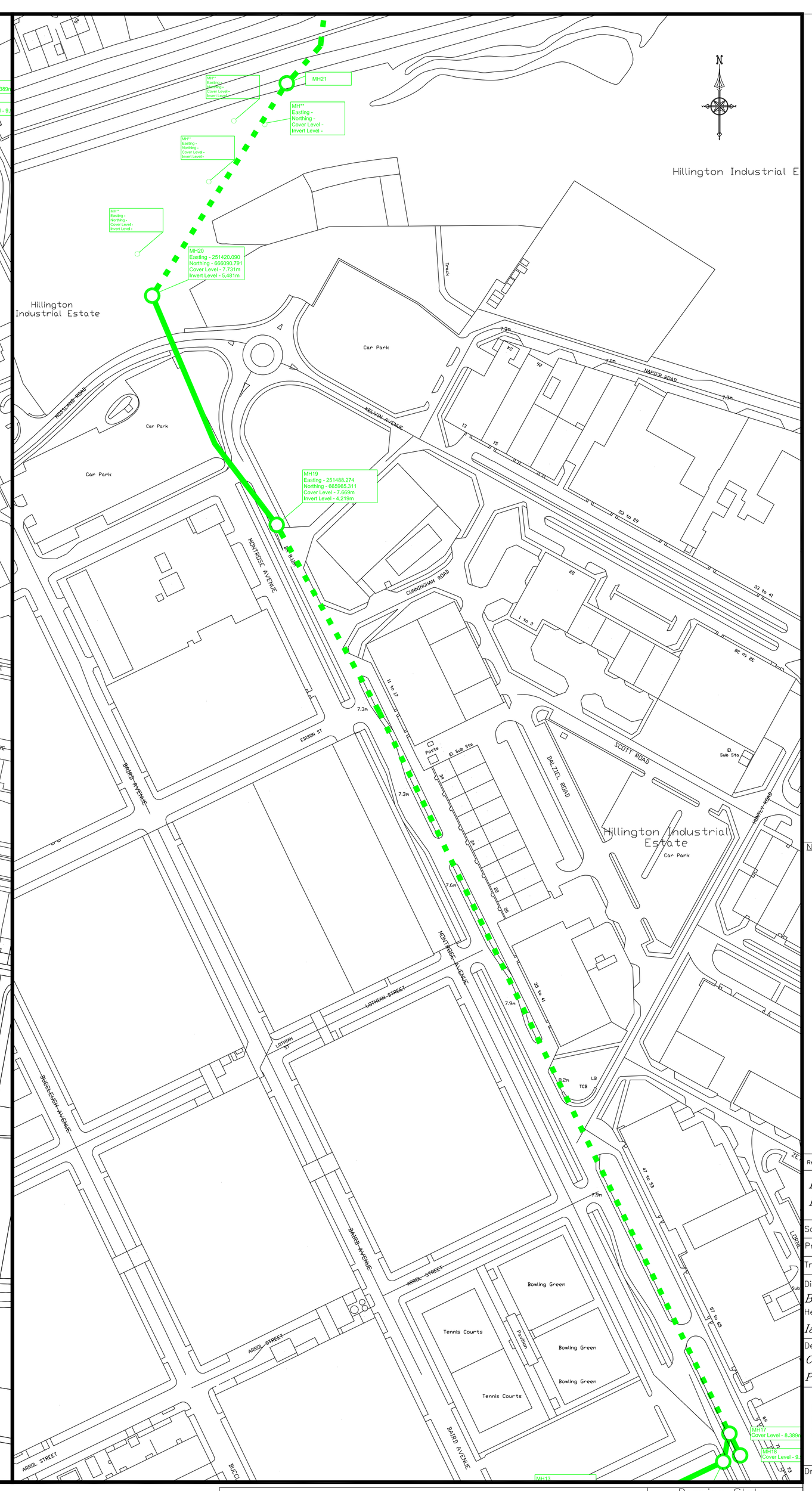
Drawing No: PPA/CE111F/R03-04
Rev:
File No: NW/RIC349/COR/65

design GROUP
Original Drawing Size A1 841 x 1189 (A0)

Drawing Status

Preliminary		Contract	
Tender		Record	





LEGEND

- Pipe run not surveyed/cleaned
- Manhole
- Pipe run surveyed/cleaned

MH29
Easting - 251254.798
Northing - 666590.569
Cover Level - 6.538m
Invert Level - 4.288m

Information Block indicating position Level and invert level of manhole. All values are to National Grid.

NOTES:

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NORTH RENFREW FLOOD PREVENTION SCHEME
MILLBURN - MANHOLE/RIVER BED SURVEY
LOCATION PLAN No 2 OF 4

Drawing No: PPA/CE111F/R03-05
Rev:
File No: NW/RIC349/COR/65
Design GROUP
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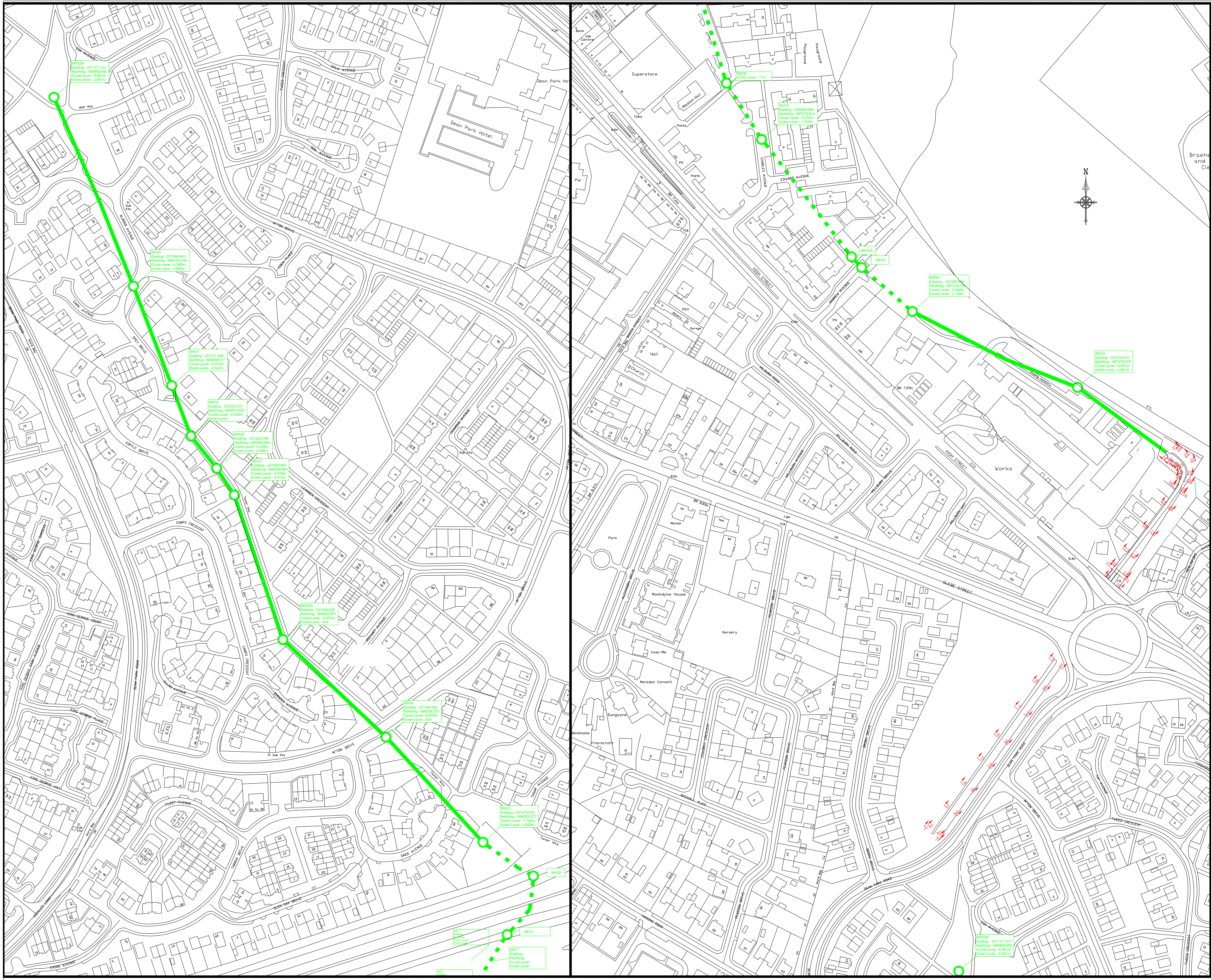
Tender		Record	



LEGEND

Pipe run not surveyed/cleaned

Manhole

Pipe run surveyed/cleaned

MH29
Easting - 251254.798
Northing - 666590.569
Cover Level - 6.538m
Invert Level - 4.288m

Information Block indicating position Level and invert level of manhole. All values are to National Grid.

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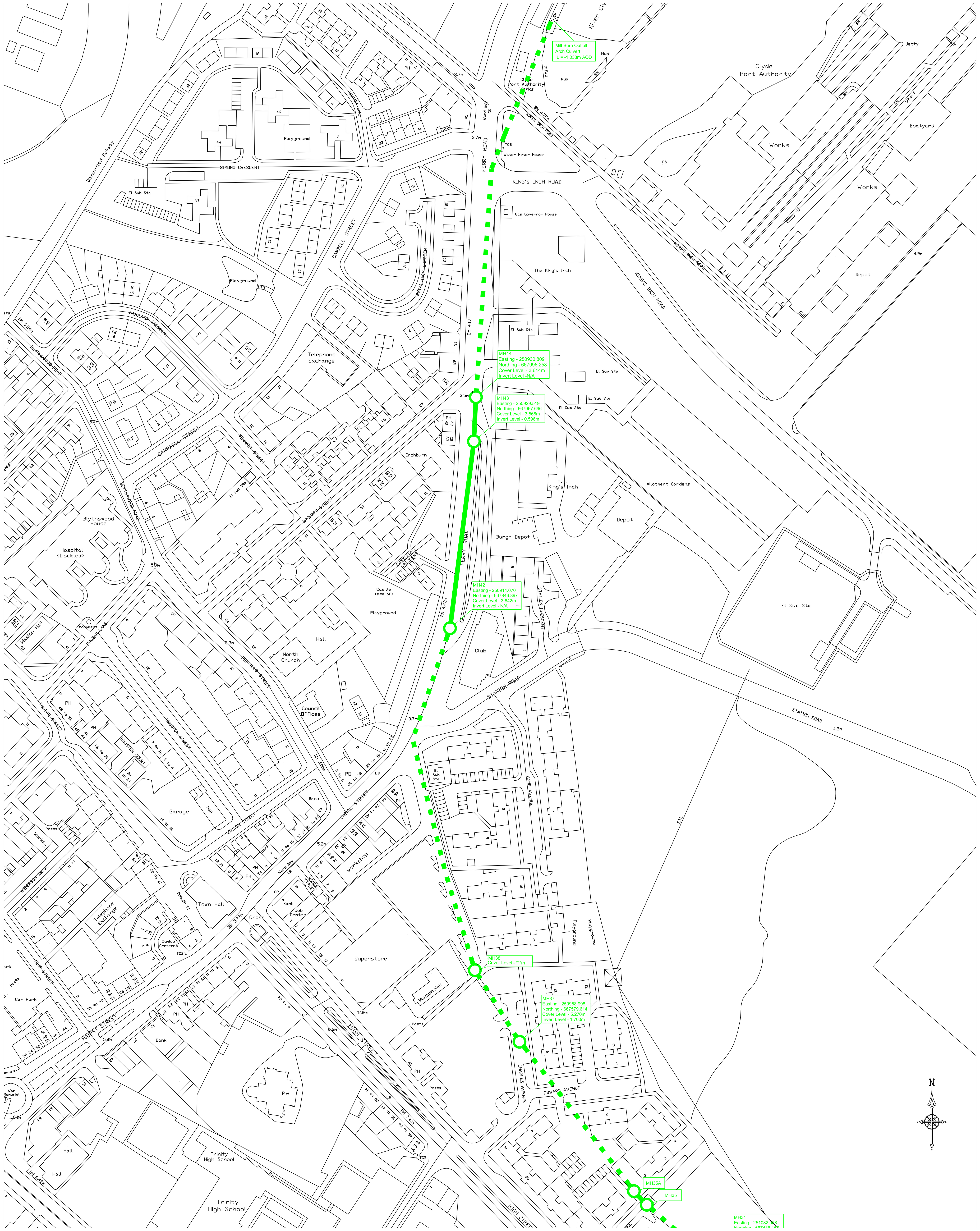
NORTH RENFREW FLOOD PREVENTION SCHEME
MILLBURN - MANHOLE/RIVER BED SURVEY
LOCATION PLAN No 3 OF 4

Drawing No: PPA/CE111F/R03-06
Rev:
File No: NW/RIC349/COR/65

design GROUP
Original Drawing Size 841 x 1189 (A0)

Drawing Status	
Preliminary	Contract
Tender	Record



LEGEND

▬ ▬ ▬	Pipe run not surveyed/cleaned
○	Manhole
▬▬▬	Pipe run surveyed/cleaned
MH29 Easting - 251254.798 Northing - 666590.569 Cover Level - 6.538m Invert Level - 4.288m	Information Block indicating position Level and invert level of manhole. All values are to National Grid.

NOTES:

This drawing is to be read in conjunction with Drawings PPA/CE111F/R03-04, 05, 06 & 08.

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Design Office:
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NORTH RENFREW FLOOD PREVENTION SCHEME
MILLBURN - MANHOLE/RIVER BED SURVEY
LOCATION PLAN No 4 OF 4

Drawing No: PPA/CE111F/R03-07
Rev:
File No: NW/RIC349/COR/65

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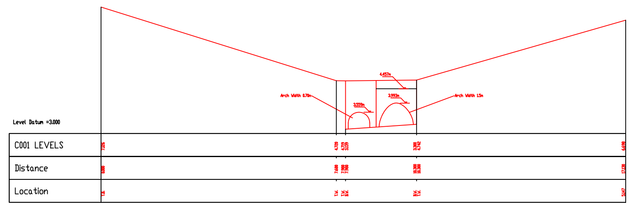
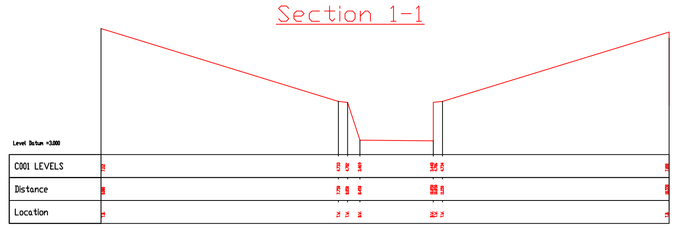
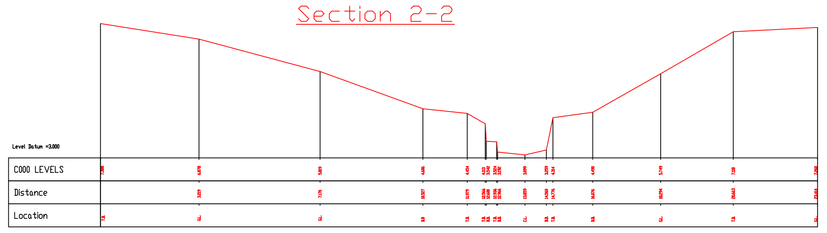


Section 1-1



Section 2-2



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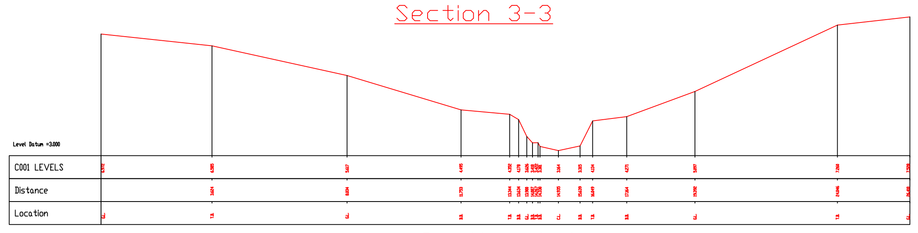

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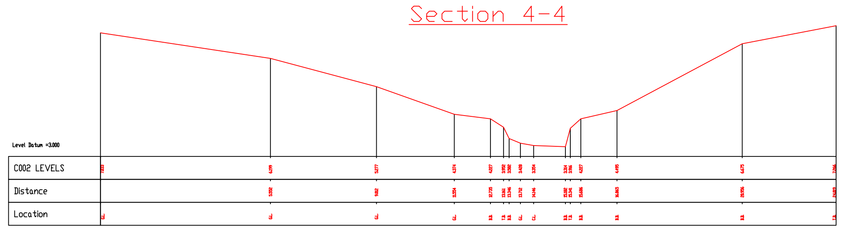

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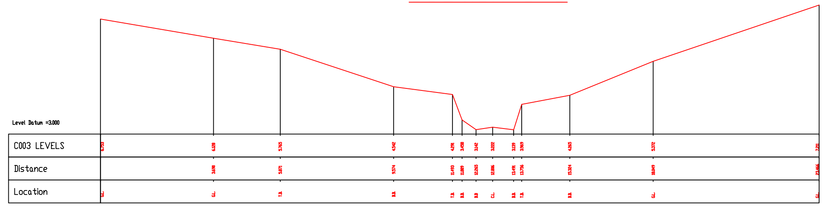

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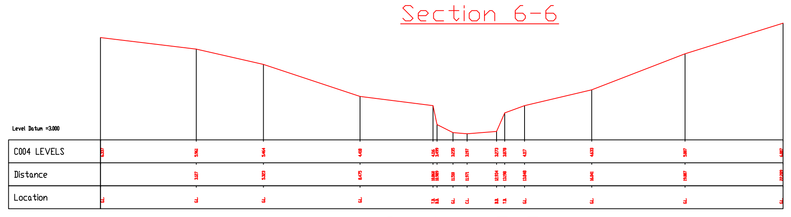

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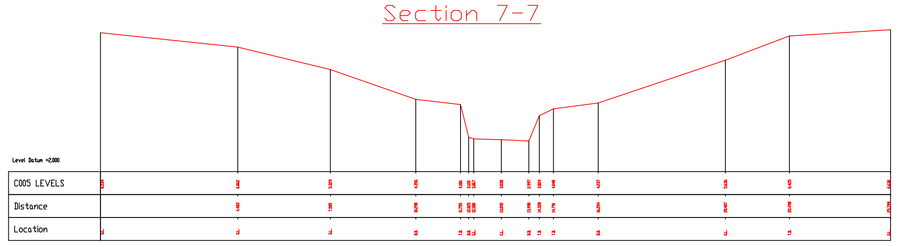

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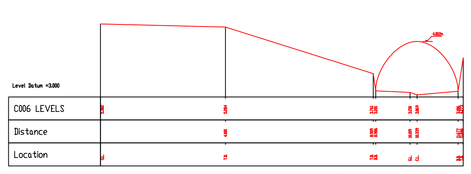

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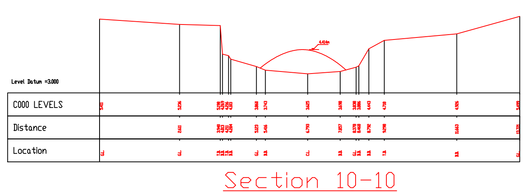

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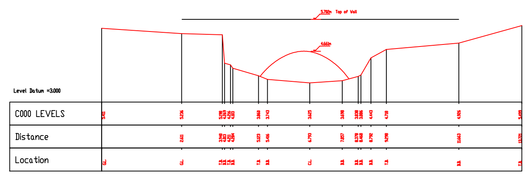

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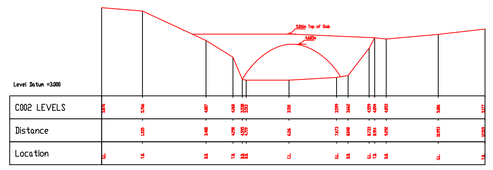

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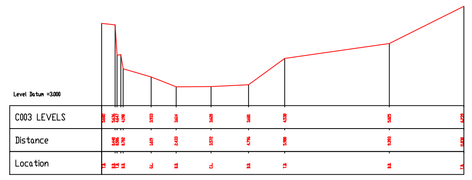

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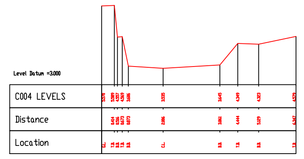

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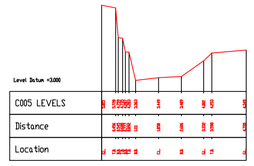

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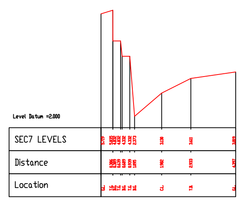

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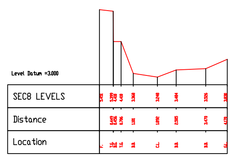

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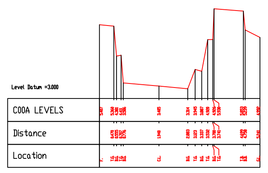

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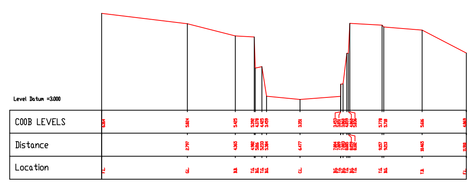

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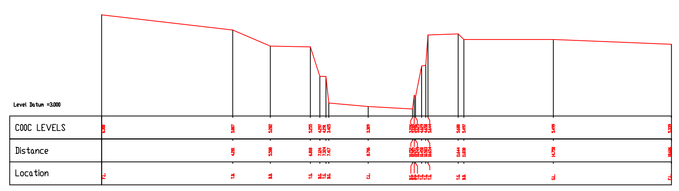

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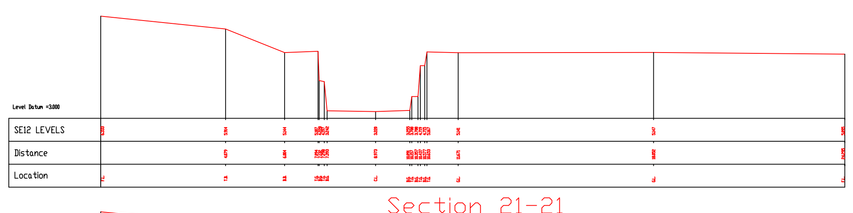
Scale 1:100



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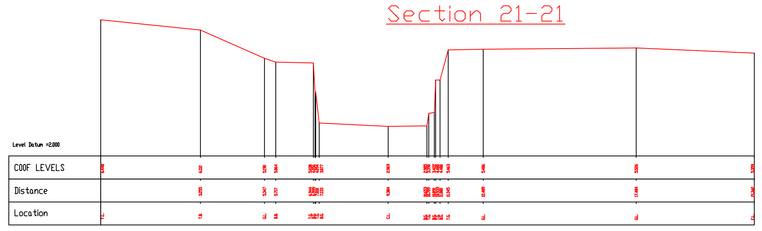

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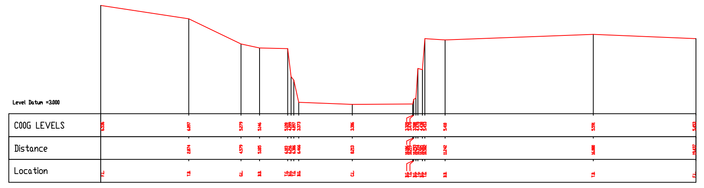

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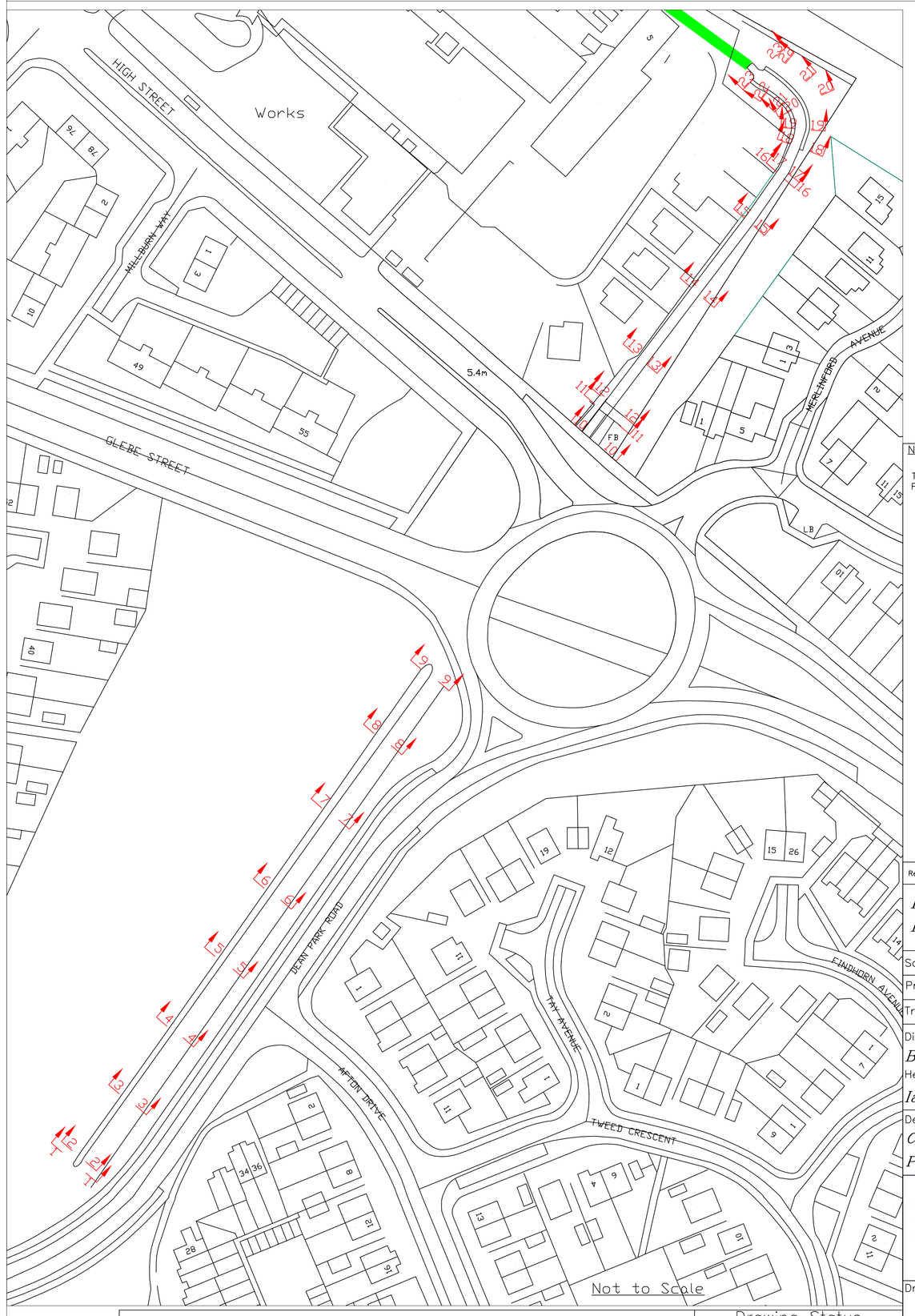


All levels are to National Grid

LEGEND
F.L. – FENCE LINE
G.L. – GROUND LEVEL
C.L. – CENTRE LINE
T.B. – TOP OF BANK
B.B. – BOTTOM OF BANK
T.G. – TOP OF GABION
B.B. – BOTTOM OF GABION
S.H. – SPOT HEIGHT
T.W. – TOP OF WALL

Notes:

This drawing is to be read in conjunction with Drawings PPA/CE111F/R03-04, 05, 06 & 07.

Rev:	Date:	Revision	Checked Date:	Appvd Date:

Renfrewshire Council
Department of Planning and Transport

Scale	: 1:100 / NTS	Date	: 23/06/05
Prepared by	: DBC	Checked by	: WF
Traced by	: ACADLT	Approved by	: SC

Director of Planning and Transport:
Bob Darracott: DipTP, Mphil, M.R.T.P.I.
Head of Roads:
Iain Hamilton: B.Sc., C.Eng., M.I.C.E., F.I.H.T.
Design Office:
Council Offices (South Block) Cotton Street, Paisley, PA1 1ST.

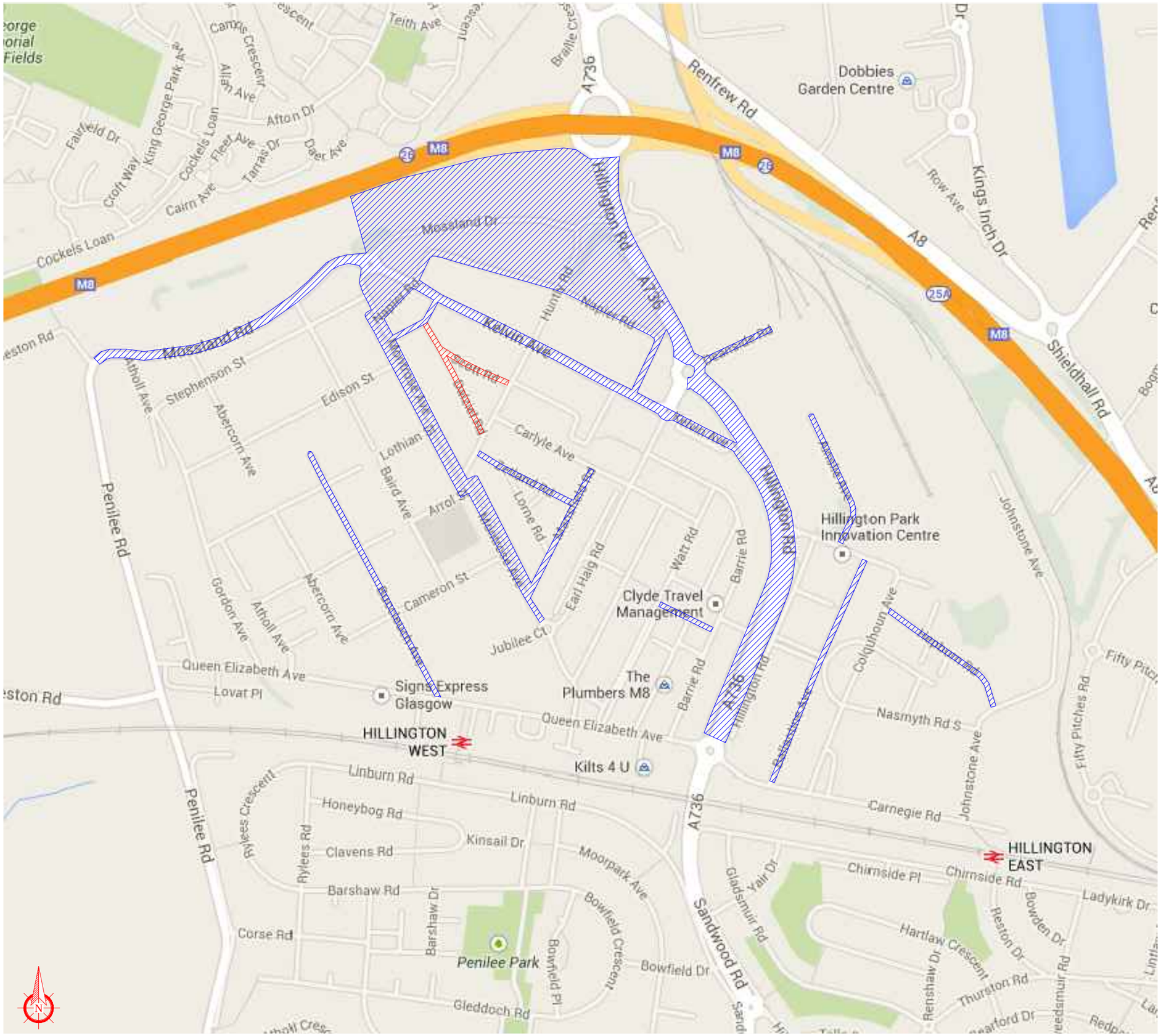
NORTH RENFREW FLOOD PREVENTION SCHEME
MILLBURN - MANHOLE/RIVER BED SURVEY
MILLBURN CROSS SECTIONS AT DEAN PARK

Drawing No: PPA/CE111F/R03-08
Rev:
File No: NW/RIC349/COR/65

Design GROUP
Original Drawing Size A1 841 x 1189 (A0)

Drawing Status

Preliminary		Contract	
Tender		Record	



Key:

- Areas not suitable for development
- Areas where mitigation will be required

Notes:

P1	R0	29-04-2014	Draft	RW	HR
Phase	Revision	Date	Issue	Drawn	Authorise

Client: MEPC

Job No: 45354

Date: 29-04-2014

Drawing No: 002

Scale: NTS

Job Title: Hillington Business Park

Drawing Title: Developable Areas Plan

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APPENDIX II
DRAINAGE CALCULATIONS

Modified Rational Method

Length (m)	3150.0	m
Area (ha)	115.080	Ha
Max Height	8.20	mAOD
Min Height	8.00	mAOD
DeltaH	0.2	
Slope (%)	0.01	
Te (mins)	86.88	mins
ARF	0.993	
SAAR	1046.000	mm
UCWI	115	mm
PIMP	100.0	%
SOIL	0.25	
Percentage Runoff PR	77.48	
DEEPSTOR	8.05	

Cv	0.774775
Cr	1.3

Peak 1 in 2 yr runoff	1592.6	l/s

Return Period	flood	2	years
Pre Development	Rainfall	2	years

Rainfall Duration (hours)	Rainfall Duration (days)	Rainfall Depth (mm)	Effective Depth (mm)	Rainfall Intensity (mm/hr)	FLOW (l/s)	FLOW (l/s/ha)
0.250	0.010	6.34	6.386	25.360	8171.708	71.009
0.500	0.021	8.46	8.521	16.920	5452.102	47.377
0.750	0.031	10.00	10.072	13.333	4296.377	37.334
1.000	0.042	11.25	11.331	11.250	3625.068	31.500
1.250	0.052	12.33	12.419	9.864	3178.459	27.620
1.500	0.063	13.28	13.376	8.853	2852.794	24.790
1.750	0.073	14.14	14.242	8.080	2603.604	22.624
2.000	0.083	14.93	15.038	7.465	2405.434	20.902
2.250	0.094	15.66	15.773	6.960	2242.709	19.488
2.500	0.104	16.34	16.458	6.536	2106.084	18.301
2.750	0.115	16.99	17.112	6.178	1990.785	17.299
3.000	0.125	17.60	17.727	5.867	1890.406	16.427
3.250	0.135	18.180	18.311	5.594	1802.495	15.663
3.500	0.146	18.730	18.865	5.351	1724.381	14.984
3.750	0.156	19.260	19.399	5.136	1654.964	14.381
4.000	0.167	19.770	19.912	4.943	1592.613	13.839
4.250	0.177	20.260	20.406	4.767	1536.081	13.348
4.500	0.188	20.730	20.879	4.607	1484.398	12.899
4.750	0.198	21.190	21.343	4.461	1437.477	12.491

Modified Rational Method

Length (m)	3150	m
Area (ha)	115.080	Ha
Max Height	8.2	mAOD
Min Height	8.0	mAOD
DeltaH	0.2	
Slope (%)	0.01	
Te (mins)	86.88	mins
ARF	0.993	
SAAR	1046.000	mm
UCWI	115	mm
PIMP	100.0	%
SOIL	0.25	
Percentage Runoff PR	77.48	
DEEPSTOR	8.05	

Cv	0.774775
Cr	1.3

Peak 1 in 50 yr runoff	3533.2	l/s

Return Period	flood	50	years
Pre Development	Rainfall	50	years

Rainfall Duration (hours)	Rainfall Duration (days)	Rainfall Depth (mm)	Effective Depth (mm)	Rainfall Intensity (mm/hr)	FLOW (l/s)	FLOW (l/s/ha)
0.250	0.010	16.470	16.589	65.880	21228.396	184.466
0.500	0.021	21.120	21.272	42.240	13610.921	118.274
0.750	0.031	24.390	24.566	32.520	10478.862	91.057
1.000	0.042	27.000	27.195	27.000	8700.162	75.601
1.250	0.052	29.210	29.421	23.368	7529.830	65.431
1.500	0.063	31.140	31.364	20.760	6689.458	58.129
1.750	0.073	32.870	33.107	18.783	6052.367	52.593
2.000	0.083	34.440	34.688	17.220	5548.770	48.217
2.250	0.094	35.890	36.149	15.951	5139.898	44.664
2.500	0.104	37.240	37.508	14.896	4799.912	41.709
2.750	0.115	38.500	38.777	14.000	4511.195	39.201
3.000	0.125	39.680	39.966	13.227	4262.006	37.035
3.250	0.135	40.800	41.094	12.554	4045.204	35.151
3.500	0.146	41.870	42.172	11.963	3854.770	33.496
3.750	0.156	42.890	43.199	11.437	3685.432	32.025
4.000	0.167	43.860	44.176	10.965	3533.233	30.702
4.250	0.177	44.800	45.123	10.541	3396.665	29.516
4.500	0.188	45.690	46.019	10.153	3271.691	28.430
4.750	0.198	46.560	46.896	9.802	3158.515	27.446

Modified Rational Method

Length (m)	3150	m
Area (ha)	115.080	Ha
Max Height	8.2	mAOD
Min Height	8.0	mAOD
DeltaH	0.2	
Slope (%)	0.01	
Te (mins)	86.88	mins
ARF	0.993	
SAAR	1046.000	mm
UCWI	115	mm
PIMP	100.0	%
SOIL	0.25	
Percentage Runoff PR	77.48	
DEEPSTOR	8.05	
Cv	0.774775	
Cr	1.3	

Peak 1 in 200 yr runoff	4837.5	l/s

Return Period	flood	200	years
Pre Development	Rainfall	200	years

Rainfall Duration (hours)	Rainfall Duration (days)	Rainfall Depth (mm)	Effective Depth (mm)	Rainfall Intensity (mm/hr)	FLOW (l/s)	FLOW (l/s/ha)
0.250	0.010	23.980	24.153	95.920	30908.133	268.580
0.500	0.021	30.290	30.508	60.580	19520.587	169.626
0.750	0.031	34.660	34.910	46.213	14891.241	129.399
1.000	0.042	38.130	38.405	38.130	12286.563	106.765
1.250	0.052	41.040	41.336	32.832	10579.398	91.931
1.500	0.063	43.580	43.894	29.053	9361.804	81.350
1.750	0.073	45.840	46.170	26.194	8440.539	73.345
2.000	0.083	47.890	48.235	23.945	7715.755	67.047
2.250	0.094	49.780	50.139	22.124	7129.121	61.949
2.500	0.104	51.520	51.891	20.608	6640.480	57.703
2.750	0.115	53.150	53.533	19.327	6227.793	54.117
3.000	0.125	54.680	55.074	18.227	5873.147	51.035
3.250	0.135	56.130	56.535	17.271	5565.130	48.359
3.500	0.146	57.500	57.914	16.429	5293.750	46.001
3.750	0.156	58.810	59.234	15.683	5053.398	43.912
4.000	0.167	60.050	60.483	15.013	4837.451	42.036
4.250	0.177	61.250	61.691	14.412	4643.878	40.353
4.500	0.188	62.400	62.850	13.867	4468.232	38.827
4.750	0.198	63.500	63.958	13.368	4307.683	37.432
5.000	0.208	64.570	65.035	12.914	4161.256	36.160
5.250	0.219	65.600	66.073	12.495	4026.319	34.987
5.500	0.229	66.600	67.080	12.109	3901.891	33.906

Modified Rational Method

Length (m)	3150.0	m
Area (ha)	132.800	Ha
Max Height	8.20	mAOD
Min Height	8.00	mAOD
DeltaH	0.2	
Slope (%)	0.01	
Te (mins)	86.88	mins
ARF	0.993	
SAAR	1046.000	mm
UCWI	115	mm
PIMP	100.0	%
SOIL	0.25	
Percentage Runoff PR	77.48	
DEEPSTOR	8.05	

Cv	0.774775
Cr	1.3

Peak 1 in 2 yr + 20% CC runoff	1837.8	l/s

Return Period	flood	2	years
Post Development	Rainfall	2	years

Rainfall Duration (hours)	Rainfall Duration (days)	Rainfall Depth (mm)	10% Increase	Effective Depth (mm)	Rainfall Intensity (mm/hr)	FLOW (l/s)	FLOW (l/s/ha)
0.250	0.010	6.34	6.97	7.024	27.896	10372.985	78.110
0.500	0.021	8.46	9.31	9.373	18.612	6920.777	52.114
0.750	0.031	10.00	11.00	11.079	14.667	5453.725	41.067
1.000	0.042	11.25	12.38	12.464	12.375	4601.581	34.650
1.250	0.052	12.33	13.56	13.661	10.850	4034.666	30.382
1.500	0.063	13.28	14.61	14.713	9.739	3621.273	27.269
1.750	0.073	14.14	15.55	15.666	8.888	3304.957	24.887
2.000	0.083	14.93	16.42	16.541	8.212	3053.404	22.993
2.250	0.094	15.66	17.23	17.350	7.656	2846.845	21.437
2.500	0.104	16.34	17.97	18.104	7.190	2673.416	20.131
2.750	0.115	16.99	18.69	18.824	6.796	2527.058	19.029
3.000	0.125	17.60	19.36	19.500	6.453	2399.639	18.070
3.250	0.135	18.180	19.998	20.142	5.594	2080.043	15.663
3.500	0.146	18.730	20.603	20.751	5.351	1989.901	14.984
3.750	0.156	19.260	21.186	21.339	5.136	1909.795	14.381
4.000	0.167	19.770	21.747	21.904	4.943	1837.843	13.839
4.250	0.177	20.260	22.286	22.447	4.767	1772.606	13.348
4.500	0.188	20.730	22.803	22.967	4.607	1712.965	12.899
4.750	0.198	21.190	23.309	23.477	4.461	1658.820	12.491

Modified Rational Method

Length (m)	3150	m
Area (ha)	132.800	Ha
Max Height	8.2	mAOD
Min Height	8.0	mAOD
DeltaH	0.2	
Slope (%)	0.01	
Te (mins)	86.88	mins
ARF	0.993	
SAAR	1046.000	mm
UCWI	115	mm
PIMP	100.0	%
SOIL	0.25	
Percentage Runoff PR	77.48	
DEEPSTOR	8.05	

Cv	0.774775
Cr	1.3

Peak 1 in 50 yr + 20%CC runoff	4077.3	l/s

Return Period	flood	50	years
Post Development	Rainfall	50	years

Rainfall Duration (hours)	Rainfall Duration (days)	Rainfall Depth (mm)	10% Increase	Effective Depth (mm)	Rainfall Intensity (mm/hr)	FLOW (l/s)	FLOW (l/s/ha)
0.250	0.010	16.470	18.117	18.248	72.468	26946.856	202.913
0.500	0.021	21.120	23.232	23.399	46.464	17277.401	130.101
0.750	0.031	24.390	26.829	27.022	35.772	13301.636	100.163
1.000	0.042	27.000	29.700	29.914	29.700	11043.793	83.161
1.250	0.052	29.210	32.131	32.363	25.705	9558.199	71.974
1.500	0.063	31.140	34.254	34.501	22.836	8491.450	63.942
1.750	0.073	32.870	36.157	36.418	20.661	7682.740	57.852
2.000	0.083	34.440	37.884	38.157	18.942	7043.486	53.038
2.250	0.094	35.890	39.479	39.764	17.546	6524.473	49.130
2.500	0.104	37.240	40.964	41.259	16.386	6092.902	45.880
2.750	0.115	38.500	42.350	42.655	15.400	5726.411	43.121
3.000	0.125	39.680	43.648	43.963	14.549	5410.095	40.739
3.250	0.135	40.800	44.880	45.203	12.554	4668.084	35.151
3.500	0.146	41.870	46.057	46.389	11.963	4448.327	33.496
3.750	0.156	42.890	47.179	47.519	11.437	4252.914	32.025
4.000	0.167	43.860	48.246	48.594	10.965	4077.279	30.702
4.250	0.177	44.800	49.280	49.635	10.541	3919.683	29.516
4.500	0.188	45.690	50.259	50.621	10.153	3775.465	28.430
4.750	0.198	46.560	51.216	51.585	9.802	3644.863	27.446

Modified Rational Method

Length (m)	3150	m
Area (ha)	132.800	Ha
Max Height	8.2	mAOD
Min Height	8.0	mAOD
DeltaH	0.2	
Slope (%)	0.01	
Te (mins)	86.88	mins
ARF	0.993	
SAAR	1046.000	mm
UCWI	115	mm
PIMP	100.0	%
SOIL	0.25	
Percentage Runoff PR	77.48	
DEEPSTOR	8.05	
Cv	0.774775	
Cr	1.3	

Peak 1 in 200 yr + 20% CC runoff	5582.3	l/s

Return Period	flood	200	years
Post Development	Rainfall	200	years

Rainfall Duration (hours)	Rainfall Duration (days)	Rainfall Depth (mm)	10% Increase	Effective Depth (mm)	Rainfall Intensity (mm/hr)	FLOW (l/s)	FLOW (l/s/ha)
0.250	0.010	23.980	26.378	26.568	105.512	39234.098	295.437
0.500	0.021	30.290	33.319	33.559	66.638	24779.000	186.589
0.750	0.031	34.660	38.126	38.401	50.835	18902.611	142.339
1.000	0.042	38.130	41.943	42.245	41.943	15596.290	117.442
1.250	0.052	41.040	45.144	45.469	36.115	13429.253	101.124
1.500	0.063	43.580	47.938	48.284	31.959	11883.667	89.485
1.750	0.073	45.840	50.424	50.787	28.814	10714.233	80.679
2.000	0.083	47.890	52.679	53.059	26.340	9794.209	73.752
2.250	0.094	49.780	54.758	55.153	24.337	9049.548	68.144
2.500	0.104	51.520	56.672	57.080	22.669	8429.278	63.473
2.750	0.115	53.150	58.465	58.886	21.260	7905.422	59.529
3.000	0.125	54.680	60.148	60.582	20.049	7455.242	56.139
3.250	0.135	56.130	61.743	56.535	17.271	6422.047	48.359
3.500	0.146	57.500	63.250	57.914	16.429	6108.880	46.001
3.750	0.156	58.810	64.691	59.234	15.683	5831.520	43.912
4.000	0.167	60.050	66.055	60.483	15.013	5582.321	42.036
4.250	0.177	61.250	67.375	61.691	14.412	5358.941	40.353
4.500	0.188	62.400	68.640	62.850	13.867	5156.249	38.827
4.750	0.198	63.500	69.850	63.958	13.368	4970.979	37.432
5.000	0.208	64.570	71.027	65.035	12.914	4802.005	36.160
5.250	0.219	65.600	72.160	66.073	12.495	4646.290	34.987
5.500	0.229	66.600	73.260	67.080	12.109	4502.704	33.906