LAND AT ELTON PARKLANDS, RADCLIFFE ROAD, GREATER MANCHESTER

FLOOD RISK ASSESSMENT & OUTLINE DRAINAGE STRATEGIES

Job Number: FRA 18 1024
Date: July 2020
Client: Peel Investments (North) Ltd

INCREASING LAND VALUE

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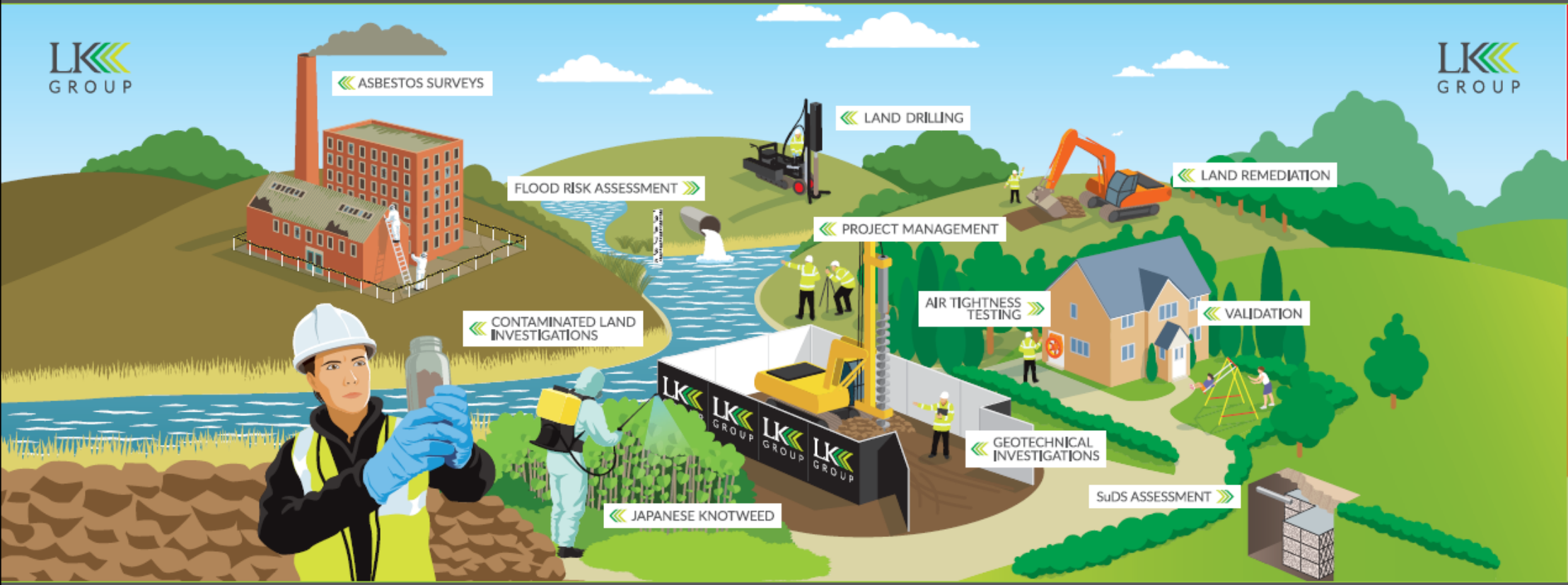

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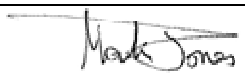
Document Verification

Site Address	Land at Elton Parklands, Radcliffe Road, Radcliffe, Manchester, M26 2ZS		
Report Title	Flood Risk Assessment & Outline Drainage Strategies		
Job Number	FRA 18 1024	**Document Ref.**	FRA 18 1024 R2
Date Issued	July 2020	**Report Version**	R2
Prepared By	Mark Jones - Associate	**Signature**	
Reviewed By	Matthew Craig - Geo-Environmental Engineer	**Signature**	
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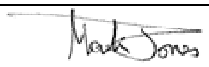
Revision Record			
Revision No.	**Date**	**Nature of Revision**	**Approved By**
R2	July 2020	Plot H removed from development and access revised.	

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EXECUTIVE SUMMARY

Scope and Background

This Flood Risk Assessment and Outline Drainage Strategies (FRA) has been undertaken by LK Consult Ltd (LKC) to support the Greater Manchester Spatial Framework a planning process for the development of land at Elton Parklands, Radcliffe. The development comprises of a residential development and a link road with associated infrastructure and amenities.

LKC has prepared this FRA in line with the NPPF and Technical Guidance where appropriate.

In considering the proposals the following key principles have therefore been applied:-

- Identification of flood risks.
- Protection of users of the new development.
- No increased flood risk to third parties.

As the proposed development covers a significant area there will be different conditions encountered within the special framework development boundary. To provide a more appropriate assessment this report has been split into different areas based upon the initial masterplan layout.

Consultations

The Environment Agency (EA) has been consulted to inform the preparation of this report. They have provided a more detailed flood map for the River Irwell and modelled flood levels. For the Crow Trees Farm Brook catchment but no modelled data was available.

Bury Metropolitan Borough Council and United Utilities were also consulted concerning flood risk.

All relevant consultees have confirmed that there is a Negligible to Low risk of flooding to this residential development from all sources except for parcels C & G. Medium risks of flooding were recorded from one or more sources for parcels C & G.

Flood Risk

Environment Agency flood maps indicate that the site is potentially vulnerable to fluvial flooding from the Crow Trees Farm Brook within the southern area of the site.

In general, the site is shown on the Environment Agency's (EA) website Flood Zone Mapping as being in Flood Zone 1 (PPG Table 1).

The majority of the site is in Flood Zone 1 – Very Low Risk – annual probability of flooding less than 0.1% (1 in 1000).

The EA have informed the developer that they have remodelled the Brook recently that shows the extent of the flooding to be reduced. There is an area adjacent to Crow Trees Brook to the west of the canal is that is currently shown in Flood Zone 3 that will be revised down to a limited area of Flood Zone 2 rather than Flood Zone 3. The flooding risk is due to the potential for overspill from Withins Reservoir. Flood Zone 2 – Low risk - annual probability of flooding of between 0.1% and 1.0% from rivers. Over the lifetime of the development there may be an increased risk of fluvial flooding.

There is a limited area of Flood Zone 2 adjacent to the canal to the south and west of Elton Reservoir that is likely to be from the fluvial event flows spilling into and over the canal side. This is

classified as Low Risk – between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% – 0.1%).

These areas of flood risk will be discussed in more detail within the appropriate section of the report.

Mitigation

Design

Site falls will be arranged to allow reasonably level access for occupants and visitors and allowing the site to be free-draining in case of local ponding at times of heavy rainfall. Floor levels of dwellings will be set as high as possible above the flood level giving regard to necessary access for the less-able.

The development will not result in any reduction in flood plain storage compared to the existing situation for all the parcels. the latest published Flood Map for Planning has recorded part of the eastern edge of parcel G is within Flood Zone 3. But the EA have confirmed in correspondence that it is not in Flood Zone 3. There is potential that over the lifetime of the development that a limited area of plot G adjacent to the canal may be affected due to climate change.

In considering the potential drainage options for the sites at present it is assumed that surface water runoff arising from the development will discharge into existing ditches and surface water culverts.

The proposed development will significantly increase the proportion of the site covered by impermeable surfaces and will therefore generate more runoff. Attenuation will therefore be required.

The outline drainage strategy for the proposed residential areas considers the use of attenuation based SuDS to be feasible with a discharge to existing watercourses within the site boundary or links to the adjacent watercourses. The eastern end of the proposed link road may need to be connected to a sewer. Therefore, the most effective strategy, in line with the SuDS management train, would be to have detention basins adjacent to the lower areas of each development area.

Access

Access close to the site is potentially elevated above potential flood levels and will always provide safe access to and from the site from the indicative accesses to the site.

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APPENDICES

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1 INTRODUCTION

1.1 Background

LK Consult Ltd (LKC) were commissioned by Peel Investments (North) Ltd to carry out a Flood Risk Assessment (FRA) and Outline Drainage Strategy for Elton Parklands. The report was undertaken in support of the Greater Manchester Spatial Framework to redevelop the site for residential use.

The report will address the vulnerability to flooding from all possible sources and will also consider the impact of the development on surface water runoff accounting for climate change and the potential to increase flood risk elsewhere. The Outline Drainage Strategy in Section 5 will provide an overview of the SuDS techniques which could be considered on the site. The issues of actual flood risk are discussed in Section 4.

Government policy with respect to development in flood risk areas is contained within the Department of Communities and Local Government National Planning Policy Framework[1] and accompanying Technical Guidance of March 2012 (revised to the Planning Practice Guidance (PPG)[2], which supersedes Planning Policy Statement 25 (PPS25) 'Development and Flood Risk'. The guidance on Climate Change allowance issued by the Environment Agency in February 2016 has also been considered.

LKC has prepared this Flood Risk Assessment (FRA) in line with the NPPF and the PPG where appropriate. The level of detail entered into in any flood risk assessment is dependent upon the scale and potential impact of the proposed development, and the vulnerability classification of the proposed land-use.

[1] DCL (2019). "National Planning Policy Framework:" Department of Communities and Local Government. March 2019.
[2] DCL (2014). "Planning Practice Guidance" http://planningguidance.communities.gov.uk, April 2014.

1.2 Site Details

A summary of the general site details is presented in Table 1-1. Plans, Drawings and Figures are provided in Appendix A. Figures 1 and 2 indicate the site location and boundaries. The location of the development parcels is shown in Appendix B.

Development Parcel B – South of Bury and Bolton Road

Development Parcel B - Site Details	
Location	South of Bury and Bolton Road. Nearest postcode to the site is M26 4LE. Centred at approximate National Grid Reference 377845E 409345N.
Area	Approximately 13.4Ha.
Topography	116 metres above ordnance datum (AOD) in the north of the site and 102mAOD in the south. Site is sloping down gently to the south with a low point in the southeast corner.
Current Land Use	Site Mainly agricultural with some areas of former quarrying. A former railway line runs along the southern boundary. Several hedgerows and seasonal ditches cross the parcel area. Surrounding Area/ Boundary Treatment North: Bury and Bolton Road Residential Property. East: Pasture and farm buildings. South: Former railway and open pasture. West: Grindsbrook Road and Residential Properties.
Proposed Development	Residential properties including soft landscaping and car parking. Access will be from a new access to Bury and Bolton Road.

Table 1-1: Summary of Development Parcel B Site - Details.

Development Parcel C – West of the Manchester Metro and Radcliffe Road

Development Parcel C - Site Details	
Location	West of the Manchester Metro and Radcliffe Road. Nearest postcode to the site is M26 2XJ. Centred at approximate National Grid Reference 379090E 408610N.
Area	Approximately 21.8Ha.
Topography	90 metres above ordnance datum (AOD) in the north of the site and 86m AOD in the south. Site is sloping down to the east. There is a depression adjacent to the raised canal bank with a flatter area between the raised canal and the railway embankment to the east of the parcel.
Current Land Use	Site Mainly agricultural with some areas of low grade grazing. The site includes part of the raised canal and is bounded to the east by a low railway embankment. Several hedgerows and seasonal ditches cross the parcel area. Surrounding Area/ Boundary Treatment North: Elton Reservoir, pastureland and the River Irwell. East: Manchester Metro railway line and residential properties. South: Crow Trees Farm buildings and access and the canal. West: Crow Trees Farm buildings and access with pastureland.
Proposed Development	Residential properties including soft landscaping and car parking. New Metro station and proposed school buildings. Access will be from a new access to Radcliffe Road.

Table 1-2: Summary of Development Parcel C - Site Details.

Development Parcel C – West of the Manchester Metro and Radcliffe Road

Development Parcel C1 - Site Details	
Location	East of the Manchester Metro and west of Radcliffe Road. Nearest postcode to the site is M26 2WX. Centred at approximate National Grid Reference 379450E 408820N.
Area	Approximately 1.5Ha.
Topography	76 metres above ordnance datum (AOD) in the west of the site and 74m AOD in the east. The site is sloping gently to the east. Wrath Fold Road runs parallel to the Metro line There is a slightly raised central area.
Current Land Use	Site The area to the east of Wraith Road and the railway is currently used for recreation purposes and was formally a remnant pasture between the garden centre to the north and the housing to the south. The site includes part of the railway and Wraith Road to the west. Surrounding Area/ Boundary Treatment North: Garden Centre and the River Irwell. East: Radcliffe Road. South: Residential properties and garages off Kingston Road. West: Manchester Metro railway line and pastureland.
Proposed Development	Link road and junction with an overbridge and embankment.

Table 1-3: Summary of Development Parcel C1 - Site Details.

Development Parcel D – West of the Canal and Radcliffe Road

Development Parcel D - Site Details	
Location	West of the Canal and Radcliffe Road. Nearest postcode to the site is M26 2XJ. Centred at approximate National Grid Reference 379090E 408610N.
Area	Approximately 17.6Ha.
Topography	100 metres above ordnance datum (AOD) in the north of the site and 76m AOD in the south. Site is sloping down to the southeast towards the canal. There is a raised embankment from the former railway branch line in the south east boundary of the parcel.
Current Land Use	Site Mainly agricultural with several farm buildings within the western boundary. Several hedgerows and seasonal ditches cross the parcel area. Surrounding Area/ Boundary Treatment North: Crematorium and Withins Reservoir. East: Pastureland. South: Canal and railway branch line. West: Residential properties.
Proposed Development	Residential properties including soft landscaping and car parking. Access will be from a new access to Radcliffe Road or the proposed internal spine road.

Table 1-4: Summary of Development Parcel D - Site Details.

Development Parcel E – South of the former railway line and north of the Crematorium.

Development Parcel E - Site Details	
Location	South of the former railway line and north of the Crematorium. Nearest postcode to the site is M26 4HX. Centred at approximate National Grid Reference 377970E 408920N.
Area	Approximately 19.7Ha.
Topography	100 metres above ordnance datum (AOD) in the north and south of the site and 90m AOD in the central area and the watercourse. Site is sloping down to the Brook Bottom watercourse from the north and the south. The watercourse leads to Withins Reservoir.
Current Land Use	Site Mainly agricultural with several farm buildings within the central area to the north of the watercourse. There is a farm access track crossing the watercourse. Several hedgerows and seasonal ditches cross the parcel area. Surrounding Area/ Boundary Treatment North: Former railway line. East: Pasture Land and Withins Reservoir. South: Crematorium. West: Residential properties and stables.
Proposed Development	Residential properties including soft landscaping and car parking. Access will be from a new access to the proposed internal spine road.

Table 1-5: Summary of Development Parcel E - Site Details.

Development Parcel F – South of the former railway line and north of Elton Reservoir.

Development Parcel F - Site Details	
Location	South of the former railway line and north of Elton Reservoir. Nearest postcode to the site is M26 4LB. Centred at approximate National Grid Reference 378440E 409260N.
Area	Approximately 23.9Ha.
Topography	102 metres above ordnance datum (AOD) in the northwest and 94m AOD in the southeast. Site is sloping down to Elton Reservoir from the northwest. There are several ponds within the parcel mainly along hedge lines. There is a watercourse feeding Withins Reservoir adjacent to the northeast boundary.
Current Land Use	Site Mainly agricultural. There is a farm access track crossing the site and several hedgerows and seasonal ditches cross the parcel area. Surrounding Area/ Boundary Treatment North: Former railway line and the Spen Moor Development. East: Pastureland and Elton Reservoir. South: Pastureland and Withins Reservoir. West: Pastureland.
Proposed Development	Residential properties including soft landscaping and car parking. Access will be from a new access to the proposed internal spine road.

Table 1-6: Summary of Development Parcel F - Site Details.

Development Parcel G – North of the Canal and West of Crow Trees Farm Access.

Development Parcel G - Site Details	
Location	North of the Canal and West of Crow Trees Farm Access. Nearest postcode to the site is M26 2EW. Centred at approximate National Grid Reference 378805E 408335N.
Area	Approximately 8.7Ha.
Topography	86 metres above ordnance datum (AOD) in the northwest of the site and 76m AOD in the southeast. Site is sloping down to the southeast towards the canal. There is a watercourse along the northeast boundary. there is a depression in the ground adjacent to the canal on the southeast boundary.
Current Land Use	Site Mainly agricultural with several farm buildings adjacent to the southern boundary. Several hedgerows and seasonal ditches cross the parcel area. Surrounding Area/ Boundary Treatment North: Withins Reservoir. East: Crow Trees Farm and Brook with Pastureland. South: Canal. West: Pastureland.
Proposed Development	Residential properties including soft landscaping and car parking. Access will be from a new access to Radcliffe Road or the proposed internal spine road.

Table 1-7: Summary of Development Parcel G - Site Details.

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2 SITE SETTING

2.1 Vulnerability

As an initial phase in identifying whether a site is potentially at risk of flooding, LKC has consulted the Environment Agency's (EA) website Flood Zone Mapping. This mapping is (often) based on coarse scale modelling and provides only an initial indication of the flood risk to a site. The Environment Agency Flood Zone maps were developed using a very coarse Digital Elevation Map (DEM) and are superseded by a more detailed analysis of modelled flood levels and topographic survey levels.

The Flood Zones divide the floodplain into three categories of flood risk, and do not take flood defences into account. The NPPF defines the Flood Zones as: -

- Flood Zone 1 – little or no risk, with annual probability of flooding from rivers and the sea of less than 0.1% (1 in 1000).
- Flood Zone 2 – low risk, with annual probability of flooding of 0.1 to 1.0% from rivers and 0.1 to 0.5% from the sea.
- Flood Zone 3 – medium to high risk of flooding with an annual probability of flooding of 1.0% or greater from rivers, and 0.5% or greater from the sea.

The Flood Zone Mapping indicates the site as being mainly within Flood Zone 1, with a limited area adjacent to Crow Trees Farm Brook and the adjacent lengths of canal within Flood Zones 2 and 3 in accordance with PPG (paragraph 065, Table 1).

The development site is over 1 hectare in size, so under current regulations a Flood Risk Assessment will be necessary to accompany the Planning process.

The proposed development is for a residential and mixed end use and this is classified within the 'More Vulnerable' category in the PPG (paragraph 066, Table 2).

2.2 The Sequential and Exception Tests

The NPPF requires that the Sequential Test be applied to development proposals in Flood Zones 2 or 3 to determine if there are any 'reasonably available' and suitable alternative sites at lower flood risk. The Sequential Test is outside this scope of works and shall be undertaken by others.

However, the principles should still be applied for developments within the site such that, for example, dwellings are situated on a high part of the site when there is a risk of local surface water flooding. The issues of actual flood risk are discussed below. The issues of safety and reduction in flood risk to others required by an Exception Test are also addressed in this document.

The Local Planning Authority (LPA) will make the final decision with regard to any planning application.

2.3 Environmental Setting

LKC have previously undertaken a Preliminary Risk Assessment for the site (LKC 17 1140, June 2017) and pertinent environmental information for the site is summarised in Table 2-1 below.

Summary of the Environmental Setting		
Geology	Superficial	Till Devensian Diamicton clay-based soils over the northern parcels (B, E & F) An area of Glaciofluvial Deposits, Devensian and Glaciolacustrine Deposits to the east and south of Elton Reservoir and the Crematorium. Parcels C, C1, D, & G. Silty Sands with Clay.
	Bedrock	The bedrock is highly faulted with bands of Cannel Rock (Sandstone) and Pennine Lower Coal Measures (Mudstone, Siltstone and Sandstone) to the north. Parcels B, E & F. To the south again the bedrock is highly faulted with a mixture of Pennine Upper Coal Measures (Mudstone, Siltstone and Sandstone) and Hall Rock (Sandstone). Parcels C, C1, D & G.
	BGS Boreholes	BH Ref: SD70NE254: topsoil to 0.4m, silty sandy gravel to 1.8m, silty sandy gravel and cobbles to 3.85m, clayey sandy silt to 11.6m, clayey silt to 22.2m, sand and gravel to 27.7m, boulder clay to 29, sandstone and interbedded siltstone to 36m, and sandstone to 49.7m. BH Ref: SD70NE256: topsoil to 0.3m, sandy clayey silt to 0.7m, clayey silty sand to 1.95m, silty sand to 3.2m, silty sand to 4.0m, sandy silt to 7.3m, clayey silt to 14.4m, clayey sandy silt to 24.5m, siltstone to 40.7m, coal to 41.45m, mudstone to 42.7m, sandstone and siltstone to 48m, sandstone to 79m, mudstone to 81.6m, coal to 83m, mudstone to 85m, and sandstone to 87.6m. BH Ref: SD70NE: sandy boulder clay to 3.80m, sandstone to 4.5m, mudstone to 10.4m, sandstone to 11.1m, mudstone to 15.5m, coal to 17.8m, mudstone to 25.0m, sandstone to 27.3m and mudstone to 30m. BH Ref: SD70NE121: sandy boulder clay to 3.8m, sandstone to 4.9m, coal to 5.6m, mudstone to 6.7m, coal to 6.9m, mudstone to 7.4m, coal to 10.2m, mudstone to 14.0m, coal to 15.4m, and mudstone/sandstone bands to 30.0m. BH Ref: SD70NE255: topsoil to 0.4m, sandy silt to 3.3m, silty sand to 8.95m, silty clay to 13.45m, silty sand to 15m, silty clay to 23.5m, sand, gravel and cobbles to 26.3m, sandstone to 26.7m, siltstone to 28.8m, sandstone to 29.6m, siltstone to 32.8m, coal to 33.5m, mudstone to 34.55m, and siltstone to 40.2m. BH Ref: SD70NE19: sand or gravel to 19.2m. Coal (thickness) at 40.84m (12.7cm), 41.1m (12.7cm), 41.5m (25.4cm), 67.1m (38cm), and 44.8m (18cm). BH Ref: SD70NE25: soil and gravel to 2.44m with natural marl below. Shallowest coal identified at 27.5m (13cm in thickness).

Table 2-1: Summary of the Environmental Setting.

Summary of the Environmental Setting		
Hydrogeology	Superficial	Secondary Undifferentiated Aquifer beneath parcels B, E & F. Secondary A Aquifer beneath parcels C, C1, D & G.
	Bedrock	Secondary A Aquifer. Not within a Source Protection Zone.
Hydrology	All adjacent and internal surface water	There are several ordinary watercourses within the site and a number of seasonal ponds. There are two reservoirs; Elton Reservoir is owned and operated by the Canal and Rivers Trust. This provides the water to the canal flowing through the site. The other reservoir is Withins Reservoir was constructed to serve as the water supply to several former mills to the south of Radcliffe Road. There are no available records of any associated infrastructure. The River Irwell flows from north to south adjacent to the northern part of the eastern boundary. the only connectivity is the overflow from the canal that discharges to the river. There are a few culverts passing beneath the Metro line that drain the watercourses crossing the Elton Parklands development area.
Site History		A few coal mines are recorded adjacent to the site. the site has been utilised for pasture and farming and contains several farm buildings.

Table 2-1 (continued): Summary of the Environmental Setting.

2.4 Site Reconnaissance

A site reconnaissance was undertaken, and photographs are provided in Appendix B.

Relevant features identified on site are summarised below:

Parcel B

- This area comprises pastoral grassland. The fields are bounded by well-established hedges, trees and wire fences.
- Two ponds were noted on site. Evidence of several historic infilled ponds were also noted.
- Evidence of a drain/water course was present in the south west area of the area noted as an aqueduct on historical maps, this had been filled across with a new track.
- A high-pressure gas main was noted on site running from north east to south west.

Parcel C

- A watercourse is present in the centre of the parcel, running from the north to the south.
- The watercourse passes beneath the canal by the means of a syphon.
- The Manchester, Bolton & Bury Canal is present in the east of the area.
- The area is bounded by hedges, wire fencing and trees.
- The majority of the area comprises of pastoral grassland divided by hedgerows, trees and wire fencing.
- The Manchester, Bolton & Bury Canal runs from north to south through the parcel.
- Made ground was observed, which contained brick, ash, clinker to 0.5mbgl over natural sandy clay to >0.6mbgl.

Parcel C1

- Used for leisure purposes and is accessed off Radcliffe Road to the east and Wrath Fold Road to the west.
- The railway lines form the western boundary with Wrath Fold Road running adjacent to the line within the parcel.
- This road crosses the railway line at a level crossing to the north with a track continuing north towards the River Irwell.
- The central area is marked out as a sports pitch and is raised above the outer edges.
- The raised area is probably made ground above the natural sandy clay.

Parcel D

- The majority of the parcel comprises pastoral grassland divided into fields separated by hedgerows, shrubs, trees and wire fencing.
- The Manchester, Bolton & Bury Canal runs from northeast to southwest across the centre of parcel.
- Three ponds are present in the east of the parcel.
- Land drainage pipes were noted running off the fields into the canal.
- Made ground was observed to the west, which contained brick, ash, clinker, coal and glass to 0.4mbgl over natural sandy clay to >0.5mbgl.

Parcel E

- Most of the parcel comprises pastoral grassland. The fields are bounded by well-established hedges, trees and barbed wire fences.
- Ponds are present in the northeast and southwest of the parcel.
- One electricity pylon is present in the northeast with overhead power lines running across the from the north to the northwest of the area.
- Brook Bottom Farm was noted adjacent to the central west boundary. The farm consisted of 6 barns and a farmhouse.
- The area is bounded by hedge rows, wire fencing and trees.
- A high-pressure gas main was noted on Area E.
- Made ground was observed, which contained glass, ash, clinker to 0.3-0.6mgl over natural clay.
- Trial holes encountered up to >0.5m of blackish brown slightly gravelly sandy clay (topsoil) with occasional coal fragments and sandstone gravel.

Parcel F

- The parcel is covered by grassland and is partially divided into horse paddocks in the northwest and northeast and pastoral farming in the east. The parcels were separated by field boundaries comprising hedges, trees and wire fencing.
- Woos Nab Farm is present in the south of the area comprising of a farmhouse, barn and associated metal structures.
- Lower Spen Moor Farm is present in the northwest of the area and comprises what appears to be a newly developed farmhouse of approximately 3 adjoining buildings.
- To the north the parcel is bounded by a dismantled railway.
- A larger stream flowing from the north eastern flows down to Elton Reservoir is adjacent to the northern corner.
- Two electricity pylons were present in the north of the parcel.
- Three trial holes identified up to 0.5m of topsoil underlain by natural grey sandy silty clay.

Parcel G

- Manchester, Bolton & Bury Canal runs to the south of parcel G from east to west.
- Crow Trees Farm Brook is present to the east of the area. A significant drop from site levels to the watercourse was observed, with evidence of instability of the slopes in this area.
- Made ground was identified adjacent to the canal comprising laminated clay with rare brick to 0.3m overlying clay with ash, clinker, brick and coal to 0.5m.
- There is a depression adjacent to the canal where the canal bank has been raised where surface water was seen to collect.

Other observations within the Elton Parkland

- The River Irwell and Manchester, Bolton & Bury Canal flow in parallel within the northern part of the eastern boundary. An overflow from the canal to the river is present in this area.
- There are a number of valve chambers and overflow channels between the Elton Reservoir and the canal associated with the Elton Reservoir. The structures are present for the maintenance and control of the reservoir.
- A large manhole was noted adjacent to the eastern section of Withins Reservoir it is assumed this must be part of the control system for the former mills.
- A vehicle bridge is present between parcels C and G, providing access to Crow Trees Farm. A ramp is present providing vehicular access to the south side of the canal.
- Withins Reservoir may need a condition survey.
- There is an isolated mill race from Withins Reservoir flowing into the area between the canal and the railway adjacent to the Crow Trees farm access and a culvert that would discharge into an open channel on Withins Lane but there is a raised berm isolating it from the culvert beneath the railway.

2.5 Site and Access Levels

A survey of the site has been undertaken to OS GPS datum, and information is included on the drawings in Appendix B. The site falls from north to south in general. The final site levels and ground floor levels of dwellings have not yet been determined. The proposed accesses would join the Bury and Bolton Road at around 116m AOD, Spring Road at around 73m and Radcliffe Road at approximately 74m AOD.

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3 CONSULTATIONS

Information from consultees (Environment Agency (EA), Lead Local Flood Authority Bury Metropolitan Borough Council (BMBC) and United Utilities Ltd (UU)) is summarised in Table 3-1 below.

Relevant correspondence / information is provided in Appendices C (EA) and D (others).

For modelled levels refer to extracted Level table and node location map in Appendix C.

Source	Details	
Environment Agency	The majority of Elton Parkland is within Flood Zone 1: Very Low risk, with annual probability of flooding from rivers and the sea of less than 0.1% (1 in 1000). A limited area of parcel C to the west of the canal is shown within Flood Zone 2: Low risk, with annual probability of flooding of 0.1 to 1.0% from rivers and 0.1 to 0.5% from the sea. The northern edge of parcel G and the area adjacent to the canal is shown within Flood Zone 3: Medium to High risk of flooding with an annual probability of flooding of 1.0% or greater from rivers, and 0.5% or greater from the sea. A revised model for Crow Trees Farm Brook produced by the EA shows that parcel G is not within Flood Zone 3.	
	Modelled Levels for River Irwell Nearest Node: 4 No modelled levels have been provided for Crow Trees Farm Brook.	Level of 72.86m for 1% annual probability event. Level of 73.91m for 0.1% annual probability event. The Flood Zones have only recently added to the Flood Map for planning as it is now classified as a Main River.
	Records of Flooding	There are records of flooding to the south of the River Irwell and Radcliffe Road but none directly affecting the site.
	Records of Flood Warning Service	Not within a flood warning service area.
	Surface Water Flooding	There are limited risks of surface water flooding within the majority of the Elton Parklands site. There is a low risk of shallow surface water flooding associated with depressions and existing water features. There are more significant risks of surface water flooding towards the southeast of the development area where a depression is formed by the embankment to the canal. If the current culverts become blocked the depth of surface water flooding could reach up to a depth of over 900mm although the flow velocity would generally be less than 0.25m/s.
	Flooding from reservoirs	The risk of flooding from reservoirs is discussed within the specialist report provided by Wallingford[3] for the site. The potential flooding would occur to the south of Elton and Withins Reservoirs. The mapping shows the extents of flooding for a breach of the dam for a 1 in 10000 year event. This is the worst case scenario used for Emergency Planning purposes and is considered a low risk. Although there is a low probability of such an event occurring it would be a danger to life to those close to such a failure. The level of risk will be dependant on the potential depth of flooding.
	Groundwater Source Protection Zone	Not within a Source Protection Zone.
Lead Local Flood Authority (Bury MBC)	Discussions have been held in relation to suitability for the development for the lower parcels and the reservoir risk study. The revised SFRA is currently being developed.	

Table 3-1: Summary of Consultee Information.

[3] Report MCR 5780-RT003-R01; Elton Reservoir Baseline Studies, March 2018, HR Wallingford Ltd.

Source	Details	
United Utilities Ltd. (UU)	Likely conditions for connecting into their sewerage system	UU would request conditions for a separate system with only foul draining to foul / combined sewers and surface water draining to soakaway/SuDS, watercourse or surface water sewer. UU was contacted regarding sewer flooding history for the site. UU confirmed that they did not have any record of internal or external sewer flooding of properties in the vicinity of the site as a result of overloaded sewers.
	Sewer maps	There are no public sewers shown within the site boundary. There are a number of combined sewers that may be accessible of Bury and Bolton Road and the southwest boundary of the site. There may be private sewers serving the existing farm buildings. There are culverted watercourses leaving the site along the south east boundary that connect to the public surface water drainage system off site.
Strategic Flood Risk Assessment (SFRA)	Level 1 SFRA[4]	The site has had a recorded incidence of flooding from surface water in parcel C between the canal and the railway. The surface water maps show a Low to Medium susceptibility to flooding between the canal and the railway embankments. The site is within a critical drainage area. There is a potential for groundwater flooding within the south of the site.
	Level 2 SFRA[5]	The area to the south and west of the canal is recorded as being within a Canal Hazard Zone. The embankments are low and made of clay. In 2008 the Elton Reservoir overflowed into the River Irwell adding to flooding downstream.
Preliminary Flood Risk Assessment (PFRA)[6]	The Preliminary Flood Risk Assessment (PFRA) for the area indicates that there are records of flooding for the area which conforms with information supplied by the EA. The PFRA also indicates that the site is in an area susceptible to groundwater flooding.	

Table 3-1 (continued): Summary Consultee Information.

[4] SFRA Volume 2, Level 1, Bury, Rochdale & Oldham, November 2009, JBA Consulting
[5] SFRA Volume 2, Level 2, Bury, Rochdale & Oldham, November 2009, JBA Consulting
[6] Preliminary Flood Risk Assessment: Bury MBC; May 2011, JBA Consulting.

4 ASSESSMENT OF FLOOD RISK

4.1 Flood Zones

The detailed flood map provided by the EA indicates that the site is in Flood Zones 1, 2 and 3 (see Appendix C).

The EA have not provided any modelled levels for the stretch of the Crow Trees Farm Brook within the site boundary; however recent correspondence with the EA has indicated that parcel G is not currently within the extent of Flood Zone 3 but maybe within the lifetime of the development. New mapping has yet to be published (see appendix C).

Adjacent to Crow Trees Farm Brook to the north of the canal the 1.0% (100-year) flood level is coincident with the 78m contour on the LiDAR data. To the south of the canal the 1.0% fluvial flood level appears to be coincident with the 74m contour.

The extents of the 0.1% (1000-year) flood level cover a similar area of the development to the 1.0% level so should be at a slightly increased level above the 100-year level (see Appendix C).

The extent of the fluvial Flood Zone 2 to the west of the canal within parcel C is coincidental with the 78m contour. This is likely to be from overspill from the canal. There is a sheet pile wall retaining the canal in this location this may not have been recognised within the LiDAR used for the modelling.

The fluvial flood levels from the River Irwell are over 3m below the Elton Parklands site level for the 100-year event and 2m for the 1000- year event at its closest approach.

4.2 Sources of flooding

The risk of flooding from the following flood sources has been considered:

4.2.1 Development Parcel B – South of Bury and Bolton Road.

Fluvial – The EA has confirmed the study area is within Flood Zone 1. Therefore, the flood risk associated with this source is considered Very Low.

Tidal – The study area is remote from the sea and tidally influenced water bodies. Therefore, the flood risk associated with this source is considered Negligible.

Pluvial (Rainfall) – The surface water flood risk maps show some areas that have the potential to flood during prolonged heavy rainfall. These areas are associated with natural depressions that are likely to be removed/positively drained following the development process. These areas need consideration within the detailed design or there is the potential to have areas of standing water in gardens and landscaped areas not positively drained if overland flow routes are not considered. Therefore, the risk of flooding from pluvial flooding is Low but should be considered further during the detailed design. No areas of shallow standing water were observed during the site visit but there are several established ponds.

Surface Water (Overland flow) - The only observed impermeable area at a level generally above that of the study area is Bury and Bolton Road to the north. Any surface water arising from the north of the study area is likely to be intercepted by the highway drains and therefore pose no threat to the development. If there was a drainage failure causing overland flow it would flow towards the southern boundary. The former railway line on the Southern

boundary will have a slight damming effect but should drain to the north east along the existing railway drain. Therefore, the risk of flooding from surface water flooding is Low but should be considered further during the detailed design.

Groundwater – The EA/BGS groundwater flooding maps show a potential for groundwater to be below the surface with some potential for emergence towards the western edge for Parcel B. The superficial Till deposits are more than 3m thick which would make it unlikely for groundwater flooding to occur. No evidence of shallow groundwater was observed during the walkover. Therefore, the flood risk associated with this source is considered Low.

Sewers – UU sewer records show foul and surface water sewers within the vicinity of the study area within the surrounding housing developments. The Pre-development Enquiry states there are no records of sewer flooding at the site location. The highway drainage to the west would intercept any overland flow before it enters the site. Therefore, the flood risk associated with this source is considered Very Low.

Artificial sources – According to the EA online maps, the study area is not at risk from reservoir flooding. The ponds located within the parcel are in depressions and do not have an observable inflow and overflow routes. They are on internal field boundary lines that may contain land drainage. Therefore, the flood risk associated with this source is considered Low.

Source of Flooding	Risk assessment Level
Fluvial	Very Low
Pluvial (Rainfall)	Low
Surface Water	Low
Tidal	Negligible
Groundwater	Low
Sewers	Very Low
Artificial Sources	Low

Table 4-1: Summary of Existing Risk Level.

4.2.2 Development Parcel C – West of the Manchester Metro and Radcliffe Road

Fluvial – The EA has shown the study area is partially within Flood Zone 2. This appears to be from fluvial flows entering the canal and spilling over the lowest part of the embankment to the west of the canal into a depression formed by the canal embankment. Therefore, the flood risk associated with this source should be considered Low but should also be considered further in terms of finished floor levels and flood resilience.

Tidal – The study area is remote from the sea and tidally influenced water bodies. Therefore, the flood risk associated with this source is considered Negligible.

Pluvial (Rainfall) – The surface water flood risk maps show some areas that have the potential to flood during prolonged heavy rainfall. These areas are associated with the artificial depressions that are likely to be positively drained following the development process. These areas need consideration within the detailed design or there is the potential to have areas of standing water in gardens and landscaped areas not positively drained if overland flow routes are not considered. Therefore, the risk of flooding from pluvial flooding is Low but should be considered further during the detailed design. No areas of shallow standing water were observed during the site visit, but it was observed that the drain beneath the railway embankment has been reduced in diameter by insertion of a replacement pipe into the culvert.

Surface Water (Overland flow) – There is potential for water to spill over the canal embankment and into the site area. the area between the canal and the railway embankments is classified as a Canal Hazard Zone in the Level 2 SFRA. The existing culverted watercourse beneath the canal passes through an inverted syphon that may require maintenance or it may contribute to surface water flooding within the depression to the north of the canal. There is no impermeable area at a level generally above parcel C that would contribute to flooding. Any surface water arising from the north of the study area is likely to be intercepted by the natural drainage system and therefore pose little threat to the development. If there was a drainage failure causing overland flow it would flow towards the western boundary. Therefore, the flood risk associated with this source is considered Medium.

Groundwater – The EA/BGS has groundwater records for the study area in the form of mapping and borehole records. The records show the water table is recorded at 1.2m below the surface and there is potential for groundwater emergence adjacent to the canal. The shallow groundwater records indicate that water may enter any deep excavations or service trenches during construction and de-watering may be necessary. No evidence of shallow groundwater was observed during the walkover. Therefore, the flood risk associated with this source is considered Medium as the natural topography will cause any groundwater to be collected towards the central area of the parcel.

Sewers – UU sewer records show foul and surface water sewers within the vicinity of the parcel within the existing housing developments to the east. The Pre-development Enquiry states that there are no records of sewer flooding at the site location. The ditch/ highway to the direction would intercept any overland flow before it enters the site. Therefore, the flood risk associated with this source is considered Very Low.

Artificial sources – According to the EA online maps, the study area is at risk from reservoir flooding. The likely risk of an incident occurring if the reservoir is adequately maintained and monitored is low. The SFRA shows it to be in a Canal Hazard Zone. Therefore, the flood risk associated with this source is considered Low; however, improvements are recommended during redevelopment to reduce the potential hazard risk (see section 6).

Source of Flooding	Risk assessment Level
Fluvial	Low
Pluvial (Rainfall)	Low
Surface Water	Medium
Tidal	Negligible
Groundwater	Medium
Sewers	Very Low
Artificial Sources	Low

Table 4-2: Summary of Existing Risk Level.

4.2.3 Development Parcel C1 – East of the Manchester Metro and West of Radcliffe Road

Fluvial – The EA has confirmed the study area is partially within Flood Zone 1. Therefore, the flood risk associated with this source should be considered Very Low.

Tidal – The study area is remote from the sea and tidally influenced water bodies. Therefore, the flood risk associated with this source is considered Negligible.

Pluvial (Rainfall) – The surface water flood risk maps show a limited area of potential shallow flooding adjacent to the railway line that has the potential to flood during prolonged

heavy rainfall. This area is associated with the artificial depression formed by the railway construction and is probably be positively drained. Therefore, the risk of flooding from pluvial flooding is Low but should be considered further during the detailed design or the proposed Metro railway station. No areas of shallow standing water were observed during the site visit.

Surface Water (Overland flow) – The only observed impermeable area at a level generally above that of the study area is Wrath Fold Road within the west of the plot. Any surface water arising from the north of the study area is likely to be intercepted by the highway drains and therefore pose no threat to the proposals. If there was a drainage failure causing overland flow it would flow towards the eastern boundary. Therefore, the risk of flooding from surface water flooding is Very Low but should be considered further during the detailed design.

Groundwater – The EA/BGS has groundwater records for the study area in the form of mapping and borehole records. The records show there is potential for groundwater flooding below ground level. The shallow groundwater records indicate that water may enter any deep excavations or service trenches during construction and de-watering may be necessary. No evidence of shallow groundwater was observed during the walkover. Therefore, the flood risk associated with this source is considered Low.

Sewers – UU sewer records show combined sewers running beneath Wrath Fold Road to the west and Radcliffe Road to the east. The Pre-development Enquiry states that there are no records of sewer flooding at the site location. These are both near the head of systems and have limited catchments. Therefore, the flood risk associated with this source is considered Very Low.

Artificial sources – According to the EA online maps, the study area is at risk from reservoir flooding along its outer edges. The likely risk of an incident occurring if the reservoir is adequately maintained and monitored is low. The SFRA shows it to be in a Canal Hazard Zone. Therefore, the flood risk associated with this source is considered Low; however, improvements are recommended during redevelopment to reduce the potential hazard risk (see section 6).

Source of Flooding	Risk assessment Level
Fluvial	Very Low
Pluvial (Rainfall)	Low
Surface Water	Very Low
Tidal	Negligible
Groundwater	Low
Sewers	Very Low
Artificial Sources	Low

Table 4-3: Summary of Existing Risk Level.

4.2.4 Development Parcel D – West of the Canal and Radcliffe Road

Fluvial – The EA has mapped that the study area is partially within Flood Zone 2. This appears to be from fluvial flows entering the canal and spilling over the lowest part of the embankment to the northwest of the canal into a depression formed by the canal embankment. Therefore, the flood risk associated with this source should be considered Low but should also be considered further in terms of finished floor levels and flood resilience.

Tidal – The study area is remote from the sea and tidally influenced water bodies. Therefore, the flood risk associated with this source is considered Negligible.

Pluvial (Rainfall) – The surface water flood risk maps show small areas that have the potential to flood during prolonged heavy rainfall. These areas are associated with natural depressions that are likely to be removed/positively drained following the development process. These areas need consideration within the detailed design or there is the potential to have areas of standing water in gardens and landscaped areas not positively drained if overland flow routes are not considered. Therefore, the risk of flooding from pluvial flooding is Low but should be considered further during the detailed design.

Surface Water (Overland flow) - The only observed impermeable area at a level generally above that of the parcel area is the crematorium to the northwest. Any surface water arising from the north of the study area is likely to be intercepted by the intermediate field boundary drains and therefore pose no threat to the development. If there was a drainage failure causing overland flow it would flow towards the southeast boundary. Therefore, the risk of flooding from surface water flooding is Very Low but should be considered further during the detailed design

Groundwater – The EA/BGS has groundwater records for the study area in the form of groundwater flooding susceptibility mapping. The mapping shows the lower area of the parcel may be susceptible for groundwater emergence in deep excavations or service trenches during construction and de-watering may be necessary. No evidence of shallow groundwater was observed during the walkover. Therefore, the flood risk associated with this source is considered Low as the natural topography will cause any groundwater to be shed towards the southeast of the site.

Sewers – UU sewer records show foul and surface water sewers within the vicinity of the parcel within the existing housing developments to the west. The Pre-development Enquiry states that there are no records of sewer flooding at the site location. The highway to the west would intercept any overland flow before it enters the site. Therefore, the flood risk associated with this source is considered Very Low.

Artificial sources – According to the EA online maps, the study area is not at risk from reservoir flooding. The ponds located to the south of the parcel are seasonal and located in local depressions. Therefore, the flood risk associated with this source is considered Very Low.

Source of Flooding	Risk assessment Level
Fluvial	Very Low
Pluvial (Rainfall)	Low
Surface Water	Very Low
Tidal	Negligible
Groundwater	Low
Sewers	Very Low
Artificial Sources	Very Low

Table 4-4: Summary of Existing Risk Level.

4.2.5 Development Parcel E – South of the former railway line and north of the Crematorium

Fluvial – The EA has confirmed the study area is within Flood Zone 1. Therefore, the flood risk associated with this source is considered Very Low.

Tidal – The study area is remote from the sea and tidally influenced water bodies. Therefore, the flood risk associated with this source is considered Negligible.

Pluvial (Rainfall) – The surface water flood risk maps show small areas that have the potential to flood during prolonged heavy rainfall. These areas are associated with natural depressions that are likely to be removed/positively drained following the development process. These areas need consideration within the detailed design or there is the potential to have areas of standing water in gardens and landscaped areas not positively drained if overland flow routes are not considered. Therefore, the risk of flooding from pluvial flooding is Low but should be considered further during the detailed design.

Surface Water (Overland flow) – There is limited impermeable area at a level generally above that of the parcel. Any surface water arising from the north of the study area is likely to be intercepted by the former railway drains and therefore pose no threat to the development. If there was a drainage failure causing overland flow it would flow towards the southeast boundary. Therefore, the risk of flooding from surface water is Low but should be considered further during the detailed design. A source of the potential surface water is the watercourse adjacent to the western boundary. This watercourse flows through the site at Brook Bottom before discharging into Withins Reservoir.

Groundwater – The EA/BGS has groundwater records for the study area in the form of potential groundwater flood maps. The records show there is a potential for groundwater flooding at the surface in the west and potential for groundwater flooding below ground to the east. The superficial Till deposits are more than 3m thick which would make it unlikely for groundwater flooding to occur. This makes it unlikely for groundwater flooding to occur. No evidence of shallow groundwater was observed during the walkover. Therefore, the flood risk associated with this source is considered Low.

Sewers – UU sewer records show foul and surface water sewers within the vicinity of the parcel within the existing housing developments to the west. The Pre-development Enquiry states that there are no records of sewer flooding at the site location. The highway to the west would intercept any overland flow before it enters the site. Therefore, the flood risk associated with this source is considered Very Low.

Artificial sources – According to the EA online maps, the study area is not at risk from reservoir flooding. The ponds located to the south of the parcel are seasonal and located in local depressions. Therefore, the flood risk associated with this source is considered Very Low.

Source of Flooding	Risk assessment Level
Fluvial	Very Low
Pluvial (Rainfall)	Low
Surface Water	Low
Tidal	Negligible
Groundwater	Low
Sewers	Very Low
Artificial Sources	Very Low

Table 4-5: Summary of Existing Risk Level.

4.2.6 Development Parcel F – South of the former railway line and north of Elton Reservoir

Fluvial – The EA has confirmed the study area is within Flood Zone 1. Therefore, the flood risk associated with this source is considered Very Low.

Tidal – The study area is remote from the sea and tidally influenced water bodies. Therefore, the flood risk associated with this source is considered Negligible.

Pluvial (Rainfall) – The surface water flood risk maps show small areas that have the potential to flood during prolonged heavy rainfall. These areas are associated with natural depressions that are likely to be removed/positively drained following the development process. These areas need consideration within the detailed design or there is the potential to have areas of standing water in gardens and landscaped areas not positively drained if overland flow routes are not considered. Therefore, the risk of flooding from pluvial flooding is Low but should be considered further during the detailed design.

Surface Water (Overland flow) - The only observed impermeable area at a level generally above that of the study area is the Spen Moor Development. Any surface water arising from the north of the study area is likely to be intercepted by the highway drains and sustainable drainage system and therefore pose no threat to the development. Therefore, the risk of flooding from surface water is Low but should be considered further during the detailed design. If there was a drainage failure causing overland flow it would flow towards the southeast boundary. A source of the potential surface water is the watercourse to the eastern boundary.

Groundwater – The EA/BGS has groundwater records for the study area in the form of potential groundwater flood maps. The records show there is a potential for groundwater flooding below ground. The superficial 'head' deposits are more than 3m thick which would make it unlikely for groundwater flooding to occur. This makes it unlikely for groundwater flooding to occur. No evidence of shallow groundwater was observed during the walkover. Therefore, the flood risk associated with this source is considered Low.

Sewers – UU sewer records show foul and surface water sewers within the vicinity of the Parcel within the existing housing developments to the north. The Pre-development Enquiry states that there are no records of sewer flooding at the site location. The highway to the west would intercept any overland flow before it enters the site. Therefore, the flood risk associated with this source is considered Very Low.

Artificial sources – According to the EA online maps, the study area is not at risk from reservoir flooding. The ponds located to the south of the parcel are seasonal and located in local depressions. Therefore, the flood risk associated with this source is considered Very Low.

Source of Flooding	Risk assessment Level
Fluvial	Very Low
Pluvial (Rainfall)	Low
Surface Water	Low
Tidal	Negligible
Groundwater	Low
Sewers	Very Low
Artificial Sources	Very Low

Table 4-6: Summary of Existing Risk Level.

4.2.7 Development Parcel G – North of Bury and Bolton Road

Fluvial – The EA has confirmed the study area is partially within Flood Zone 2 at present which contradicts the current published mapping where an area of Flood Zone 3, the mapping has not been updated to reflect the current modelling. Therefore, the flood risk associated with this source is considered Medium to Low and should be considered further in terms of vulnerability and flood resilience. Although there is little information available from the EA in relation to flood levels the affected areas should be considered further in terms of finished floor levels and flood resilience.

Tidal – The study area is remote from the sea and tidally influenced water bodies. Therefore, the flood risk associated with this source is considered Negligible.

Pluvial (Rainfall) – The surface water flood risk maps show small areas that have the potential to flood during prolonged heavy rainfall. These areas are associated with natural depressions that are likely to be removed/positively drained following the development process. These areas need consideration within the detailed design or there is the potential to have areas of standing water in gardens and landscaped areas not positively drained if overland flow routes are not considered. Therefore, the risk of flooding from pluvial flooding is Low but should be considered further during the detailed design.

Surface Water (Overland flow) - There is limited impermeable area at a level generally above that of the parcel. Any surface water arising from the north of the study area is likely to be intercepted by Crow Trees Farm Brook and therefore pose no threat to the development. If there was a drainage failure causing overland flow it would flow towards the southeast boundary. Therefore, the risk of flooding from surface water flooding is Low but should be considered further during the detailed design. A source of the potential surface water is Crow Trees Farm Brook adjacent to the northeast boundary.

Groundwater – The EA/BGS has groundwater records for the study area in the form of in the form of potential groundwater flood maps. The mapping indicates that water may enter any deep excavations or service trenches during construction and de-watering may be necessary. There are potential sources of Artesian Pressure to force the water to spring in the area to the east. This makes it possible for groundwater flooding to occur. No evidence of shallow groundwater was observed during the walkover. Therefore, the flood risk associated with this source is considered Low as the natural topography will cause any groundwater to be shed towards the eastern boundary of the parcel.

Sewers – UU sewer records show no foul and surface water sewers within the vicinity of the parcel area. The Pre-development Enquiry states there are no records of sewer flooding at the site location. The highway drainage to the west would intercept any overland flow before it enters the site. Therefore, the flood risk associated with this source is considered Very Low.

Artificial sources – According to the EA online maps, the study area is at risk from reservoir flooding. The likely risk of an incident occurring if the reservoir is adequately maintained and monitored is low. Therefore, the flood risk associated with this source is considered Low; however, improvements are recommended during redevelopment to reduce the potential hazard risk (see section 6).

Source of Flooding	Risk assessment Level
Fluvial	Medium to Low
Pluvial (Rainfall)	Low
Surface Water	Low
Tidal	Negligible
Groundwater	Low
Sewers	Very Low
Artificial Sources	Low

Table 4-7: Summary of Existing Risk Level.

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5 SURFACE WATER MANAGEMENT

The NPPF recognises that flood risk and other environmental damage can be managed by minimising changes in the volume and rate of surface run-off from development sites through the use of Sustainable Drainage Systems (SuDS), this being complementary to the control of development within the floodplain.

SuDS will not alleviate flooding in an area prone to flooding; however, properly designed SuDS have the potential to prevent the surface water runoff from new development worsening the flood risk. The effective disposal of surface water from development is a material planning consideration in determining proposals for the development and use of land.

The accepted principles are that surface water arising from a developed area should, as far as practicable, be managed in a sustainable manner to mimic the surface water flows arising from the site prior to the proposed development, while reducing the flood risk to the site itself and elsewhere, taking climate change into account.

The Building Regulations Requirement H3[7] stipulates that rainwater from roofs and paved areas is carried away from the surface to discharge to one of the following, listed in order of priority:

a) an adequate soakaway or other adequate infiltration system,
b) a watercourse or, where that is not practicable,
c) a sewer.

The concept of a sustainable drainage system has been incorporated into the outline drainage strategy for the study area in order to comply with the Flood and Water Management Act 2010[8].

5.1 Infiltration

The Groundwater Source Protection Zone mapping from the EA website shows that the site is not within any identified protection zones.

A summary of the British Geological Survey superficial and bedrock aquifer descriptions and classifications supplemented by local records is shown in Table 5-1 below:

Classification	Description	Aquifer Classification	Recorded Water Table Depth	Soakaway Potential
Glacial Till Deposits to the north.	Silty, sandy Clay.	Secondary Undifferentiated	N/A	Poor
Glaciofluvial Sheet Deposits to the south.	Sand and Gravel with clay.	Secondary A	N/A	Limited
Bands of Cannel Rock and Pennine Lower Coal Measures to the north.	Mudstone, Siltstone and Sandstone.	Secondary A	N/A	Limited
To the south, the bedrock is a mixture of Pennine Upper Coal Measures and Hall Rock.	Mudstone, Siltstone and Sandstone	Secondary A	N/A	Limited

Table 5-1: Geological and Hydrogeological Setting.

[7] Building Regulations part H3 2010: Approved Document, Drainage and Waste Disposal
[8] Flood and Water Management Act 2010: UK Government.

Infiltration methods such as soakaways are unlikely to be feasible, but this may be investigated further at the detailed design stage if required.

There are several open watercourses occasionally culverted and culverted watercourse running through the site that currently collects the surface water. These watercourses are culverted beneath the canal and railway embankments and the onward routes may be constricted.

There are surface water sewers to the north and east of parcel B.

5.2 Surface Water Drainage Strategy

The drainage options relating to the final discharge of surface water for this section of the site are listed in Table 5-2 in order of priority within the NPPF:

Option No:	Drainage Solution	Most feasible solution	Comments
a	Soakaway/Infiltration	3	Low permeability of soils to the northern parcels (B, E & F) and potentially high watertable for the southern parcels (C, C1, D,& G).
b	Connection to Watercourse	1	Would require EA/LLFA consent.
c	Discharge into a sewer	2	Limited availability of sewers to make connections to, with the exception of parcel C1 where connection to a sewer may be necessary – subject to approval from LLFA/UU.

Table 5-2: Drainage Options.

Table 5-3 provides a summary of the SuDS options appraisal with consideration of CIRIA C697 (The SUDS Manual)[9] for the development:

SuDS Option	Appropriate to Development	Comments
Soakaways	X	Due to the nature of the ground conditions, the use of infiltration systems may not be feasible.
Infiltration basin	X	Depressions that store and dispose of water via infiltration. May not be appropriate given the ground conditions.
Sand filter	X	Treatment devices using sand beds as filter media.
Filter strip	✓	Engineered filters that use vegetation to remove and treat runoff. The filter strip is sloped to allow sheet flow across the vegetated strip. A filter strip offers no storage and is used solely to remove pollutants from surface water.
Filter drains	✓	Linear trenches filled with a permeable granular material, often with a perforated pipe in the base of the trench.
Detention basin	✓	Dry depressions designed to hold water for a specific retention time.
Swales	✓	Swales are shallow grass-lined channels that provide capacity for conveying flows at a controlled rate into ponds and watercourses.
Rain water harvesting	*	Rainwater harvesting collects the rain which falls onto roofs, then stores it in a tank until required for a non-potable use. When required, the water is pumped to the point of use, thus displacing what would otherwise be a demand for mains-water. In the process, a volume of water is kept out of the storm-water management system, thereby helping to reduce flooding risks. Rainwater harvesting systems are currently not included in the development proposals.
Green roofs	*	Green roof installations can help to reduce surface water runoff from roof areas depending on the system specified. Green roofs are not currently included in the development proposals.
Geo-cellular storage systems	✓	Modular block systems can be used to provide an underground storage facility. Any geo-cellular storage systems should be lined with a geo-membrane to provide attenuation storage.
Permeable Pavements – with granular and geo-cellular storage systems	✓	Permeable pavements allow inflow of rainwater into underlying construction. Any geo-cellular storage systems would have to be lined with an impermeable membrane to provide storage rather than infiltration for runoff from highways.
Ponds	✓	Attenuation ponds can be used to offset the increase in surface water flows attributable to increased area of hard standing, in order to minimise the risk of flooding to and from the proposed development. Ponds will attenuate the surface water flow prior to discharging to the public surface water sewers. The storage volume afforded by these features should not include any permanent water in the pond.
Oversized Pipes	✓	Oversizing the pipes that make up the on-site drainage network is a cost effective method for providing attenuation storage within the network. Such systems could be considered on the parts of the development where gradients are relatively flat.
Tanks	✓	Prefabricated underground tanks could be considered at the detailed design stage in order to provide storage to attenuate surface water runoff.
Flow control devices	✓	The peak flow rates will be controlled by flow control devices e.g. hydrobrake style flow control systems, and restricted orifices. Flow control devices enable the discharge to be restricted to a constant rate from the development.

Table 5-3: Summary of the SuDS Options Appraisal.

Notes

✓ Suitable for use given the nature and scale of the development
* Possibly suitable for use – not included in the client and architect design proposal at present
X Not suitable

[9] CIRIA C697 - The SUDS Manual. London 2015.

5.3 Surface Water Attenuation Requirements

From correspondence with the LPA/EA the flow should be limited to a 'greenfield scenario' for estimating the attenuation volumes required.

It is estimated from the supplied plan (see Appendix A) that the site will have the following designated areas (Table 5-4).

Parcel B Designated Areas	**Plot Area**
Total area (ha)	13.40
Impermeable split (ha)	7.37
Permeable split (ha)	6.03
Parcel C Designated Areas	**Plot Area**
Total area (ha)	21.80
Development Area (ha)	14.69
Green Infrastructure (ha)	7.11
Impermeable split (ha)	8.08
Permeable split (ha)	6.61
Parcel C1 Designated Areas	**Plot Area**
Total area (ha)	1.45
Paved Area (ha)	0.20
Permeable Area (ha)	1.25
Parcel D Designated Areas	**Plot Area**
Total area (ha)	17.60
Development Area (ha)	17.22
Green Infrastructure (ha)	0.38
Impermeable split (ha)	9.47
Permeable split (ha)	7.75
Parcel E Designated Areas	**Plot Area**
Total area (ha)	19.70
Development Area (ha)	15.10
Green Infrastructure (ha)	2.60
Northern Catchment	
Catchment Area (ha)	13.37
Developable Area (ha)	12.07
Impermeable split (ha)	6.64
Permeable split (ha)	5.43
Green Infrastructure (ha)	1.30
Southern Catchment	
Catchment Area (ha)	4.23
Developable Area (ha)	2.93
Impermeable split (ha)	1.61
Permeable split (ha)	1.32
Green Infrastructure (ha)	1.30

Table 5-4: Assumed Parcel Areas

Parcel F Designated Area	Plot Area
Total area (ha)	23.90
Development Area (ha)	10.52
Green Infrastructure (ha)	13.38
Western Catchment	
Catchment Area (ha)	9.84
Developable Area (ha)	4.68
Impermeable split (ha)	2.57
Permeable split (ha)	2.11
Green Infrastructure (ha)	5.16
Eastern Catchment	
Catchment Area (ha)	14.06
Developable Area (ha)	5.84
Impermeable split (ha)	3.21
Permeable split (ha)	2.63
Green Infrastructure (ha)	8.22
Parcel G Designated Areas	**Plot Area**
Total area (ha)	8.70
Development Area (ha)	8.70
Impermeable split (ha)	4.79
Permeable split (ha)	3.91
Parcel H Designated Areas	**Plot Area**
Total area (ha)	3.95
Development Area (ha)	3.95
Impermeable split (ha)	2.18
Permeable split (ha)	1.78

Table 5-4 (continued): Assumed Parcel Areas.

Table 5-4 shows the assumed split in area included within the calculations.

5.3.1 Attenuation Estimate

Surface water storage and greenfield runoff estimations based on the HR Wallingford procedure (IH 124[10]) have been undertaken for the development and the output report is presented in Appendix E.

Parcel B

For the contributing catchment an estimate has been produced assuming a developable area of 13.40ha. Assuming conservatively that 55% of the developed area comprises roofs and hard surfacing with an allowance for urban creep, the resulting impermeable area would be 7.37ha. This gives the following runoff rates and attenuation requirements for this section based on the Wallingford IH 124 method:

- Q_{bar}: **99.89 l/s**
- 1 in 1 year greenfield runoff rate: **84.91 l/s**
- 1 in 30 year greenfield runoff rate: **167.81 l/s**
- 1 in 100 year greenfield runoff rate: **209.78 l/s**

The following attenuation has been estimated for the development using greenfield runoff rates and utilises the FSR methodology as:

[10] IH124 Flood Estimation of Small Catchments.

- Attenuation storage volume: **1149.5 m³** (1 in 30 year event)
- Retention on site volume: **2047.5 m³** (1 in 100 year + 20% Climate Change)
- Retention on site volume: **2576.0 m³** (1 in 100 year + 40% Climate Change)

Parcel C

For the contributing catchment an estimate has been produced assuming a developable area of 14.69ha and a public open space of 7.11ha from the 21.80ha plot. Assuming conservatively that 55% of the developed area comprises roofs and hard surfacing with an allowance for urban creep, the resulting impermeable area would be 8.08ha. This gives the following runoff rates and attenuation requirements for this section based on the Wallingford IH 124 method:

- Q_{bar}: **162.52 l/s**
- 1 in 1 year greenfield runoff rate: **138.14 l/s**
- 1 in 30 year greenfield runoff rate: **273.03 l/s**
- 1 in 100 year greenfield runoff rate: **341.28 l/s**

The following attenuation has been estimated for the development using greenfield runoff rates and utilises the FSR methodology as:

- Attenuation storage volume: **1557.2 m³** (1 in 30 year event)
- Retention on site volume: **2784.9 m³** (1 in 100 year + 20% Climate Change)
- Retention on site volume: **3515.4 m³** (1 in 100 year + 40% Climate Change)

Parcel C1

For the contributing catchment an estimate has been produced assuming a total road pavement area of 0.2ha and a landscaped open space of 1.25ha from the 1.45ha plot. This gives the following runoff rates and attenuation requirements for this section based on the Wallingford IH 124 method:

- Q_{bar}: **10.81 l/s**
- 1 in 1 year greenfield runoff rate: **9.19 l/s**
- 1 in 30 year greenfield runoff rate: **18.16 l/s**
- 1 in 100 year greenfield runoff rate: **22.70 l/s**

The following attenuation has been estimated for the development using greenfield runoff rates and utilises the FSR methodology as:

- Attenuation storage volume: **103.6 m³** (1 in 30 year event)
- Retention on site volume: **185.4 m³** (1 in 100 year + 20% Climate Change)
- Retention on site volume: **234.0 m³** (1 in 100 year + 40% Climate Change)

Parcel D

For the contributing catchment an estimate has been produced assuming a developable area of 17.22ha and a public open space of 0.38ha from the 17.60ha plot. Assuming conservatively that 55% of the developed area comprises roofs and hard surfacing with an allowance for urban creep, the resulting impermeable area would be 9.47ha. This gives the following runoff rates and attenuation requirements for this section based on the Wallingford IH 124 method:

- Q_{bar}: **131.20 l/s**

- 1 in 1 year greenfield runoff rate: **111.52 l/s**
- 1 in 30 year greenfield runoff rate: **220.42 l/s**
- 1 in 100 year greenfield runoff rate: **257.53 l/s**

The following attenuation has been estimated for the development using greenfield runoff rates and utilises the FSR methodology as:

- Attenuation storage volume: **1458.4 m³** (1 in 30 year event)
- Retention on site volume: **2689.4 m³** (1 in 100 year + 20% Climate Change)
- Retention on site volume: **3379.5 m³** (1 in 100 year + 40% Climate Change)

Parcel E (North)

For the contributing catchment an estimate has been produced assuming a developable area of 12.07ha and a public open space of 1.30ha from the 13.37ha plot. Assuming conservatively that 55% of the developed area comprises roofs and hard surfacing with an allowance for urban creep, the resulting impermeable area would be 6.64ha. This gives the following runoff rates and attenuation requirements for this section based on the Wallingford IH 124 method:

- Q_{bar}: **99.67 l/s**
- 1 in 1 year greenfield runoff rate: **84.72 l/s**
- 1 in 30 year greenfield runoff rate: **167.45 l/s**
- 1 in 100 year greenfield runoff rate: **209.31 l/s**

The following attenuation has been estimated for the development using greenfield runoff rates and utilises the FSR methodology as:

- Attenuation storage volume: **955.7 m³** (1 in 30 year event)
- Retention on site volume: **1709.2 m³** (1 in 100 year + 20% Climate Change)
- Retention on site volume: **2157.5 m³** (1 in 100 year + 40% Climate Change)

Parcel E (South)

For the contributing catchment an estimate has been produced assuming a developable area of 2.93ha and a public open space of 1.30ha from the 4.23ha plot. Assuming conservatively that 55% of the developed area comprises roofs and hard surfacing with an allowance for urban creep, the resulting impermeable area would be 1.61ha. This gives the following runoff rates and attenuation requirements for this section based on the Wallingford IH 124 method:

- Q_{bar}: **31.53 l/s**
- 1 in 1 year greenfield runoff rate: **26.80 l/s**
- 1 in 30 year greenfield runoff rate: **52.98 l/s**
- 1 in 100 year greenfield runoff rate: **66.22 l/s**

The following attenuation has been estimated for the development using greenfield runoff rates and utilises the FSR methodology[11] as:

- Attenuation storage volume: **302.4 m³** (1 in 30 year event)
- Retention on site volume: **540.8 m³** (1 in 100 year + 20% Climate Change)
- Retention on site volume: **682.8 m³** (1 in 100 year + 40% Climate Change)

[11] Flood Studies Report Wallingford NERC 1975.

Parcel F (West)

For the contributing catchment an estimate has been produced assuming a developable area of 4.68ha and a public open space of 5.16ha from the 9.84ha plot. Assuming conservatively that 55% of the developed area comprises roofs and hard surfacing with an allowance for urban creep, the resulting impermeable area would be 2.57ha. This gives the following runoff rates and attenuation requirements for this section based on the Wallingford IH 124 method:

- Q_{bar}: **73.36 l/s**
- 1 in 1 year greenfield runoff rate: **62.35 l/s**
- 1 in 30 year greenfield runoff rate: **123.24 l/s**
- 1 in 100 year greenfield runoff rate: **154.05 l/s**

The following attenuation has been estimated for the development using greenfield runoff rates and utilises the FSR methodology[12] as:

- Attenuation storage volume: **703.4 m³** (1 in 30 year event)
- Retention on site volume: **1257.9 m³** (1 in 100 year + 20% Climate Change)
- Retention on site volume: **1587.8 m³** (1 in 100 year + 40% Climate Change)

Parcel F (East)

For the contributing catchment an estimate has been produced assuming a developable area of 5.84ha and a public open space of 8.22ha from the 14.06ha plot. Assuming conservatively that 55% of the developed area comprises roofs and hard surfacing with an allowance for urban creep, the resulting impermeable area would be 3.21ha. This gives the following runoff rates and attenuation requirements for this section based on the Wallingford IH 124 method:

- Q_{bar}: **104.81 l/s**
- 1 in 1 year greenfield runoff rate: **89.09 l/s**
- 1 in 30 year greenfield runoff rate: **176.09 l/s**
- 1 in 100 year greenfield runoff rate: **220.11 l/s**

The following attenuation has been estimated for the development using greenfield runoff rates and utilises the FSR methodology as:

- Attenuation storage volume: **1005.0 m³** (1 in 30 year event)
- Retention on site volume: **1797.4 m³** (1 in 100 year + 20% Climate Change)
- Retention on site volume: **2268.8 m³** (1 in 100 year + 40% Climate Change)

Parcel G

For the contributing catchment an estimate has been produced assuming a developable area of 8.70ha. Assuming conservatively that 55% of the developed area comprises roofs and hard surfacing with an allowance for urban creep, the resulting impermeable area would be 4.79ha. This gives the following runoff rates and attenuation requirements for this section based on the Wallingford IH 124 method:

- Q_{bar}: **64.86 l/s**
- 1 in 1 year greenfield runoff rate: **55.13 l/s**
- 1 in 30 year greenfield runoff rate: **108.96 l/s**

[12] Flood Studies Report Wallingford NERC 1975.

- 1 in 100 year greenfield runoff rate: **136.20 l/s**

The following attenuation has been estimated for the development using greenfield runoff rates and utilises the FSR methodology as:

- Attenuation storage volume: **746.3 m³** (1 in 30 year event)
- Retention on site volume: **1329.4 m³** (1 in 100 year + 20% Climate Change)
- Retention on site volume: **1672.5 m³** (1 in 100 year + 40% Climate Change)

Attenuation storage aims to limit the peak rate of runoff from the development to the corresponding greenfield runoff for a range of annual flow rate probabilities before discharge to watercourse. As the flow from the development would be restricted to the greenfield equivalent there should be little change in the flows that enter the watercourses and thus the risk of flooding and the level of erosion created as a result from the development should not increase the risk of flooding off-site.

Overall Catchment Flows

The overall Elton Parklands development is split over two catchments within the boundary of the site, the site the majority of the parcels are discharging into the Crow Trees Brook via various ordinary watercourses and Withins Reservoir. The exception being Parcels C and C1 that flow towards Hutchins Brook the surface water drainage system to the east of Bury Road and part of parcel F that discharges via the Elton Reservoir directly into the River Irwell.

Crow Trees Catchment

The total greenfield catchment is 73.19ha. By utilising the IH 124 methodology this gives the following flows off site:

- Q_{bar}: **498.01 l/s**
- 1 in 1 year greenfield runoff rate: **423.31 l/s**
- 1 in 30 year greenfield runoff rate: **836.66 l/s**
- 1 in 100 year greenfield runoff rate: **1045.83 l/s**

Parcels C & C1

The total greenfield catchment is 23.25ha. By utilising the IH 124 methodology this gives the following flows off site:

- Q_{bar}: **523.22 l/s**
- 1 in 1 year greenfield runoff rate: **444.74 l/s**
- 1 in 30 year greenfield runoff rate: **879.01 l/s**
- 1 in 100 year greenfield runoff rate: **1098.77 l/s**

Part Parcel F

The total greenfield catchment is 14.06ha. By utilising the IH 124 methodology this gives the following flows off site:

- Q_{bar}: **104.81 l/s**
- 1 in 1 year greenfield runoff rate: **89.09 l/s**
- 1 in 30 year greenfield runoff rate: **176.09 l/s**
- 1 in 100 year greenfield runoff rate: **220.11 l/s**

These overall catchment flows do not take into account the existing storage within the site boundary, slopes and the time of travel for the flows.

The use of permeable paving may be viable dependant on the detailed design of the proposed development. If this drainage technique is considered to be feasible then it will reduce the requirement for attenuation as it will reduce the contributing area.

Assuming that the outline drainage strategy is acceptable to the Local Authority, a more detailed design can be presented and agreed with the appropriate regulatory bodies during the detailed design phase.

A preliminary drainage strategy (shown in Appendix F) has been developed based on an indicative development plan.

5.4 Foul Drainage

It is likely that the foul drainage system will need to be reinforced to cope with the potential flows. There are limited potential connections to the west and the north of the development.

6 MITIGATION MEASURES

6.1 Proposed Site levels and Development Level

Current Environment Agency guidance recommends that the minimum ground floor levels of residential developments are set at a minimum of 600mm above the 1% annual probability (1 in 100 year) flood level including an additional fluvial allowance for climate change. It is generally accepted that vehicle parking can be accommodated within the flood zone with suitable safeguards. The 'design' flood level for the site should therefore be the 1% annual probability event with allowance for climate change plus an allowance for freeboard.

Only the lower parcels are affected by potential fluvial flooding. On this basis the finished floor levels (FFL) should be set at a nominal height above the finalised ground levels for residential properties within parcels B, E & F to allow for any overland flow from a drainage failure. No further mitigation measures are therefore recommended.

The remaining parcels should be considered on an individual basis as only parts of them are in the current Flood Zones 2, the flood levels have not been released by the EA so the extent of the flood zones and Finished Floor Levels within the parcels affected will need to be determined.

6.2 Safe Access

Safe and dry access is available via each of the proposed accesses for the northern parcels B, E & F as they are significantly above the extents of the flood zones. Therefore, no mitigation is proposed.

For parcels C, D & G safe and dry access to the north will be available. Access to the south may pass through the area of Flood Zones 2, but it is likely to be raised above the flood levels by the requirements to bridge the railway and canal crossings. If a tunnelled access is utilised the accesses should be considered in terms of potential flooding and a formal evacuation plan may be required.

6.3 Flood Resistance and Resilience

For parcels B, E & F The development proposed may be subject to flooding at more extreme events than those considered. However the risk appears to be sufficiently low that flood resilience measures need not be included into ground floor construction to aid recovery after any event. If utilised, typical measures would include solid floors, use of suitable materials and services fed from upper floors with outlets at high level. The need can be discussed and agreed with building control officers during detailed design.

For parcels D & G the development proposed may be subject to groundwater entering excavations for foundations and services due to the potentially shallow water table. Dewatering may be required for excavations and means of limiting flows in service trench bedding be incorporated. However the risk appears to be sufficiently low that flood resilience measures need not be included into ground floor construction to aid recovery after any event. If utilised, typical measures would include solid floors, use of suitable materials and services fed from upper floors with outlets at high level. The need can be discussed and agreed with building control officers during detailed design.

For parcel C the development proposed may be subject to flooding at more extreme events than those considered. Flood resilience measures should be included into ground floor construction to aid recovery after any event. If utilised, typical measures would include solid

floors, use of suitable materials and services fed from upper floors with outlets at high level. The need can be discussed and agreed with building control officers during detailed design.

The embankment areas to the canal may need raising to contain any spill water within the banks before it can overflow via the purpose built structure towards the River Irwell.

The ordinary watercourse within parcel C passes beneath the canal within an Inverted Syphon. This should be subject to regular inspection by the C&RT and the LLFA to check it is free flowing.

6.4 Residual Risks

It is impossible to completely guard against flooding since extreme events greater than the design standard event are always possible. However, for parcels B, E & F it is likely that with the 1% annual probability flood event with allowance for climate change significantly below the lowest site levels, the relatively elevated position of the development will safeguard it from localised fluvial flooding during extreme rainfall events and fluvial flooding events outside the scope of this assessment. However, ground floor levels should be set above proposed levels across the development and provide a nominal freeboard to allow overland flow under exceptional conditions. Overland flow routes should be considered in case of drainage failure and the extreme events.

For parcels C, D, & G ground floor levels should be set 600mm above the modelled 1% plus climate change event level adjacent to the flood zones. Proposed finished floor levels above this level across the remainder of the parcels should provide a nominal freeboard to allow overland flow under exceptional conditions. Overland flow routes should be considered in case of drainage failure and the extreme events.

6.5 Potential Mitigation

Over the lifetime of the development it is likely that the Fluvial Flood levels will increase and overspill into these areas and there will be an increased risk from overland surface water flows. Although the potential raised finished floor levels should raise the residential properties above the flood levels it may be worth considering setting aside potential flood compensation areas to minimise the risk to residents by filling in existing depressions.

7 CONCLUSIONS

The majority of the proposed development is shown on published mapping to be located within the Environment Agency's Flood Zone 1. Comparison of topographical data with the EA modelled flood level data indicates that the parcels in Flood Zone 1 have a Very Low Risk of fluvial flooding. Parcels C, D & G have a Low Risk of fluvial flooding. This will need to be reviewed following the release of the recent fluvial flood modelling data produced by the EA. Early correspondence indicates that the flood extents may be less than shown on the current published flood maps.

All the development parcels have a Low to Negligible risk of flooding from all sources with the exception of the following development parcels.

Parcel C has a Medium Risk of surface water flooding due to the artificial depressions created by the canal and railway embankments. It also has a Medium risk of groundwater flooding due to the shallow water table and the superficial soil types.

Parcel G has a Low Risk of fluvial flooding towards its eastern boundary due to the updated Flood Zone Maps. There is a potential surface water risk adjacent to the raised canal embankment.

An assessment of these risks in conjunction with the development proposals have resulted in the following recommendations for the safe development of the site:

- The recommended minimum finished floor level of 600mm above the 1% plus climate change level for the fluvial flood zone affected areas and a nominal height above the finished ground levels to allow for overland flow routes in extreme events and drainage failures.

- Pedestrian and vehicular safe access to and from the site is achievable under all conditions via the access road to the north of the site.

- The requirements for a formal evacuation plan should be discussed with the LPA.

- Potential for soakaway use for rainwater disposal is low; however this could be investigated further at the detailed design phase if required.

- Foul sewage could be discharged into the existing public foul sewer system but may need reinforcement subject to the agreement of United Utilities.

- Surface water flow will probably need to be attenuated to the greenfield runoff rate or a rate agreed with the LLFA/EA/UU. There are potential capacity issues to the south of Radcliffe Road so there may be further restrictions on any discharges from Parcels D & G.

- Surface water arising from the site could potentially discharge into a the watercourses or a surface water culvert. With the exception of the Link Road to the southeast of the canal at the junction with Spring Lane which may need a sewer connection.

Further details on the proposed mitigation measures are provided in Section 6. All proposed measures should be agreed with the Local Authority prior to commencement of the development.

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APPENDIX A

FIGURES, PLANS, AND DRAWINGS

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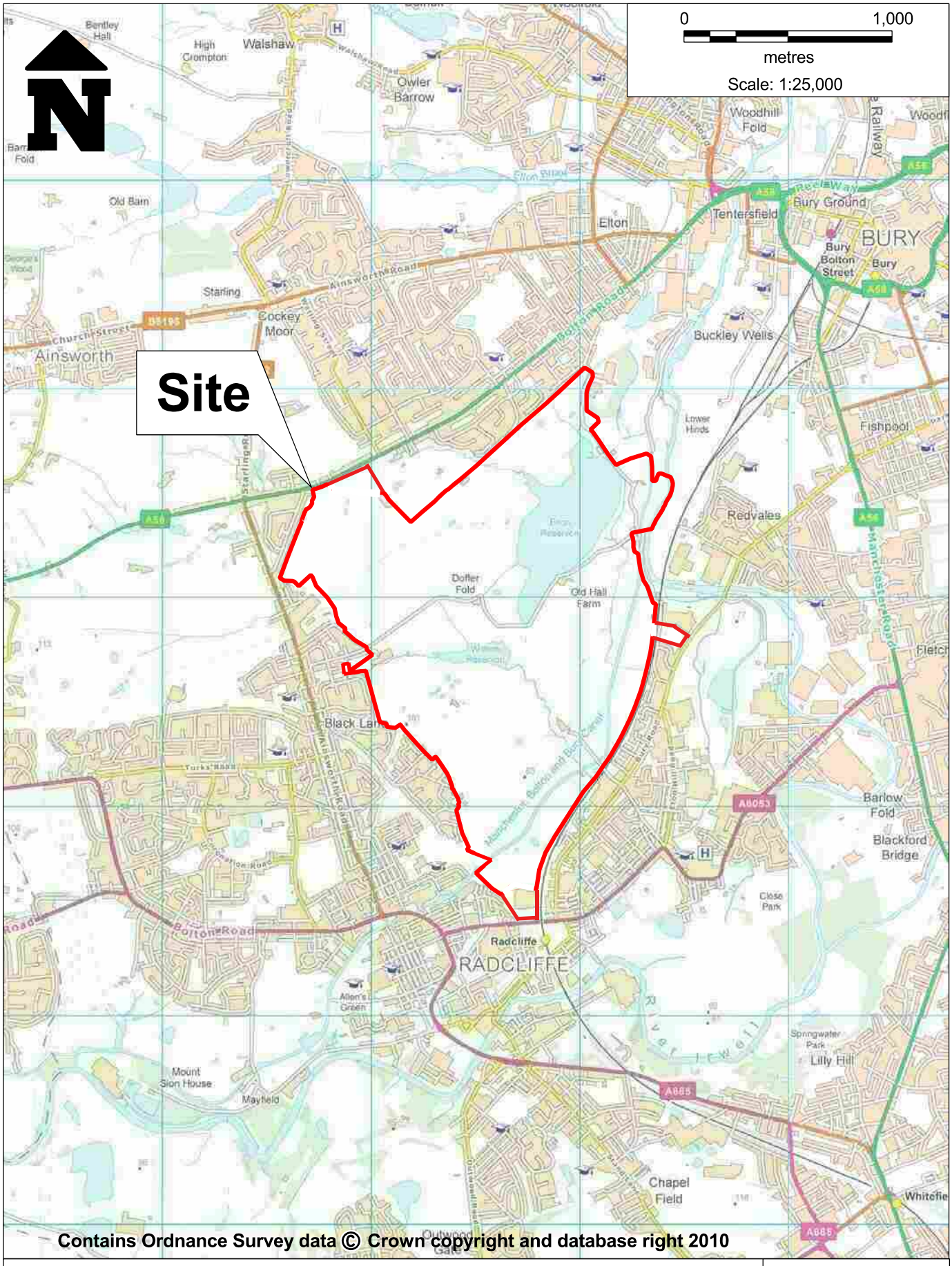

Figure 1: Site Location & Site Boundary Plan, Elton Part of the Draft Greater Manchester Spatial Framework

Drawn: Feb 2019 Scale: 1:25,000 @ A4 (see scale bar)

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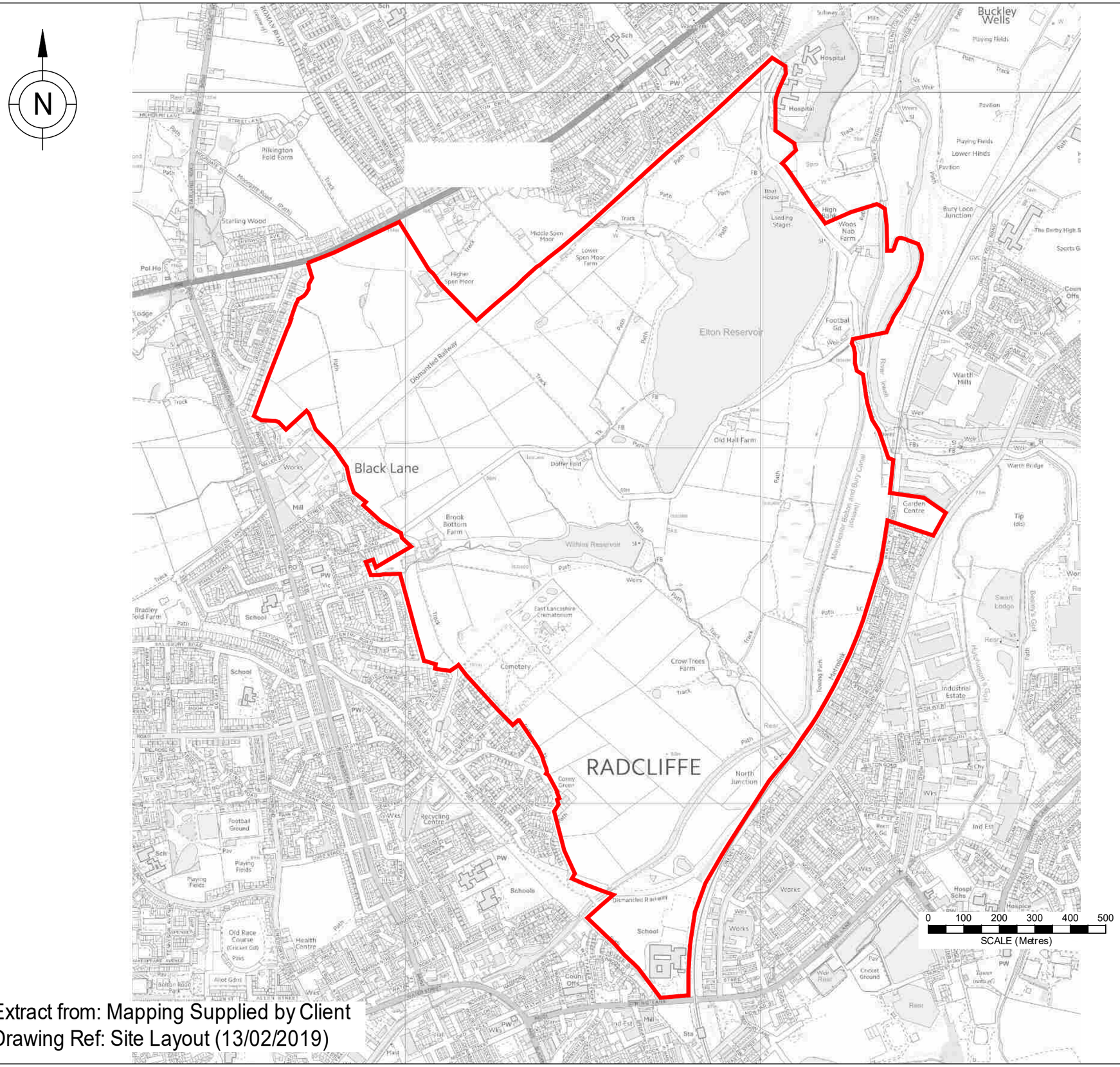

Extract from: Mapping Supplied by Client
Drawing Ref: Site Layout (13/02/2019)

KEY

Site Boundary

Sampling Locations and features annotated by LK Consult Ltd are approximate and are based upon observed measurements unless otherwise stated. Do not scale from this drawing and work from marked dimensions only. All dimensions and features should be confirmed on site by the Contractor. Where this drawing includes information provided to LK Consult Ltd by others, LK Consult Ltd gives no warranty, representation or assurance as to the accuracy of such information.

LK CONSULT LIMITED

Client: Peel Investments (North) Ltd

Site: Elton Parklands, Part of the Draft Greater Manchester Spatial Framework

Title: Site Area Layout Plan

Job No.:	Scale (See Scale Bar)	Figure:	Revision:
FRA 18 1024	scale bar	2	A

Drawn By:	Checked By:	Drawn:
AC	BS	July 2020

APPENDIX B

SITE INFORMATION

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Do not scale from this drawing and work from marked dimensions only. All dimensions and features should be confirmed on site by the Contractor. Where this drawing includes information provided to LK Consult Ltd by others, LK Consult Ltd gives no warranty, representation or assurance as to the accuracy of such information.

LK CONSULT LIMITED

Client: Turley

Site: Elton Reservoir

Title: Contour Map

Job No.:	Scale (See Scale Bar):	Figure:	Revision:
FRA 18 1024		1	

Drawn By:	Checked By:	Drawn:
AC	MC	April 2018

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Geology 1:50,000 Maps Legends

Artificial Ground and Landslip

Map Colour	Lex Code	Rock Name	Rock Type	Min and Max Age
	WMGR	Infilled Ground	Artificial Deposit	Cenozoic - Cenozoic
	WGR	Worked Ground (Undivided)	Void	Holocene - Holocene
	MGR	Made Ground (Undivided)	Artificial Deposit	Holocene - Holocene

Superficial Geology

Map Colour	Lex Code	Rock Name	Rock Type	Min and Max Age
	SUPNM	Superficial Theme Not Mapped [For Digital Map Use Only]	Unknown/Unclassified Entry	Not Supplied - Not Supplied
	ALV	Alluvium	Clay, Silt, Sand and Gravel	Flandrian - Flandrian
	TILLD	Till, Devensian	Diamicton	Devensian - Devensian
	GFDUD	Glaciofluvial Deposits, Devensian	Sand and Gravel	Devensian - Devensian
	GLLDD	Glaciolacustrine Deposits, Devensian	Clay and Silt	Devensian - Devensian
	GFSDD	Glaciofluvial Sheet Deposits, Devensian	Sand and Gravel	Devensian - Devensian
	RTD1	River Terrace Deposits, 1	Sand and Gravel	Quaternary - Quaternary
	RTD2	River Terrace Deposits, 2	Sand and Gravel	Quaternary - Quaternary

Bedrock and Faults

Map Colour	Lex Code	Rock Name	Rock Type	Min and Max Age
	NR	Nob End Rock	Sandstone	Bolsovian - Bolsovian
	PMCM	Pennine Middle Coal Measures Formation	Mudstone, Siltstone and Sandstone	Bolsovian - Duckmantian
	PMCM	Pennine Middle Coal Measures Formation	Sandstone	Bolsovian - Duckmantian
	PR	Peel Hall Rock	Sandstone	Duckmantian - Duckmantian
	PLCM	Pennine Lower Coal Measures Formation	Mudstone, Siltstone and Sandstone	Langsettian - Langsettian
	PLCM	Pennine Lower Coal Measures Formation	Sandstone	Langsettian - Langsettian
	TRBR	Trencherbone Rock	Sandstone	Langsettian - Langsettian
	CAR	Cannel Rock (South Lancashire)	Sandstone	Langsettian - Langsettian
	OL	Old Lawrence Rock	Sandstone	Langsettian - Langsettian
		Faults		
		Rock Segments		

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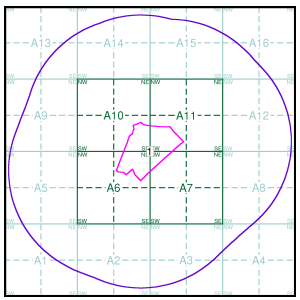
Geology 1:50,000 Maps

This report contains geological map extracts taken from the BGS Digital Geological map of Great Britain at 1:50,000 scale and is designed for users carrying out preliminary site assessments who require geological maps for the area around the site. This mapping may be more up to date than previously published paper maps.
The various geological layers - artificial and landslip deposits, superficial geology and solid (bedrock) geology are displayed in separate maps, but superimposed on the final 'Combined Surface Geology' map. All map legends feature on this page. Not all layers have complete nationwide coverage, so availability of data for relevant map sheets is indicated below.

Geology 1:50,000 Maps Coverage

Map ID:	**1**
Map Sheet No:	**085**
Map Name:	**Manchester**
Map Date:	**2011**
Bedrock Geology:	**Available**
Superficial Geology:	**Available**
Artificial Geology:	**Available**
Faults:	**Not Supplied**
Landslip:	**Available**
Rock Segments:	**Not Supplied**

Geology 1:50,000 Maps - Slice A



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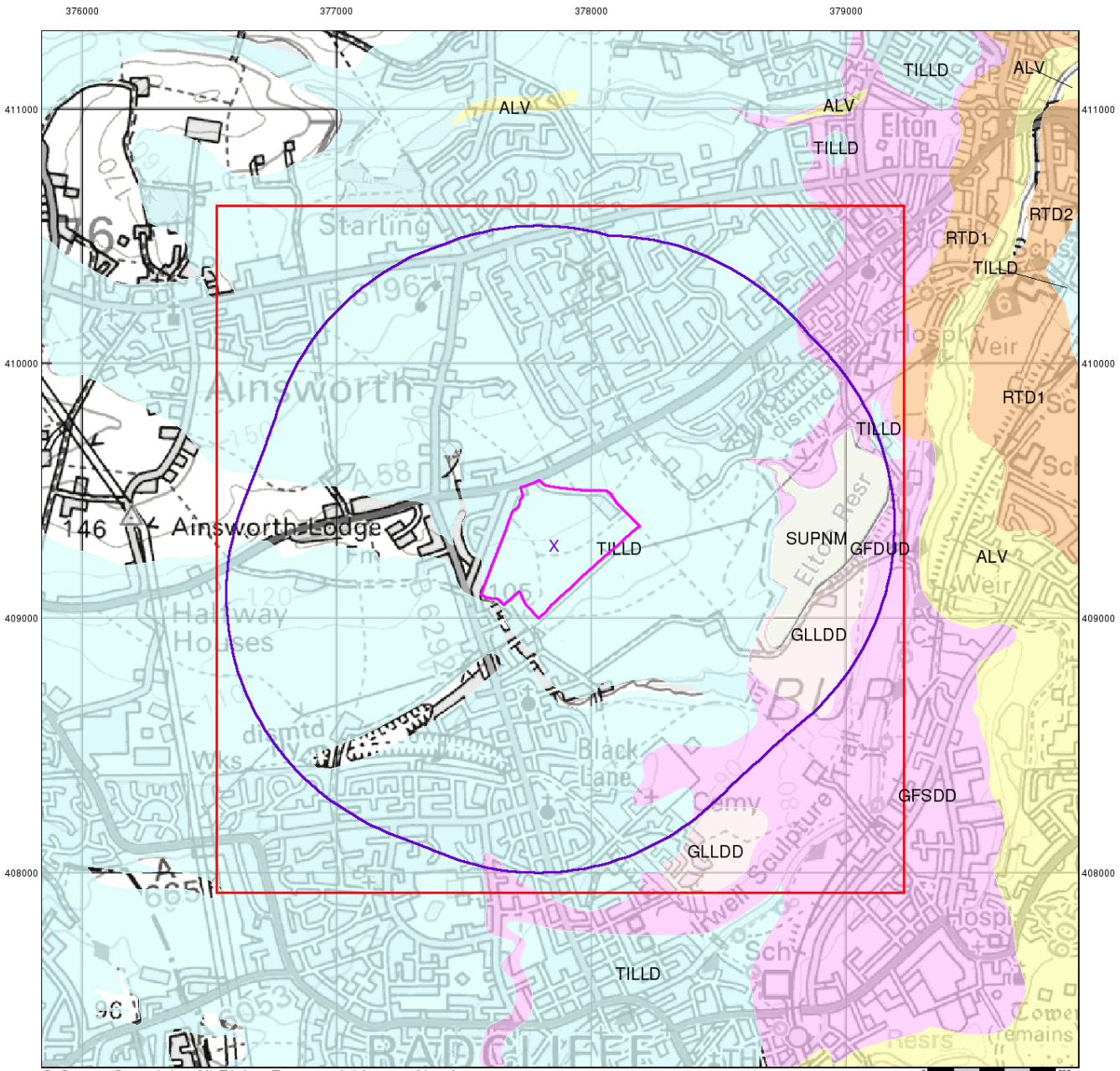
National Grid Reference:	377850, 409280
Slice:	A
Site Area (Ha):	18.57
Search Buffer (m):	1000

Site Details:

Site at 377877,409271

Landmark INFORMATION GROUP
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



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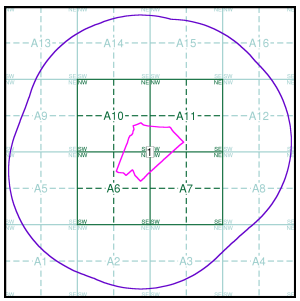
Superficial Geology

Superficial Deposits are the youngest geological deposits formed during the most recent period of geological time, the Quaternary, which extends back about 1.8 million years from the present.

They rest on older deposits or rocks referred to as Bedrock. This dataset contains Superficial deposits that are of natural origin and 'in place'. Other superficial strata may be held in the Mass Movement dataset where they have been moved, or in the Artificial Ground dataset where they are of man-made origin.

Most of these Superficial deposits are unconsolidated sediments such as gravel, sand, silt and clay, and onshore they form relatively thin, often discontinuous patches or larger spreads.

Superficial Geology Map - Slice A



Order Details:

Order Number:	123188887_1_1
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National Grid Reference:	377850, 409280
Slice:	A
Site Area (Ha):	18.57
Search Buffer (m):	1000

Site Details:

Site at 377877,409271

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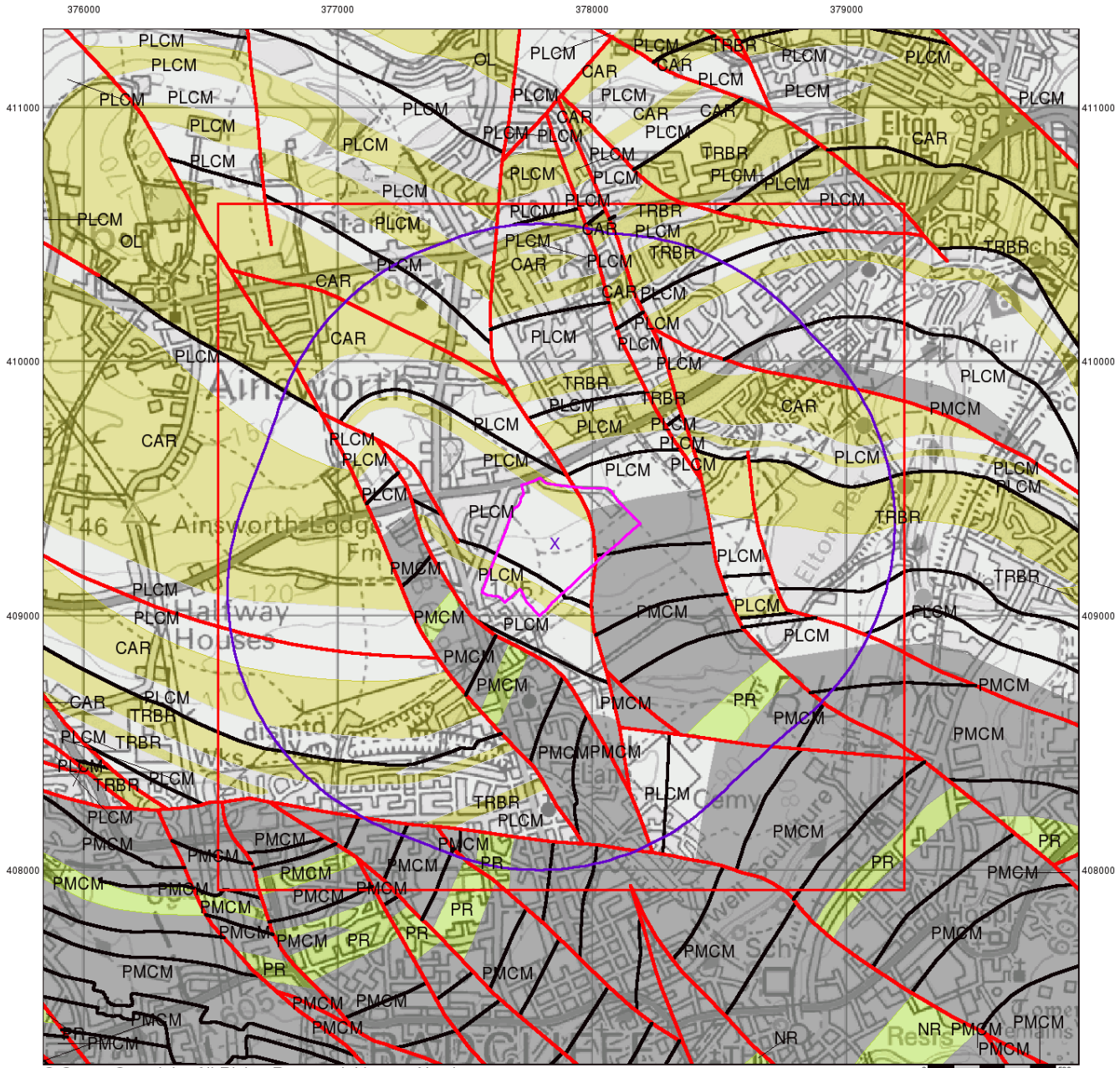
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



LK CONSULT LIMITED

Bedrock and Faults

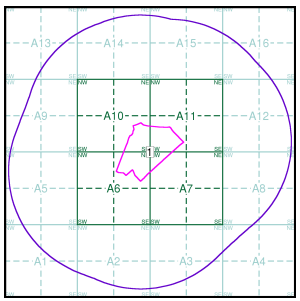
Bedrock geology is a term used for the main mass of rocks forming the Earth and are present everywhere, whether exposed at the surface in outcrops or concealed beneath superficial deposits or water.

The bedrock has formed over vast lengths of geological time ranging from ancient and highly altered rocks of the Proterozoic, some 2500 million years ago, or older, up to the relatively young Pliocene, 1.8 million years ago.

The bedrock geology includes many lithologies, often classified into three types based on origin: igneous, metamorphic and sedimentary.

The BGS Faults and Rock Segments dataset includes geological faults (e.g. normal, thrust), and thin beds mapped as lines (e.g. coal seam, gypsum bed). Some of these are linked to other particular 1:50,000 Geology datasets, for example, coal seams are part of the bedrock sequence, most faults and mineral veins primarily affect the bedrock but cut across the strata and post date its deposition.

Bedrock and Faults Map - Slice A



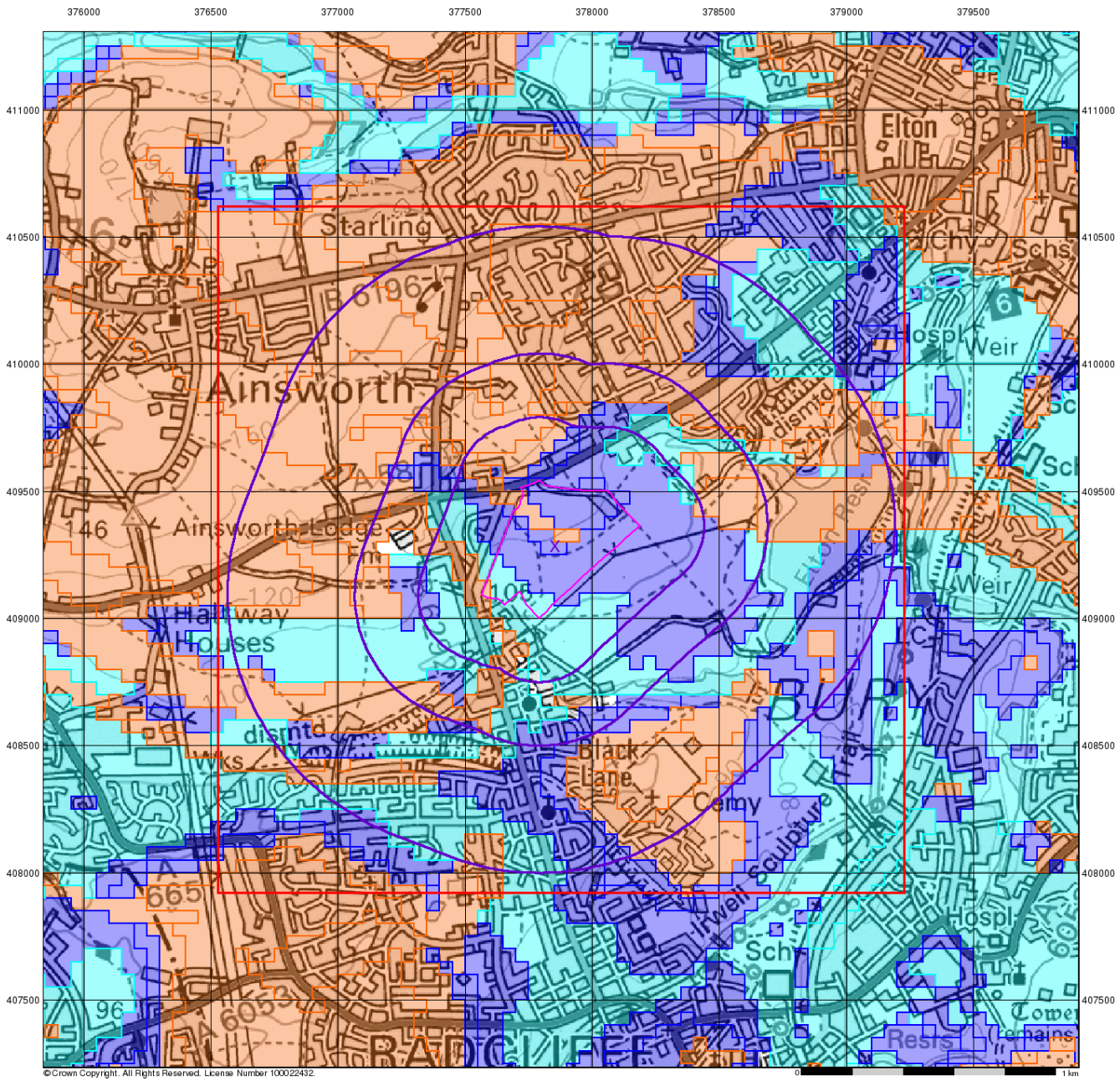
Order Details:

Order Number:	123188887_1_1
Customer Reference:	LKC 17 1140a
National Grid Reference:	377850, 409280
Slice:	A
Site Area (Ha):	18.57
Search Buffer (m):	1000

Site Details:

Site at 377877,409271

Landmark INFORMATION GROUP
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



LK CONSULT LIMITED

BGS Flood GFS Data

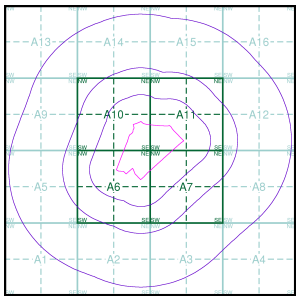
General

Specified Site
Specified Buffer(s)
Bearing Reference Point
Slice

Agency and Hydrological (Flood)

Limited Potential for Groundwater Flooding to Occur
Potential for Groundwater Flooding of Property Situated Below Ground Level
Potential for Groundwater Flooding to Occur at Surface

Site Sensitivity Context Map - Slice A



Order Details

Order Number:	123188887_1_1
Customer Ref:	LKC 17 1140a
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Slice:	A
Site Area (Ha):	18.57
Search Buffer (m):	1000

Site Details

Site at 377877,409271

Landmark INFORMATION GROUP
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk

Parcel B	
	**Photograph 8 (facing W):** Area of site in westernmost corner that falls towards the watercourse off site in 3rd party land.
	**Photograph 9 (facing NW):** Northwest boundary.
	**Photograph 10 (facing W):** Line of potential land drain from wet area.

	**Photograph 11 (facing E):** New track on southern boundary on top of former railway drain.
	**Photograph 12 (facing SW):** Ponds within existing hedge line on northeast boundary.
Parcel C	
	**Photograph 13 (facing N):** Area adjacent to the Canal embankment canal.

	**Photograph 14 (facing S):** Syphon headwall adjacent to the canal.
	**Photograph 15 (facing W):** Watercourse flowing through Parcel C backing up at headwall with marsh grass adjacent.
	**Photograph 16 (facing SW):** Raised canal bank trapping undrained water adjacent to the canal.

	**Photograph 17 (facing E):** Piped crossing of watercourse beneath the railway.
	**Photograph 18 (facing E):** Parcel C from western corner.
	**Photograph 19 (facing S):** Southern corner of Parcel C view towards canal embankment.

Parcel C1

Photograph 20 (facing W): Playing Fields between housing and garden centre.

Photograph 21 (facing N): Railway boundary Wrath Fold Road and western edge of the playing fields.

Photograph 22 (facing NE): Location of tie-in of proposed Link Road.

Parcel D

	**Photograph 23 (facing NW):** View towards northern corner from western boundary.
	**Photograph 24 (facing SW):** View towards eastern corner and canal from western boundary .
	**Photograph 25 (facing NW):** South eastern corner of Parcel D view towards cemetery area.

	**Photograph 26 (facing NE):** View along canal base from southern boundary.
	**Photograph 27 (facing W):** View across canal towards southern and western boundary.
	**Photograph 28 (facing S):** View of watercourse adjacent to former railway embankment in the SW corner.

Parcel E	
	**Photograph 29 (facing SW):** Northern area of Parcel E from former railway line.
	**Photograph 30 (facing S):** View of site central section of the parcel.
	**Photograph 31 (facing N):** View towards the northern boundary from the centre of the parcel.

	**Photograph 32 (facing SW):** View towards western boundary north of the access track.
	**Photograph 33 (facing NE):** View towards the eastern boundary.
	**Photograph 34 (facing E):** View along boundary with access track.

	**Photograph 35 (facing W):** View to west from eastern boundary.
	**Photograph 36 (facing SE):** View south of the access track.

Parcel F	
	**Photograph 37 (facing S):** View along the western boundary from railway line.
	**Photograph 38 (facing S):** View along line of the Aqueduct.
	**Photograph 39 (facing NW):** Ditch above line of the aqueduct with overflow to pond.

	**Photograph 40 (facing N):** View of pond adjacent to the aqueduct.
	**Photograph 41 (facing SE):** View of southeast of Parcel F.
	**Photograph 42 (facing S):** View along line of the aqueduct.

	**Photograph 43 (facing SW):** View from centre of the NW boundary adjacent to the former railway.
	**Photograph 44 (facing NE):** View along cycleway track with filter drain adjacent.
	**Photograph 45 (facing S):** View of pond adjacent to hedge line from cycleway.

	**Photograph 46 (facing SE):** View towards the southeast boundary.
	**Photograph 47 (facing N):** View of watercourse adjacent to eastern boundary.
	**Photograph 48 (facing N):** Outfall from parcel F towards the watercourse to the east.

	**Photograph 49 (facing NE):** Dip in the ground showing the route of the land drain within the plot.
	**Photograph 50 (facing N):** View of eastern edge of parcel F.
	**Photograph 51 (facing W):** Land drain outfall from Parcel F towards a pond on the southeast boundary.

	**Photograph 52 (facing W):** View of watercourse adjacent to the lower eastern boundary.
Parcel G	
	**Photograph 53 (facing SW):** Canal embankment raised above the low spot.
	**Photograph 54 (facing NE):** Canal embankment raised above the low spot.

	**Photograph 55 (facing NW):** Canal embankment raised above the flooded low spot.
	**Photograph 56 (facing NW):** Crow Nest Farm Brook downstream of Withins reservoir.

	**Photograph 57 (facing NW):** Central area of parcel G towards parcel D.
	**Photograph 58 (facing SE):** Overflow from Withins Reservoir. Head of Crow Tree Farm Brook.
	**Photograph 59 (facing NW):** Withins Reservoir adjacent to dam face.

	**Photograph 60 (facing N):** Crow Trees Farm Brook downstream of farm buildings.
	**Photograph 61 (facing N):** Headwall from land drain feeding tributary to Crow Trees Farm Brook.
	**Photograph 62 (facing N):** View of land to the north of the parcel.

		**Photograph 63 (facing SW):** View of land to the south of the parcel showing raised canal embankment.

APPENDIX C

ENVIRONMENT AGENCY DATA

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Mark Jones

From: GMMC Info Requests <Inforequests.gmmc@environment-agency.gov.uk>
Sent: 19 April 2018 10:25
To: Matthew Craig
Subject: GMMC82152AB Response attached from the Environment Agency
Attachments: GMMC82152AB_DFM.PDF; GMMC82152AB_P4..pdf; GMMC82152AB_RFO.PDF

Dear Matthew,

Thank you for your enquiry which was received on 6/4/18.

We respond to requests under the Freedom of Information Act 2000 and Environmental Information Regulations 2004.

I enclose the data requested. We recommend that you also contact United Utilities and Trafford Metropolitan District who may hold additional information (the former especially in relation to sewer flooding).

There are no flood defences within the vicinity of the site.

Please be aware you can check your risk of flooding on our external website https://flood-warning-information.service.gov.uk/long-term-flood-risk/

Please also note that all current EA flood risk strategy documents can be found on our external website https://www.gov.uk/guidance/flood-risk-assessment-local-planning-authorities and https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Please refer to the Open Government Licence which explains the permitted use of this information.

Please get in touch if you have any further queries or contact us within two months if you'd like us to review the information we have sent.

Kind regards,

Anne Ball
Customer and Engagement Officer
Greater Manchester, Merseyside and Cheshire
External: 020 302 51232
Mobile: 07769285094
Email: Inforequests.gmmc@environment-agency.gov.uk

Mark Jones

From: Matthew Craig
Sent: 25 July 2018 11:29
To: Mark Jones
Subject: FW: Ref 180717/GH10 GMMC82152AB - RE: 180413/EAS04 FW: FRA query - Radcliffe Road, Bury

---

From: GMMC Info Requests [mailto:Inforequests.gmmc@environment-agency.gov.uk]
Sent: 18 July 2018 11:00
To: Matthew Craig <m.craig@thelkgroup.com>
Subject: RE: Ref 180717/GH10 GMMC82152AB - RE: 180413/EAS04 FW: FRA query - Radcliffe Road, Bury

Dear Matthew,

Our officer has advised that Crow Trees Farm Brook has no model data associated with it.

The nearest model is the DRAFT Radcliffe and Redvales 2016 for the River Irwell (as previously supplied).

Please inform us if you require the River Irwell data for the area around the confluence with the Brook (roughly 870m from site boundary).

Kind regards,

Anne
Anne Ball - Customer and Engagement Officer
Greater Manchester, Merseyside and Cheshire
Direct line: 020 302 51232
Mobile: 07769285094
Direct email: **Inforequests.GMMC@environment-agency.gov.uk**
Office address: Richard Fairclough House, Knutsford Road, Latchford, Warrington, WA4 1HT

From: Enquiries, Unit
Sent: 17 July 2018 15:32
To: 'Matthew Craig' <m.craig@thelkgroup.com>
Subject: RE: Ref 180717/GH10 GMMC82152AB - RE: 180413/EAS04 FW: FRA query - Radcliffe Road, Bury

Dear Matthew

I have passed your e-mail to the local customer team who will deal with your request.

The Freedom of Information Act and Environmental Information Regulations state that a public authority must respond to requests for information within 20 working days, but we aim to respond to all enquiries as quickly as we can.

Kind Regards

Gary Hickey
Customer Service Adviser
National Customer Contact Centre - Part of National Operations Services

☎ Tel: 03708 506 506
Web Site: www.gov.uk/environment-agency

Click an icon to keep in touch with us:-

Detailed Flood Map centred on land at Radcliffe Road, Bury, BL8 2DF. Created 18 April 2018 [GMMC82152AB]

Environment Agency

1:20,500

N

Legend

- Site Location
- Model Measurements
- Main River
- Flood Zone 3
- Flood Zone 2

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 08708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

					Undefended									Defended								
Map Reference	Model Node Reference	Easting	Northing	Data	50 % AEP (1 in 2 year)	10 % AEP (1 in 10 year)	5 % AEP (1 in 20 year)	4 % AEP (1 in 25 year)	2 % AEP (1 in 50 year)	1.33 % AEP (1 in 75 year)	1 % AEP (1 in 100 year)	0.5 % AEP (1 in 200 year)	0.1 % AEP (1 in 1000 year)	50 % AEP (1 in 2 year)	10 % AEP (1 in 10 year)	5 % AEP (1 in 20 year)	4 % AEP (1 in 25 year)	2 % AEP (1 in 50 year)	1.33 % AEP (1 in 75 year)	1 % AEP (1 in 100 year)	0.5 % AEP (1 in 200 year)	0.1 % AEP (1 in 1000 year)
1	ea013_Model_IRWE05_1298	379521	410243	Modelled Water Level (m aodN)	75.17	75.51	75.64	75.67	75.80	75.88	75.93	76.07	76.68	75.17	75.51	75.63	75.67	75.80	75.88	75.93	76.07	76.69
				Modelled Flow (cumecs)	122.72	183.97	211.10	220.44	251.61	271.49	286.60	326.22	504.23	122.72	183.97	211.10	220.44	251.61	271.49	286.60	326.42	504.14
2	ea013_Model_IRWE05_0854	379456	409858	Modelled Water Level (m aodN)	73.28	73.91	74.13	74.19	74.40	74.52	74.61	74.82	75.58	73.32	73.96	74.16	74.23	74.43	74.54	74.62	74.81	75.58
				Modelled Flow (cumecs)	122.67	183.90	209.20	217.45	243.22	258.46	269.79	298.81	393.77	122.67	183.63	208.60	216.74	242.21	257.60	269.32	299.03	392.05
3	ea013_Model_IRWE05_0457	379414	409472	Modelled Water Level (m aodN)	72.27	72.54	72.69	72.74	72.89	72.98	73.04	73.20	73.87	72.43	72.87	72.94	72.95	73.00	73.06	73.10	73.19	73.99
				Modelled Flow (cumecs)	122.53	183.68	207.34	215.59	242.93	260.24	273.28	305.87	406.72	122.66	182.66	205.92	213.90	240.88	258.52	271.52	305.74	397.35
4	ea013_Model_IRWE05_0085	379333	409124	Modelled Water Level (m aodN)	71.81	72.13	72.39	72.49	72.68	72.78	72.86	73.04	73.68	71.79	72.04	72.11	72.16	72.35	72.46	72.58	72.81	73.91
				Modelled Flow (cumecs)	115.99	157.14	164.69	166.33	178.13	186.68	193.39	211.64	294.99	122.66	180.54	198.22	203.63	219.21	228.15	232.71	243.23	307.06

Model data taken from DRAFT Radcliffe & Redvales 2016*

AEP - Annual Exceedence Probability

m aodN - metres above ordnance datum Newlyn

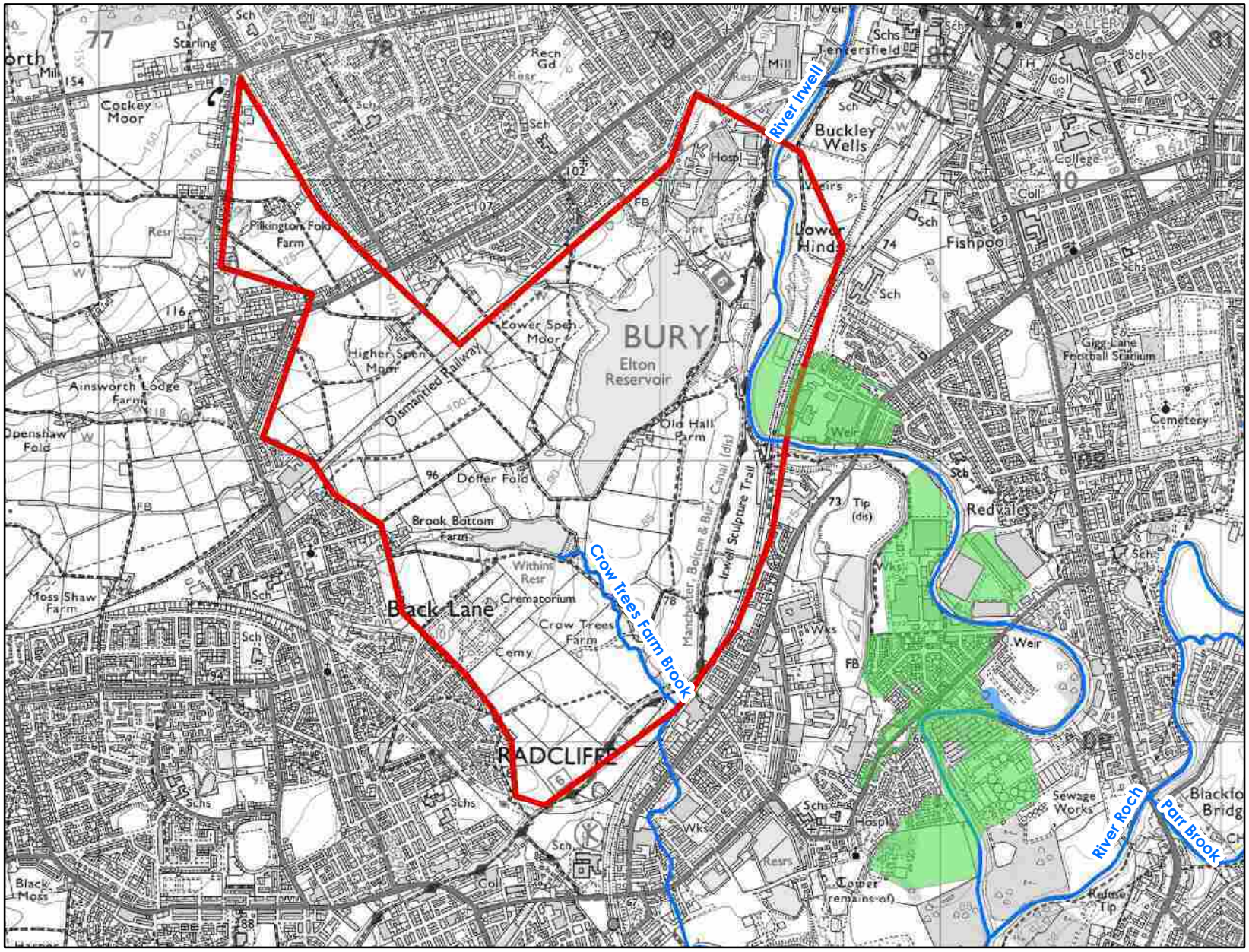
cumecs - cubic metres per second

Notes: Climate Change Scenario - We do not hold climate change measurements at this location. The new climate change guidance is available at https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances. The location of the site and the type (vulnerability) of development determine the climate change allowances to consider in any flood risk assessment.

Recorded Flood Outlines

Flood Event Code	Name	Start Date	End Date	Source of Flooding	Cause of Flooding
27105	22 June 2012 MorrisStreet	22/06/2012	22/06/2012	Main river	Channel capacity exceeded (no flood defences)
4079688	Radcliffe and Redvales	26/12/2015	26/12/2015	Main river	Channel capacity exceeded (no flood defences)

Recorded Flood Outline Map centred on land at Radcliffe Road, Bury, BL8 2DF. Created 18 April 2018 [GMMC82152AB]



Environment Agency

1:20,500

N

Legend

- Site Location
- Main River

Recorded Flood Outlines

Flood event code

- 27105
- 4079688

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 08708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Environment Agency

Flood map for planning

Your reference
Elton

Location (easting/northing)
378480/408337

Scale
1:10000

Created
3 Apr 2018 3:32

- Selected point
- Flood zone 3
- Flood zone 3: areas benefitting from flood defences
- Flood zone 2
- Flood zone 1
- Flood defence
- Main river
- Flood storage area

Project ref: ENVPAC/1/GMC/00155
System ref: SO/2019/119448/01-L01
Your ref: NICK GRAHAM

Date: 16 July 2019

Turley Associates
1 New York Street
Manchester
Lancashire
M1 4HD

Dear Sir/Madam

REVIEW OF FLOO RISK ASSESSMENT - LAND OFF VALE ROAD ADJACENT ELTON VALE RESERVOIR (PARKER'S LODGES) BURY LANCASHIRE

Thank you for accepting our offer to provide detailed planning advice. We have reviewed the following Flood Risk Assessment (FRA) by LK Consult (ref: FRA 18 1024 R1) dated Feb 2019, and would wish to make the following comments.

We are providing this advice under Agreement No. ENVPAC/1/GMC/00155. Please note we have taken 5 hours to review and provide our advice on these documents.

Environment Agency Advice

We would like to point out that since the Environment Agency's data response in appendix C (April 2018), detailed river modelling is now available in relation to Crow Trees Farm Brook. This includes results with climate change allowances added. Plus 30%, 35% and 70% results have been modelled, which relates to the latest published guidance for NW England catchments.

The sequential test and exception tests of the NPPF are referred to in section 2.2. The FRA identifies that parcels G & H are within flood zones 2 and 3. Parcel H is substantially within flood zone 3 and there appears little opportunity to develop this parcel without significantly impacting on flood risk. Parts of parcels C & D adjoining the Manchester, Bolton and Bury canal are within flood zone 2 and would also be affected when the impacts of climate change are considered. The LPA should consider whether development of these parcels is applicable having regard to the sequential test. If they are deemed appropriate there will need to be a sequential approach within the site to locate development in the lowest risk parts of the site whilst retaining flood storage to ensure risk is not increased elsewhere.

Section 4.1 states Crow Trees Farm Brook has only recently been designated “Main River”. However, the watercourse has been designated “Main River” for many years but has only recently been the subject of a detailed model assessment of flood risk.
Sections 4.2.2, 4.2.4 and 4.2.7 – Detailed modelling show the low parts of parcels C, D and G adjoining the MBB canal to be within flood zone 2. However, parts of the plots would also be affected during a 1% AEP plus climate change event. This suggests that during the lifetime of a residential development the risk would increase to “high”. Raising of floor levels and resilience may mitigate risk to the proposed development but could displace flood water elsewhere, which would not be acceptable. Avoiding development and ground levels, changes in the areas affected by fluvial risks would be the preferred option.

Section 4.2.8 - Detailed modelling shows a significant part of parcel H to be at high risk of fluvial flooding. The eastern part of the site appears wholly within the current flood zone 3. The impact of climate change will increase the risk and depths of flooding to this parcel. We recommend consideration be given to omitting parcel H from the allocation.

We recommend that the surface water drainage strategy be reviewed by the Lead Local Flood Authority (LLFA) as this is not directly within our remit. However, we note that discharge to watercourse appears to be the most likely/feasible option. Based on the potentially substantial volumes of run-off that would be generated, the impact of these volumes downstream must be considered. Crow Trees Farm Brook has existing areas of risk downstream and additional volumes of water, even at a controlled rate, could increase flooding. The watercourse downstream of Elton Reservoir may also have limited capacity to receive any discharges but the LLFA will be best placed to advise on this.

In terms of mitigation measures outlined in section 6, the FRA is not detailed enough to determine what is likely to be required at individual parcel level. The need for compensatory flood storage is not mentioned but is likely to be required if the proposals for parcels C, D, G & H do not avoid flood zones 2 and 3.

Reservoir risk associated with Elton Reservoir is referred to in section 3. We have not reviewed the specialist report (Report MCR 5780-RT003-R01) but we recommend that the Canal & Rivers Trust be consulted on these proposals. It is currently a category B reservoir assessed and regulated under the Reservoirs Act 1975. Development downstream of this reservoir will likely mean the category is upgraded to A at the next Section 10 Inspection, which will either be completed at the mandatory 10-yearly interval, or could be called early by the Reservoir Supervising Engineer based on them identifying downstream development as a reason to call for an early Inspection. This would mean the requirements for the spillway capacity of the reservoir will require review and potentially require significant upgrade works or construction of an auxiliary spillway. The provision of additional draw-down capacity would also need to be considered to comply with the Reservoirs Act 1975. The views of an All Reservoir Panel Engineer should be sought if development proposals are progressed.

It is not clear whether any recorded flood events have been considered as part of the FRA. Properties at Rigby Avenue, Withins Avenue and Blenmar Close have been flooded previously due to issues with the watercourse downstream of Elton Reservoir. This caused significant volumes of water to build up in parcel C between the MBB canal and metrolink line before flooding the properties.

Cont/d..

Next Steps

I hope the above advice is helpful. If there is any further work you anticipate needing our detailed advice on in relation to this project please let me know so it can be incorporated into this charging agreement.

Yours sincerely

Sylvia Whittingham
Sustainable Places Advisor

Disclaimer
Our opinion is based on the information available to us at the time of the enquiry. When the formal planning application is submitted, our position may change if there have been changes to environmental risk or evidence, and/or planning policy.

Yours faithfully

Mrs SYLVIA WHITTINGHAM
Planning Advisor

Direct dial 0203 0251059
Direct fax 01925 415961
Direct e-mail sylvia.whittingham@environment-agency.gov.uk

End

APPENDIX D

CONSULTEE CORRESPONDENCE

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Matthew Craig

From: Smith, Frances <F.Smith@bury.gov.uk>
Sent: 27 July 2018 16:31
To: Matthew Craig
Subject: FW: FRA query - land surrounding Elton Reservoir

Dear Mr Craig,

Apologies for the delay in getting back to you. Unfortunately we do not have any information which we can provide you with. United Utilities may be able to provide information in relation to the sewer network.

The Council's Local Flood Risk Management Strategy available here - https://www.bury.gov.uk/index.aspx?articleid=11001 - identifies the main areas in the Borough which suffer from surface water flooding based on historical evidence.

If you require any further information, please do not hesitate to contact me.

Regards

Fran

Fran Smith
Senior Planning Officer

Bury Council | Strategic Planning and Economic Development | Department for Resources and Regulation | 3 Knowsley Place | Duke Street | Bury | BL9 0EJ

Tel: 0161 253 7391 | Email: f.smith@bury.gov.uk

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From: Matthew Craig
Sent: 06 April 2018 11:58
To: 'PALocalities@bury.gov.uk'
Subject: FRA query - land surrounding Elton Reservoir

Mark Jones

From: Wiggins, David I <D.I.Wiggins@bury.gov.uk>
Sent: 10 December 2019 10:19
To: Nick Graham
Subject: Elton - Flood Risk

Hi Nick,

At our meeting last week, I promised to get back to you on flood risk matters. I've asked Fran to provide some comments and she has responded as follows:

- The assessment of the reservoir is bespoke to the Elton Res GMSF allocation. In addition, given that parts of the site are located within flood zones 2 and 3 the FRA must demonstrate the sequential and exception test or remove those parts of the site from the overall masterplan.

- All the GMSF sites in Bury have been asked to produce drainage strategies. The strategies need to consider the site as one and should not be split into individual parcels. In order to identify possible SuDs schemes, calculations of permeable areas and ground condition information will be required. UU will request that the drainage hierarchy is used when discharging surface water, with drainage to a combined sewer the last option. Sewer capacity is more of an immediate issue for the Walshaw site and new infrastructure will be required for the Northern Gateway sites. As such, more information in relation to drainage is likely to be required for these sites at this stage.

Hope this helps.

David Wiggins
Unit Manager (Development Planning)
Strategic Planning and Economic Development
Business Growth and Infrastructure
3 Knowsley Place | Duke Street | Bury | BL9 0EJ
T: 0161 253 5282 | E: d.i.wiggins@bury.gov.uk

For information on development planning in Bury click here

@buryplanning facebook.com/buryplanning

v.uk/index.aspx?articl
eid=14260

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Mark Jones

From: Dodd, Matthew <Matthew.Dodd@uuplc.co.uk>
Sent: 20 April 2018 14:16
To: Matthew Craig
Cc: Wastewater Developer Services
Subject: RE: GE1292 -: FRA query - land surrounding Elton Reservoir

Hi Matthew

United Utilities does not have any historic records of hydraulic flooding in the vicinity of the area shown.

Please note we do not hold information around flood defences or flooding from watercourses.

Kind regards

Matthew Dodd
Assistant Developer Engineer
Developer Services and Planning
Operational Services
United Utilities
T: 01925 679369 (internal 79369)
unitedutilities.com

From: Matthew Craig [mailto:m.craig@thelkgroup.com]
Sent: 06 April 2018 12:19
To: Wastewater Developer Services <WastewaterDeveloperServices@uuplc.co.uk>
Subject: RE: FRA query - land surrounding Elton Reservoir

Dear Sir/Madam,

Further to the below email, I have attached the site plan.

Kind regards
Matthew

From: Matthew Craig
Sent: 06 April 2018 11:53
To: 'wastewaterdeveloperservices@uuplc.co.uk'
Subject: FRA query - land surrounding Elton Reservoir

Dear Sir/Madam

LK Consult Ltd. has been commissioned to undertake a Flood Risk Assessment (FRA), of land surrounding Elton Reservoir, at Radcliffe Road, Bury, BL8 2DF.

Centred at approximate National Grid Reference 381577E, 404914N. The area of interest appears to be within Flood Zones 1, 2 and 3.

The wastewater development form is attached to this email, along with the site plan.

To complete the FRA we would be grateful if you could supply us with the following, if available, for the vicinity of the site

- Any existing sewer connections from buildings
- Levels of sewers
- Details of any flood defences in the immediate area, including their extent, crest levels (and datum), assumed level of standard, construction and maintenance regime, as well as any other structures which may influence the local hydraulics.
- Records of any historic flood events and potential sources of flooding from rivers, land drainage, groundwater, foul and surface water sewers on site and in the area.

If you have any queries please get in touch with me.

We are, of course, happy to pay your reasonable charge for this service. Please let me know by return what information is available and what the charge will be and we will pay the relevant fees by debit card as soon as possible.

Any advice or recommendations you may have regarding the potential discharges from the development of this site?

We will be in contact with all other relevant authorities to get a more complete understanding of the issues in the area.

Regards

Matthew Craig

LK GROUP

Matthew Craig
Environmental Scientist
LK Consult | 0161 763 7200 |
Manchester | Liverpool | Glasgow | www.thelkgroup.com

INCREASING LAND VALUE

Mark Jones

From: Harrison, William <William.Harrison1@uuplc.co.uk>
Sent: 17 April 2018 09:33
To: Matthew Craig
Cc: Wastewater Developer Services
Subject: PDE 4200020478: Land at Radcliffe Road, Bury

Good Morning Matthew,

- Any existing sewer connections from buildings

  As the proposed development area is of considerable scale there are many domestic connections at various points to the public sewerage network
- Levels of sewers

  We don't currently have this information on the sewer records, I advise in conjunction to obtaining a copy of the sewer records carrying out thorough SI to determine any existing levels.
- Details of any flood defences in the immediate area, including their extent, crest levels (and datum), assumed level of standard, construction and maintenance regime, as well as any other structures which may influence the local hydraulics.

  From a waste water point of view we don't have any flood defences, contacting my colleague on clean water at developerservices@uuplc.co.uk, and then the EA may be able to provide further information.
- Records of any historic flood events and potential sources of flooding from rivers, land drainage, groundwater, foul and surface water sewers on site and in the area.

  We have no recorded episodes of flooding in the area from public sewers,

If you need a copy of the sewer records please visit our Property Searches team at https://www.unitedutilities.com/services/wholesale-services/property-searches/ would can provide you with a copy of the sewer records,

Kind Regards,

Will Harrison BSc (Hons)
Assistant Developer Engineer
Developer Services & Planning
Operational Services
United Utilities

T : 01925 679319
E : Wastewaterdeveloperservices@uuplc.co.uk

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United Utilities Water Ltd. - Developer Services and Planning
Warrington North Wastewater Treatment Works

Barnard Street Off Old Liverpool Road
Gatewarth Industrial Estate
Warrington
WA5 1DS

From: Matthew Craig [mailto:m.craig@thelkgroup.com]
Sent: 06 April 2018 11:53
To: Wastewater Developer Services <WastewaterDeveloperServices@uuplc.co.uk>
Subject: FRA query - land surrounding Elton Reservoir

Dear Sir/Madam

LK Consult Ltd. has been commissioned to undertake a Flood Risk Assessment (FRA), of land surrounding Elton Reservoir, at Radcliffe Road, Bury, BL8 2DF.

Centred at approximate National Grid Reference 381577E, 404914N. The area of interest appears to be within Flood Zones 1, 2 and 3.

The wastewater development form is attached to this email, along with the site plan.

To complete the FRA we would be grateful if you could supply us with the following, if available, for the vicinity of the site

- Any existing sewer connections from buildings
- Levels of sewers
- Details of any flood defences in the immediate area, including their extent, crest levels (and datum), assumed level of standard, construction and maintenance regime, as well as any other structures which may influence the local hydraulics.
- Records of any historic flood events and potential sources of flooding from rivers, land drainage, groundwater, foul and surface water sewers on site and in the area.

If you have any queries please get in touch with me.

We are, of course, happy to pay your reasonable charge for this service. Please let me know by return what information is available and what the charge will be and we will pay the relevant fees by debit card as soon as possible.

Any advice or recommendations you may have regarding the potential discharges from the development of this site?

We will be in contact with all other relevant authorities to get a more complete understanding of the issues in the area.

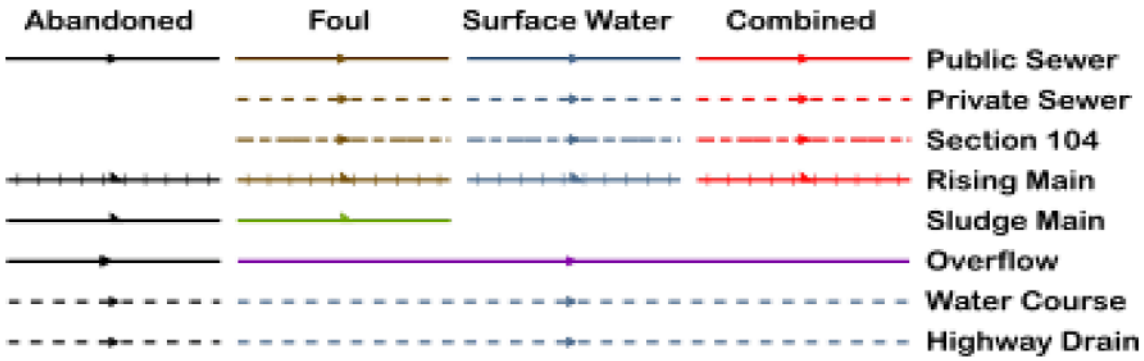
Regards

Matthew Craig

LK GROUP

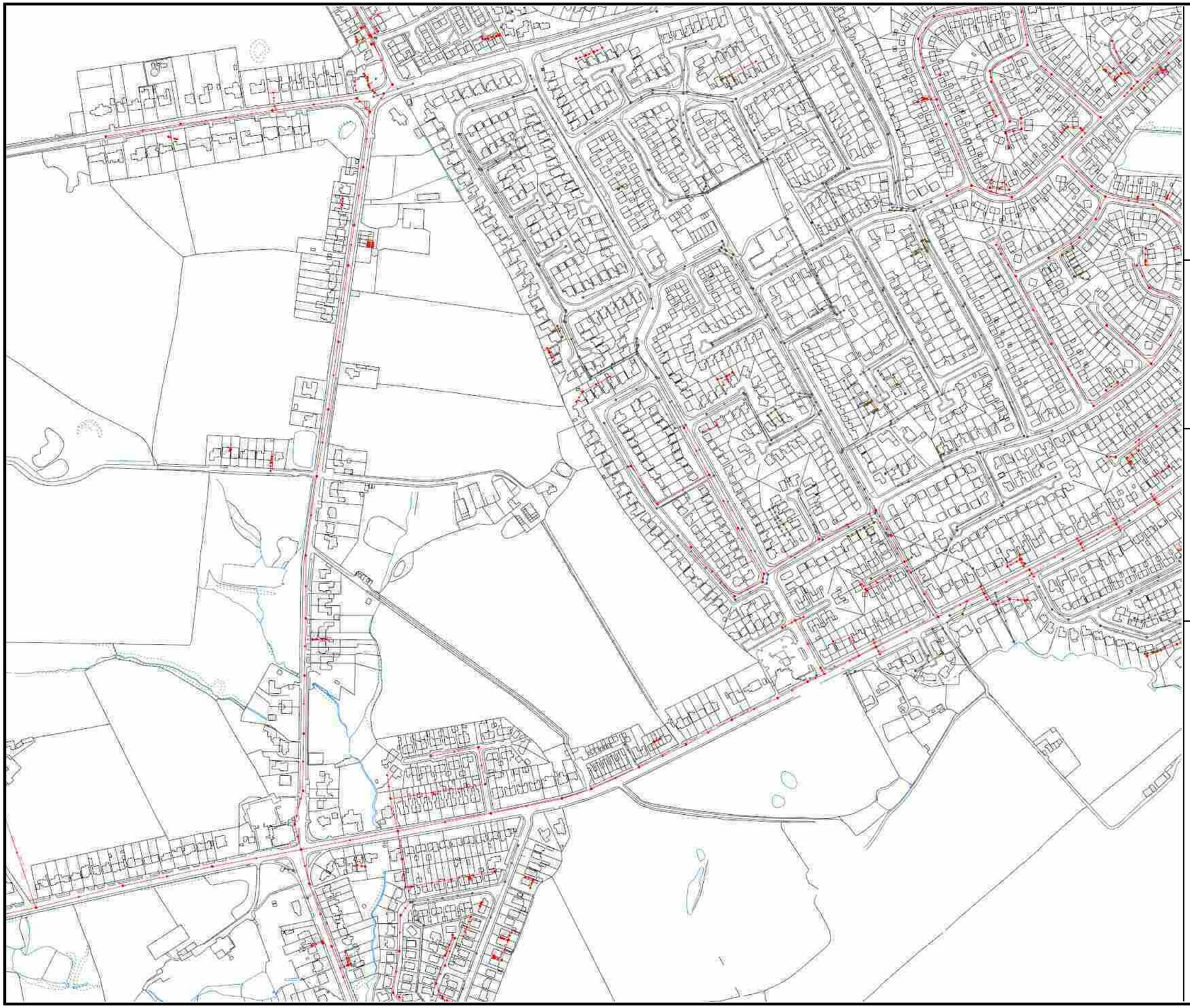
Matthew Craig
Environmental Scientist
LK Consult | 0161 763 7200 |
Manchester | Liverpool | Glasgow | www.thelkgroup.com

Wastewater Symbology



All point assets follow the standard colour convention: red – combined, brown - foul, blue – surface water, purple - overflow

- Manhole
- HS Head of System
- ES Extent of Survey
- RE Rodding Eye
- IN Inlet
- DP Discharge Point
- HY Vortex
- PE Penstock
- WO Washout Chamber
- VA Valve
- AV Air Valve
- NRV Non Return Valve
- SO Soakaway
- GU Gully
- CA Cascade
- FM Flow Meter
- HA Hatch Box
- OI Oil Interceptor
- SM Summit
- DS Drop Shaft
- OP Orifice Plate
- Side Entry Manhole
- Outfall
- Screen Chamber
- IC Inspection Chamber
- Bifurcation Chamber
- LH Lamp Hole
- T Junction / Saddle
- CA Catchpit
- VC Valve Chamber
- Vent Column
- Vortex Chamber
- Penstock Chamber
- T Network Storage Tank
- V Sewer Overflow
- WwTW Ww Treatment Works
- Ww Pumping Station
- ST Septic Tank
- CK Control Kiosk
- Change of Characteristic



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SEWER RECORDS

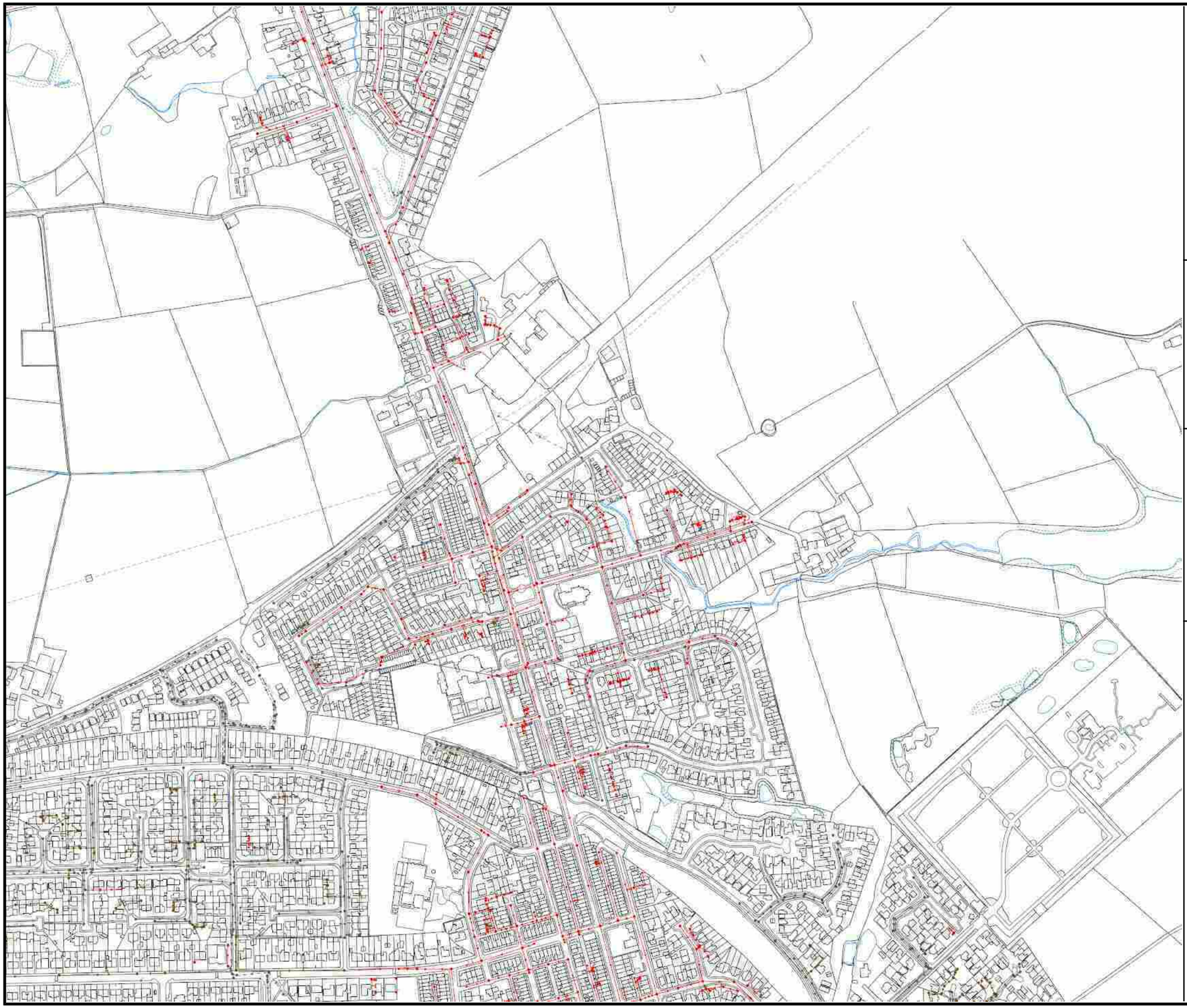
Address or Site Reference

Elton Reservoir_01,

Scale: 1:5000
Date: 17/04/2018

Printed by: Property Searches

The position of the underground apparatus shown on this plan is approximate only and is given in accordance with the best information currently available. United Utilities Water will not accept liability for any loss or damage caused by the actual position being different from those shown.



SEWER RECORDS

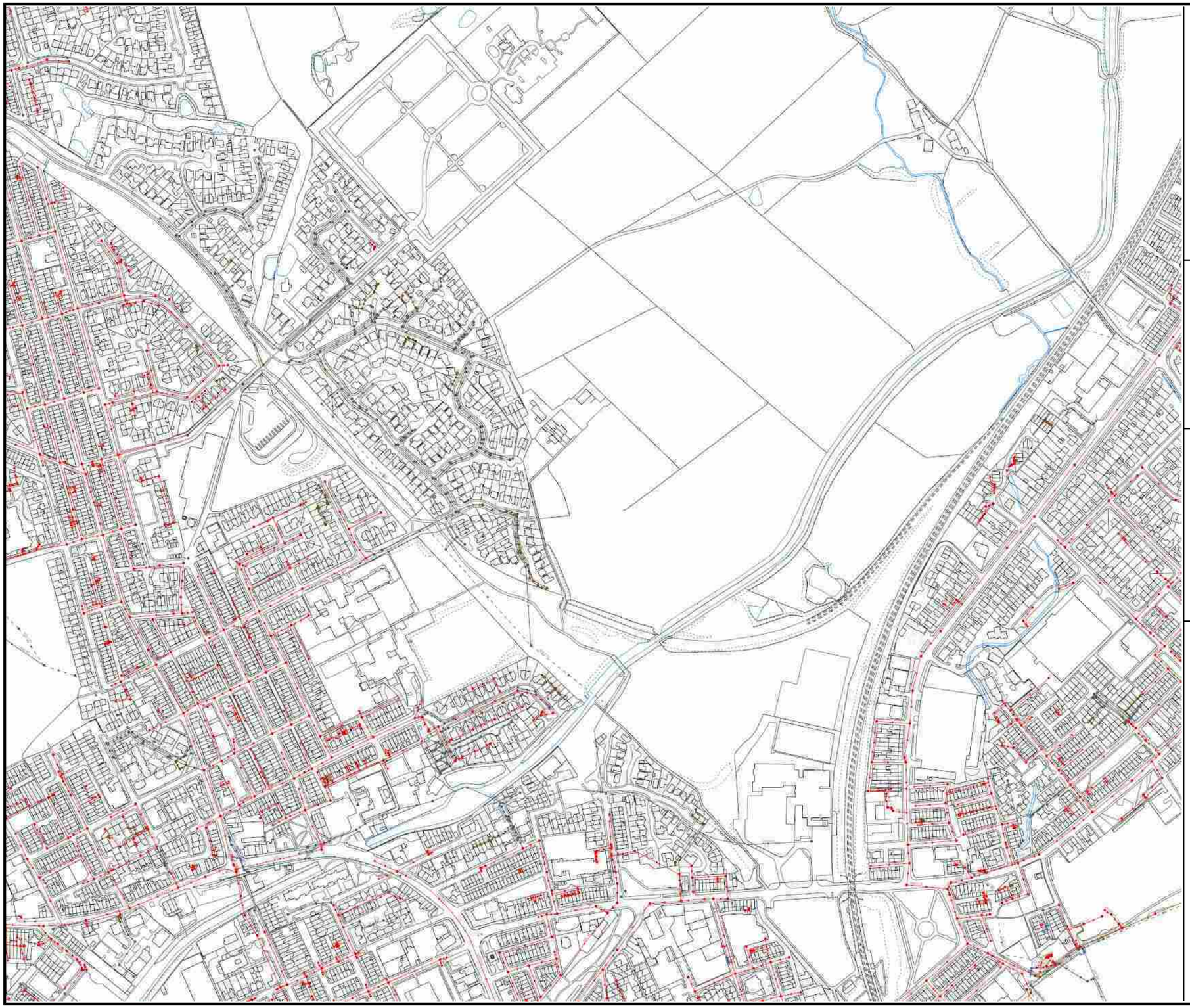
Address or Site Reference

Elton Reservoir 02,

Scale: 1:5000
Date: 17/04/2018

Printed by: Property Searches

The position of the underground apparatus shown on this plan is approximate only and is given in accordance with the best information currently available. United Utilities Water will not accept liability for any loss or damage caused by the actual position being different from those shown.



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SEWER RECORDS

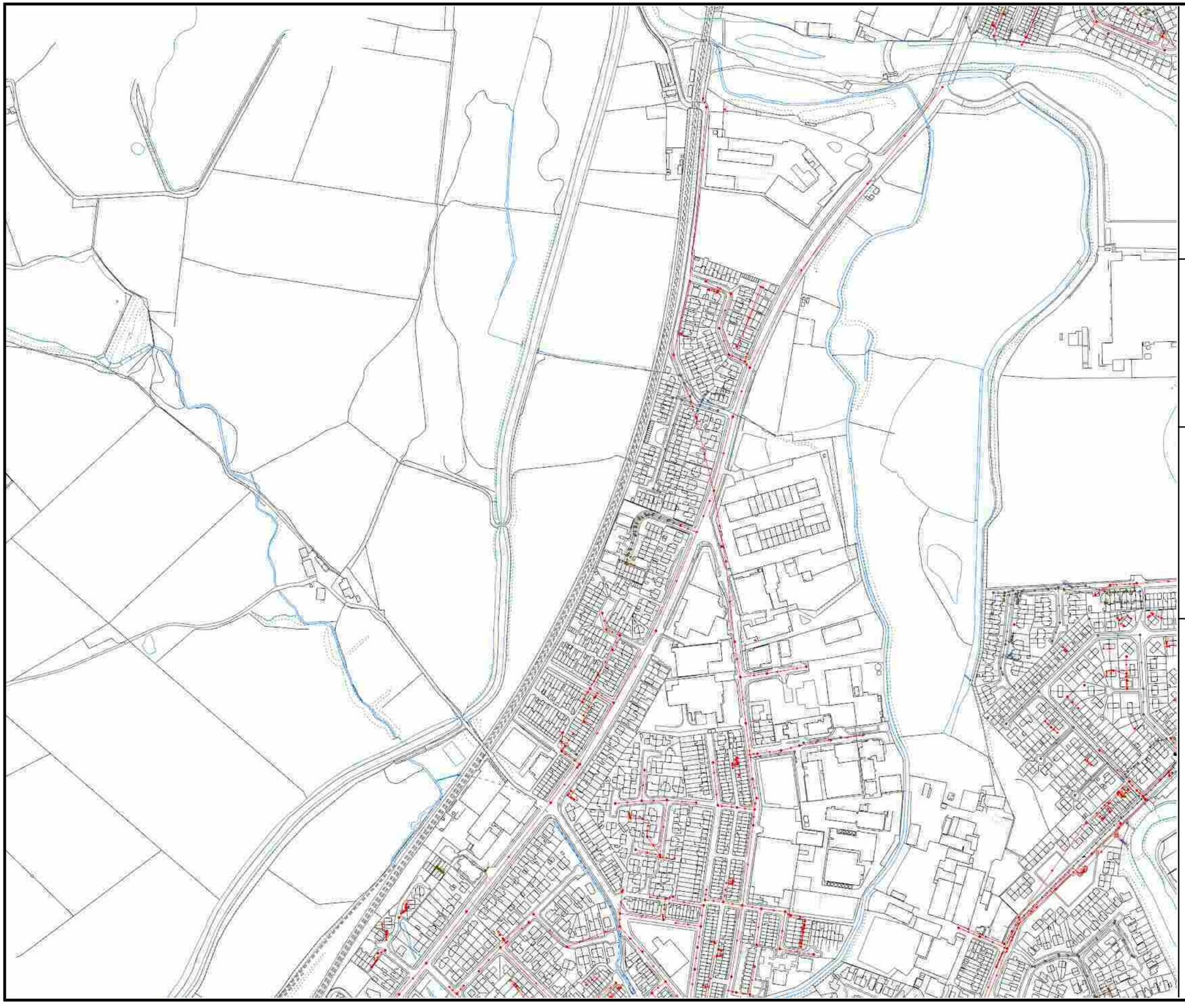
Address or Site Reference

Elton Reservoir 03,

Scale: 1:5000
Date: 17/04/2018

Printed by: Property Searches

The position of the underground apparatus shown on this plan is approximate only and is given in accordance with the best information currently available. United Utilities Water will not accept liability for any loss or damage caused by the actual position being different from those shown.



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SEWER RECORDS

Address or Site Reference

Elton Reservoir 04,

Scale: 1:5000
Date: 17/04/2018

Printed by: Property Searches

The position of the underground apparatus shown on this plan is approximate only and is given in accordance with the best information currently available. United Utilities Water will not accept liability for any loss or damage caused by the actual position being different from those shown.

SEWER RECORDS

Address or Site Reference

Elton Reservoir 05,

Scale: 1:5000
Date: 17/04/2018

Printed by: Property Searches

The position of the underground apparatus shown on this plan is approximate only and is given in accordance with the best information currently available. United Utilities Water will not accept liability for any loss or damage caused by the actual position being different from those shown.

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SEWER RECORDS

Address or Site Reference

Elton Reservoir 06,

Scale: 1:5000
Date: 18/04/2018

Printed by: Property Searches

The position of the underground apparatus shown on this plan is approximate only and is given in accordance with the best information currently available. United Utilities Water will not accept liability for any loss or damage caused by the actual position being different from those shown.

APPENDIX E

CALCULATIONS

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MasterDrain
HY 9.36

The LK Group

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Tel: 0161 763 7200
email: m.jones@thelkgroup.com

Job No.			
Sheet no.	1		
Date	31/07/18		
Project	Parcel B	By	Checked / Reviewed
Title	IoH 124 Runoff calcs for Radcliffe		

Hydrological Data:-

FSR Hydrology:-

Location = Radcliffe — Grid reference = SD7808
M5-60 (mm) = 18.9 — r = 0.32
Soil runoff = 0.45 — SAAR (mm/yr) = 1100
WRAP = 4 — Area = England & Wales
Hydrological area = 10 — Hydrological zone = 7

Soil classification for WRAP type 4
Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Design data:-

Area = 0.134 Km² - 13.4 Ha - 134000 m²

Calculation method:-

Runoff is calculated from:-

$$Q_{BAR(rural)} = 0.00108\ AREA^{0.89}\ .\ SAAR^{1.17}\ .\ SOIL^{2.17}$$

where

AREA = Site area in Km²
SAAR = Standard Average Annual Rainfall (mm/yr)
SOIL = Soil value derived from Winter Rainfall Acceptance Potential
$Q_{BAR(rural)}$ = Runoff (cumecs)

$Q_{BAR(rural)}$ is then multiplied by a growth factor - GC(T) - for different storm return periods derived from EA publication W5-074/A.

Calculated data:-

For areas less than 50Ha, a modified calculation which multiplies the 50Ha runoff value by the ratio of the site area to 50Ha is used
Reducing factor used for these calculations is 0.268

Mean Annual Peak Flow $Q_{BAR(rural)}$ = 99.89 l/s

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Job No.	
Sheet no.	2
Date	31/07/18

By	Checked	Reviewed

MasterDrain
HY 9.36

Project **Parcel B**

Title **IoH 124 Runoff calcs for Radcliffe**

Values for $Q_{BAR(rural)}$

Ret. per.	m³/hr	l/s	l/s/ha	Ret. per.	m³/hr	l/s	l/s/ha
1yr	305.678	84.910	6.337	100yr	755.204	209.779	15.655
2yr	334.447	92.902	6.933	100yr+20%	906.244	251.735	18.786
5yr	435.141	120.873	9.020	100yr+30%	981.765	272.712	20.352
10yr	496.277	137.855	10.288	200yr	863.090	239.747	17.892
30yr	604.163	167.823	12.524	200yr + 30%	1122.017	311.671	23.259
50yr	665.298	184.805	13.791	500yr	981.765	272.712	20.352
				1000yr	1093.247	303.680	22.663

Growth factors -

1yr	2yr	5yr	10yr	30yr	50yr	100yr	200yr	500yr	1000yr
0.85	0.93	1.21	1.38	1.68	1.85	2.10	2.40	2.73	3.04

The above is based on the Institute of Hydrology Report 124
to which you are referred for further details (see Sect 7).
Note that the 200 and above year growth curves were taken from W5-074.

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Job No.			
Sheet no.	1		
Date	01/08/18		
Project	30yr Parcel B	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil index	= 0.45	SAAR (mm/yr)	= 1100
Return period	= 30	WRAP	= 4
UCWI	= 113.8	Climate change	= 0

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 45.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 73700 m²	Pervious area	= 60300 m²
Total area (TA)	= 134000 m²	Equiv area	= 60300 m² (TA x RF).
Allowed discharge rate	= 167.820 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s	Climate change factor	= 0

Calculated data:-

Time to max	= 61.0 mins	Calculated storage volume	= 1149.5 m³
Rainfall at max	= 28.77 mm/hr	Allowed discharge rate	= 167.820 l/s
Pipeline storage	= 0.0 m³	Available MH storage	= 0.0 m³
Offline storage	= 0.0 m³		

Fixed 6 hour data:-

Rainfall event	= 6 hours	Calculated storage volume	= 0.0 m³
Rainfall rate	= 8.00 mm/hr	Allowed discharge rate	= 167.820 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	146382.2	1125	1156.6
150	65058.8	1200	1016.5
225	28915.0	1275	900.5
300	16264.7	1350	803.2
375	10409.4	1425	720.9
450	7228.8	1500	650.6
525	5310.9	1575	590.1
600	4066.2	1650	537.7
675	3212.8	1725	491.9
750	2602.4	1800	451.8
825	2150.7	1875	416.4
900	1807.2	1950	385.0
975	1539.9	2025	357.0
1050	1327.7	2100	331.9

Ovoid	Len
400 x 600	6385.9
600 x 900	2780.5
800 x 1200	1563.8

Box culvert	Len
500 x 500	4597.9
500 x 750	3065.2
500 x 1000	2298.9
750 x 1000	1532.6
750 x 1200	1277.2
750 x 1500	1021.7
1000 x 1000	1149.5
1000 x 1200	957.9
1000 x 1500	766.3
1000 x 1800	638.6
1000 x 2000	574.7
1500 x 1500	510.9
1500 x 1800	425.7
1500 x 2000	383.2

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Job No.	
Sheet no.	2
Date	01/08/18

MasterDrain SW

Project	30yr Parcel B	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	81.0	815.397	100.692	714.705
20	57.0	1141.300	201.384	939.916
30	45.0	1352.732	302.076	1050.656
40	38.0	1512.858	402.768	1110.090
50	33.0	1643.082	503.460	1139.622
60	29.0	1753.497	604.152	1149.345
70	26.0	1849.706	704.844	1144.862
80	24.0	1935.164	805.536	1129.628
90	22.0	2012.160	906.228	1105.932
100	21.0	2082.297	1006.920	1075.377
110	19.0	2146.745	1107.612	1039.133
120	18.0	2206.386	1208.304	998.082
130	17.0	2261.902	1308.996	952.906
140	16.0	2313.834	1409.688	904.146
150	16.0	2362.618	1510.380	852.238
160	15.0	2408.612	1611.072	797.540
170	14.0	2452.113	1711.764	740.349
180	14.0	2493.370	1812.456	680.914
190	13.0	2532.596	1913.148	619.448
200	13.0	2569.974	2013.840	556.134
210	12.0	2605.660	2114.532	491.128
220	12.0	2639.793	2215.224	424.569
230	12.0	2672.492	2315.916	356.576
240	11.0	2703.865	2416.608	287.256
250	11.0	2734.004	2517.300	216.704
260	11.0	2765.003	2617.992	147.011
270	10.0	2794.677	2718.684	75.993
280	10.0	2823.513	2819.376	4.137
290	10.0	2851.561	2920.068	0.000
300	10.0	2878.872	3020.760	0.000
310	9.0	2905.487	3121.452	0.000
320	9.0	2931.446	3222.144	0.000
330	9.0	2956.785	3322.836	0.000
340	9.0	2981.538	3423.528	0.000
350	9.0	3005.734	3524.220	0.000
360	8.0	3029.403	3624.912	0.000
370	8.0	3052.568	3725.604	0.000
380	8.0	3075.255	3826.296	0.000
390	8.0	3097.486	3926.988	0.000
400	8.0	3119.281	4027.680	0.000
410	8.0	3140.659	4128.372	0.000
420	7.0	3161.639	4229.064	0.000
430	7.0	3182.236	4329.756	0.000
440	7.0	3202.467	4430.448	0.000
450	7.0	3222.346	4531.140	0.000
460	7.0	3241.887	4631.832	0.000
470	7.0	3261.104	4732.524	0.000
480	7.0	3280.006	4833.216	0.000
490	7.0	3298.608	4933.908	0.000
500	7.0	3316.919	5034.600	0.000
510	7.0	3334.949	5135.292	0.000
520	6.0	3352.709	5235.984	0.000
530	6.0	3370.207	5336.676	0.000
540	6.0	3387.452	5437.368	0.000
550	6.0	3404.452	5538.060	0.000
560	6.0	3421.216	5638.752	0.000
570	6.0	3437.750	5739.444	0.000
580	6.0	3454.062	5840.136	0.000
590	6.0	3470.158	5940.828	0.000
600	6.0	3486.045	6041.521	0.000

Storage volume (m^3) = 1149.5 m^3

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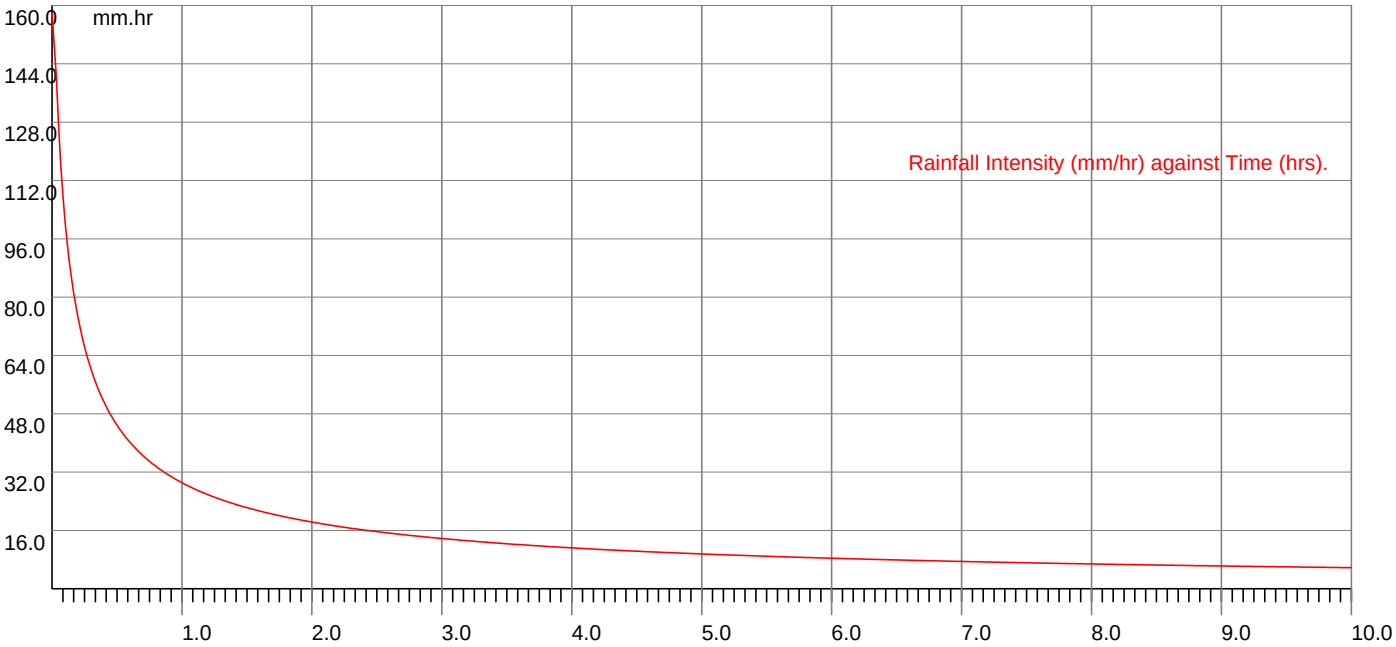
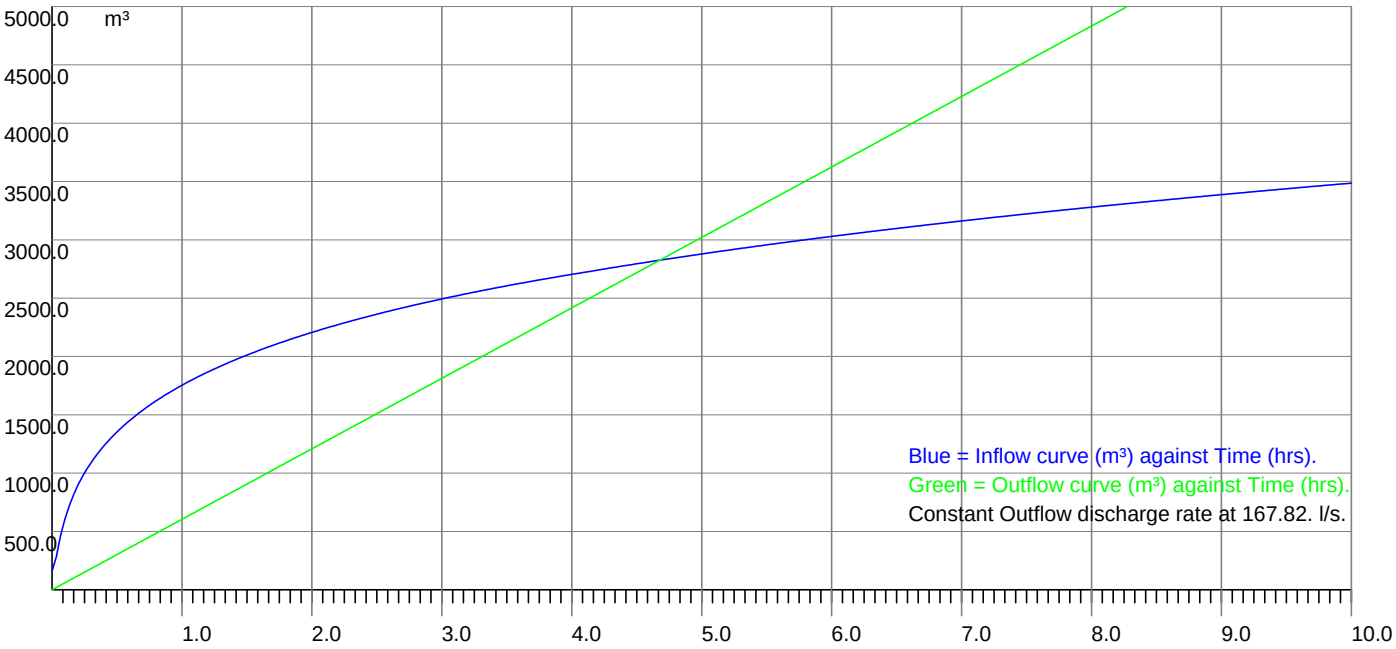
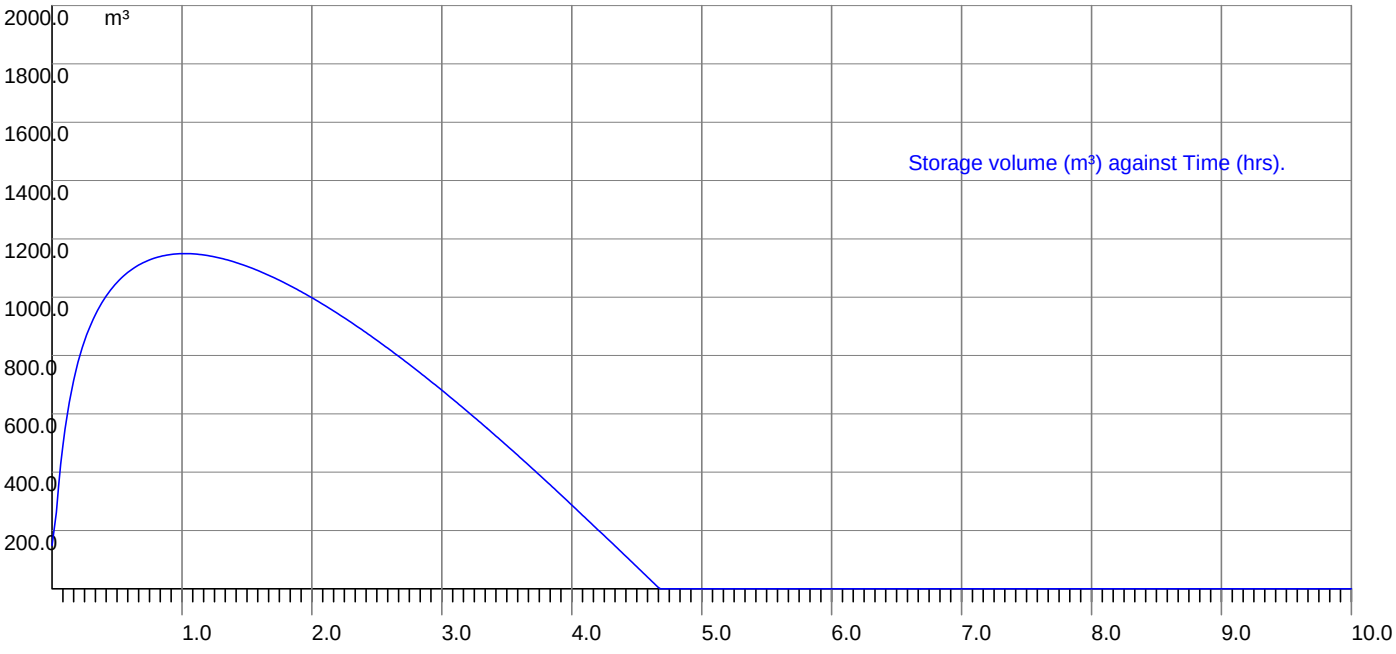
Job No.	
Sheet no.	3
Date	01/08/18

MasterDrain SW

Project	30yr Parcel B	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		







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Tel: 0161 763 7200
email: m.jones@thelkgroup.com

Job No.			
Sheet no.	1		
Date	01/08/18		
Project	100yr+20% Parcel B	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil index	= 0.45	SAAR (mm/yr)	= 1100
Return period	= 100	WRAP	= 4
UCWI	= 113.8	Climate change	= 20

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 45.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 73700 m²	Pervious area	= 60300 m²
Total area (TA)	= 134000 m²	Equiv area	= 60300 m² (TA x RF).
Allowed discharge rate	= 209.780 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s	Climate change factor	= 20

Calculated data:-

Time to max	= 82.0 mins	Calculated storage volume	= 2047.5 m³
Rainfall at max	= 37.37 mm/hr	Allowed discharge rate	= 209.780 l/s
Pipeline storage	= 0.0 m³	Available MH storage	= 0.0 m³
Offline storage	= 0.0 m³		

Fixed 6 hour data:-

Rainfall event	= 6 hours	Calculated storage volume	= 78.4 m³
Rainfall rate	= 13.00 mm/hr	Allowed discharge rate	= 209.780 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	260746.0	1125	2060.2
150	115887.1	1200	1810.7
225	51505.4	1275	1604.0
300	28971.8	1350	1430.7
375	18541.9	1425	1284.1
450	12876.3	1500	1158.9
525	9460.2	1575	1051.1
600	7242.9	1650	957.7
675	5722.8	1725	876.3
750	4635.5	1800	804.8
825	3831.0	1875	741.7
900	3219.1	1950	685.7
975	2742.9	2025	635.9
1050	2365.0	2100	591.3

Ovoid	Len
400 x 600	11375.0
600 x 900	4952.9
800 x 1200	2785.6

Box culvert	Len
500 x 500	8190.0
500 x 750	5460.0
500 x 1000	4095.0
750 x 1000	2730.0
750 x 1200	2275.0
750 x 1500	1820.0
1000 x 1000	2047.5
1000 x 1200	1706.3
1000 x 1500	1365.0
1000 x 1800	1137.5
1000 x 2000	1023.8
1500 x 1500	910.0
1500 x 1800	758.3
1500 x 2000	682.5

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Job No.	
Sheet no.	2
Date	01/08/18

MasterDrain SW

Project	100yr+20% Parcel B	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	125.0	1252.534	125.868	1126.666
20	88.0	1777.202	251.736	1525.466
30	70.0	2118.512	377.604	1740.908
40	59.0	2377.110	503.472	1873.638
50	51.0	2586.978	629.340	1957.638
60	46.0	2764.316	755.208	2009.108
70	41.0	2918.186	881.076	2037.110
80	38.0	3054.210	1006.944	2047.266
90	35.0	3176.134	1132.812	2043.322
100	33.0	3286.591	1258.680	2027.911
110	31.0	3387.510	1384.548	2002.963
120	29.0	3480.351	1510.416	1969.935
130	27.0	3566.246	1636.284	1929.962
140	26.0	3646.097	1762.152	1883.945
150	25.0	3720.631	1888.020	1832.611
160	24.0	3790.448	2013.888	1776.560
170	23.0	3856.045	2139.756	1716.289
180	22.0	3917.842	2265.624	1652.218
190	21.0	3976.198	2391.492	1584.706
200	20.0	4031.419	2517.360	1514.059
210	19.0	4083.772	2643.228	1440.544
220	19.0	4133.490	2769.096	1364.394
230	18.0	4180.776	2894.964	1285.812
240	18.0	4225.812	3020.832	1204.980
250	17.0	4268.758	3146.700	1122.058
260	17.0	4314.874	3272.568	1042.306
270	16.0	4358.522	3398.436	960.086
280	16.0	4400.884	3524.304	876.580
290	15.0	4442.039	3650.172	791.867
300	15.0	4482.062	3776.040	706.022
310	15.0	4521.021	3901.908	619.114
320	14.0	4558.978	4027.776	531.202
330	14.0	4595.987	4153.644	442.343
340	14.0	4632.101	4279.512	352.589
350	13.0	4667.366	4405.380	261.986
360	13.0	4701.825	4531.248	170.577
370	13.0	4735.518	4657.116	78.402
380	12.0	4768.482	4782.984	0.000
390	12.0	4800.753	4908.852	0.000
400	12.0	4832.361	5034.720	0.000
410	12.0	4863.335	5160.588	0.000
420	12.0	4893.704	5286.456	0.000
430	11.0	4923.493	5412.324	0.000
440	11.0	4952.726	5538.192	0.000
450	11.0	4981.426	5664.060	0.000
460	11.0	5009.614	5789.928	0.000
470	11.0	5037.310	5915.796	0.000
480	10.0	5064.532	6041.664	0.000
490	10.0	5091.298	6167.532	0.000
500	10.0	5117.625	6293.400	0.000
510	10.0	5143.529	6419.268	0.000
520	10.0	5169.022	6545.136	0.000
530	10.0	5194.123	6671.004	0.000
540	10.0	5218.841	6796.872	0.000
550	9.0	5243.191	6922.740	0.000
560	9.0	5267.184	7048.608	0.000
570	9.0	5290.831	7174.476	0.000
580	9.0	5314.143	7300.344	0.000
590	9.0	5337.132	7426.212	0.000
600	9.0	5359.805	7552.080	0.000

Storage volume (m^3) = 2047.5 m^3

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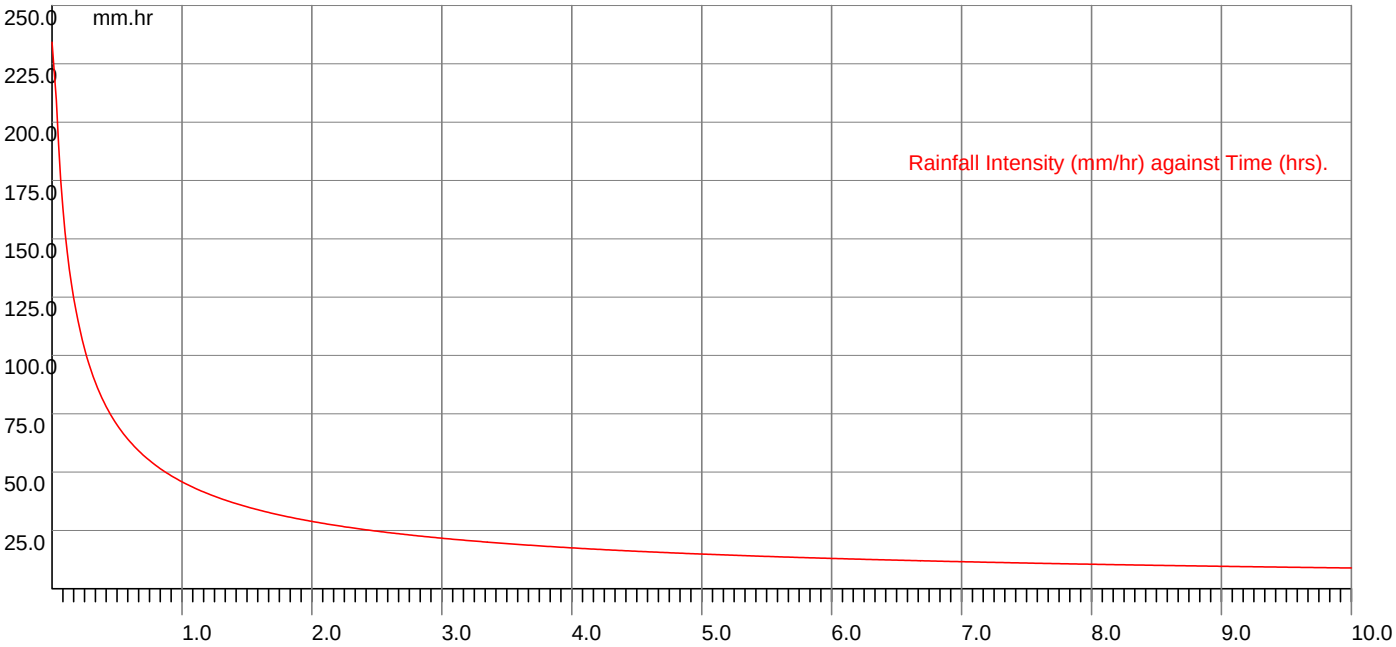
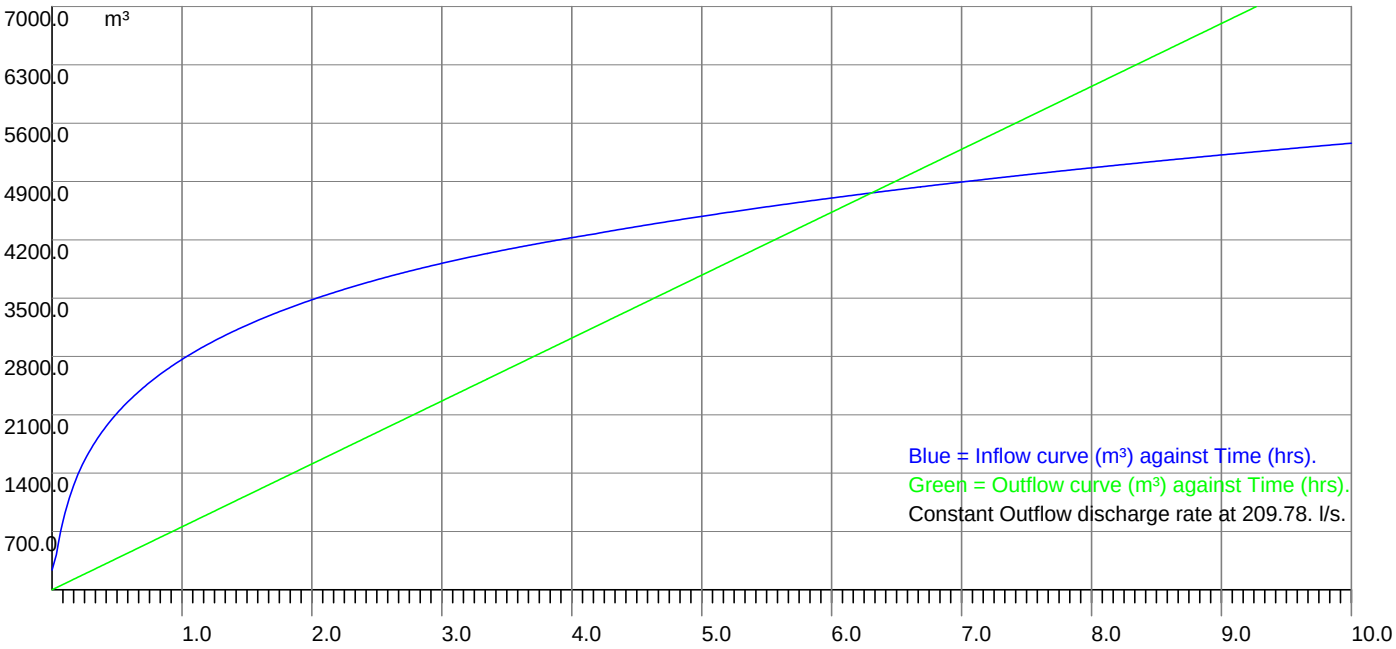
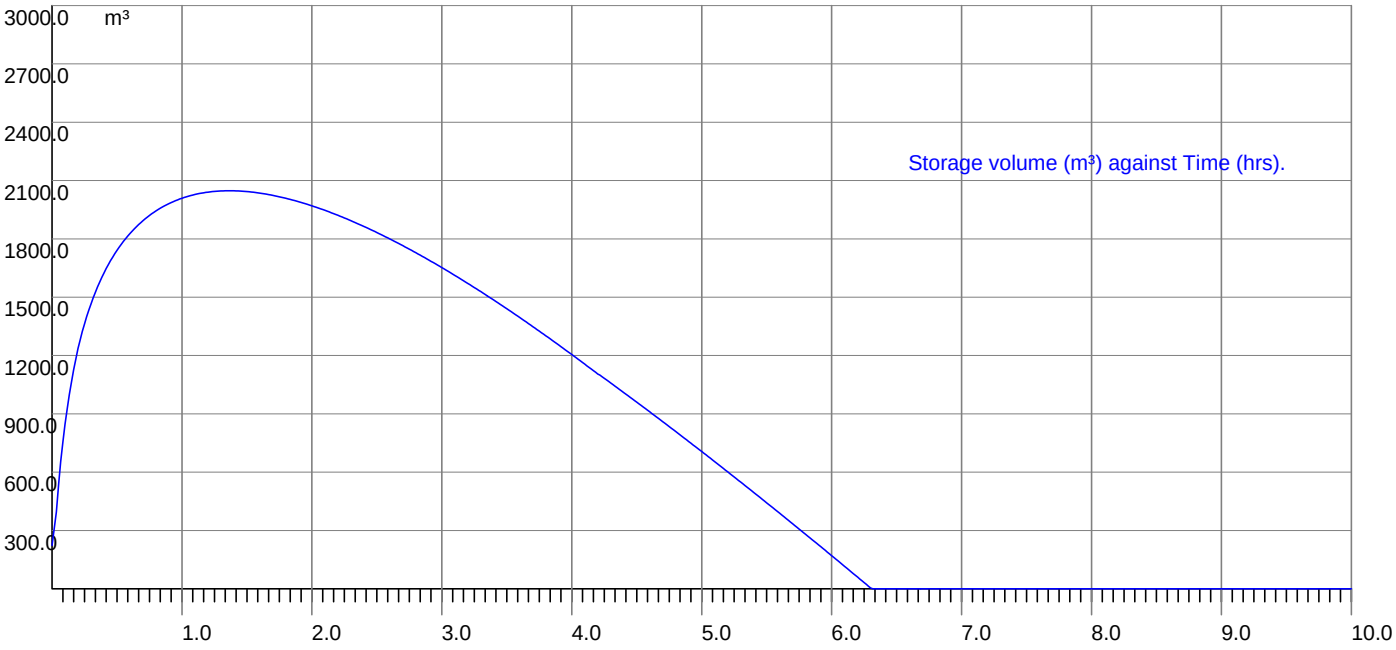
Job No.	
Sheet no.	3
Date	01/08/18

MasterDrain SW

Project	100yr+20% Parcel B	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		







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Job No.			
Sheet no.	1		
Date	01/08/18		
Project	100yr+40% Parcel B	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil index	= 0.45	SAAR (mm/yr)	= 1100
Return period	= 100	WRAP	= 4
UCWI	= 113.8	Climate change	= 40

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 45.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 73700 m²	Pervious area	= 60300 m²
Total area (TA)	= 134000 m²	Equiv area	= 60300 m² (TA x RF).
Allowed discharge rate	= 209.780 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s	Climate change factor	= 40

Calculated data:-

Time to max	= 97.0 mins	Calculated storage volume	= 2576.0 m³
Rainfall at max	= 38.95 mm/hr	Allowed discharge rate	= 209.780 l/s
Pipeline storage	= 0.0 m³	Available MH storage	= 0.0 m³
Offline storage	= 0.0 m³		

Fixed 6 hour data:-

Rainfall event	= 6 hours	Calculated storage volume	= 867.7 m³
Rainfall rate	= 15.00 mm/hr	Allowed discharge rate	= 209.780 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	328052.8	1125	2592.0
150	145801.3	1200	2278.1
225	64800.6	1275	2018.0
300	36450.3	1350	1800.0
375	23328.2	1425	1615.5
450	16200.1	1500	1458.0
525	11902.1	1575	1322.5
600	9112.6	1650	1205.0
675	7200.1	1725	1102.5
750	5832.1	1800	1012.5
825	4819.9	1875	933.1
900	4050.0	1950	862.7
975	3450.9	2025	800.0
1050	2975.5	2100	743.9

Ovoid	Len
400 x 600	14311.3
600 x 900	6231.3
800 x 1200	3504.6

Box culvert	Len
500 x 500	10304.1
500 x 750	6869.4
500 x 1000	5152.1
750 x 1000	3434.7
750 x 1200	2862.3
750 x 1500	2289.8
1000 x 1000	2576.0
1000 x 1200	2146.7
1000 x 1500	1717.4
1000 x 1800	1431.1
1000 x 2000	1288.0
1500 x 1500	1144.9
1500 x 1800	954.1
1500 x 2000	858.7

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Job No.	
Sheet no.	2
Date	01/08/18

MasterDrain SW

Project	100yr+40% Parcel B	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	145.0	1461.290	125.868	1335.422
20	103.0	2073.403	251.736	1821.667
30	82.0	2471.598	377.604	2093.994
40	69.0	2773.295	503.472	2269.823
50	60.0	3018.141	629.340	2388.801
60	53.0	3225.035	755.208	2469.827
70	48.0	3404.550	881.076	2523.474
80	44.0	3563.245	1006.944	2556.301
90	41.0	3705.490	1132.812	2572.677
100	38.0	3834.356	1258.680	2575.676
110	36.0	3952.095	1384.548	2567.547
120	34.0	4060.409	1510.416	2549.993
130	32.0	4160.620	1636.284	2524.336
140	30.0	4253.780	1762.152	2491.628
150	29.0	4340.736	1888.020	2452.716
160	28.0	4422.189	2013.888	2408.302
170	26.0	4498.719	2139.756	2358.963
180	25.0	4570.816	2265.624	2305.192
190	24.0	4638.897	2391.492	2247.406
200	23.0	4703.322	2517.360	2185.962
210	23.0	4764.401	2643.228	2121.173
220	22.0	4822.405	2769.096	2053.309
230	21.0	4877.572	2894.964	1982.608
240	20.0	4930.114	3020.832	1909.282
250	20.0	4980.218	3146.700	1833.518
260	19.0	5034.019	3272.568	1761.451
270	19.0	5084.943	3398.436	1686.507
280	18.0	5134.364	3524.304	1610.060
290	18.0	5182.377	3650.172	1532.206
300	17.0	5229.072	3776.040	1453.032
310	17.0	5274.525	3901.908	1372.617
320	17.0	5318.807	4027.776	1291.031
330	16.0	5361.985	4153.644	1208.341
340	16.0	5404.118	4279.512	1124.605
350	15.0	5445.260	4405.380	1039.880
360	15.0	5485.462	4531.248	954.214
370	15.0	5524.771	4657.116	867.655
380	15.0	5563.229	4782.984	780.245
390	14.0	5600.878	4908.852	692.026
400	14.0	5637.754	5034.720	603.035
410	14.0	5673.891	5160.588	513.303
420	14.0	5709.321	5286.456	422.865
430	13.0	5744.075	5412.324	331.751
440	13.0	5778.180	5538.192	239.988
450	13.0	5811.663	5664.060	147.603
460	13.0	5844.549	5789.928	54.622
470	12.0	5876.861	5915.796	0.000
480	12.0	5908.620	6041.664	0.000
490	12.0	5939.847	6167.532	0.000
500	12.0	5970.562	6293.400	0.000
510	12.0	6000.783	6419.268	0.000
520	12.0	6030.526	6545.136	0.000
530	11.0	6059.810	6671.004	0.000
540	11.0	6088.648	6796.872	0.000
550	11.0	6117.056	6922.740	0.000
560	11.0	6145.047	7048.608	0.000
570	11.0	6172.636	7174.476	0.000
580	11.0	6199.833	7300.344	0.000
590	11.0	6226.654	7426.212	0.000
600	10.0	6253.106	7552.080	0.000

Storage volume (m^3) = 2576.0 m^3

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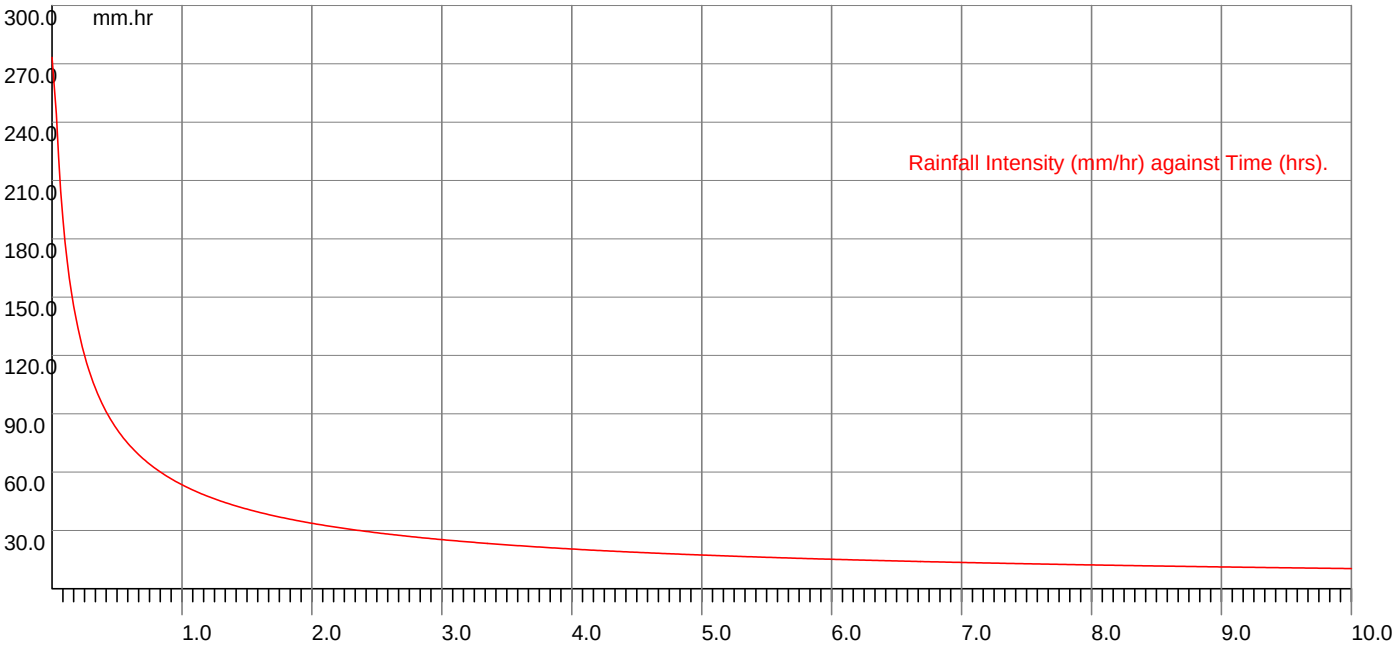
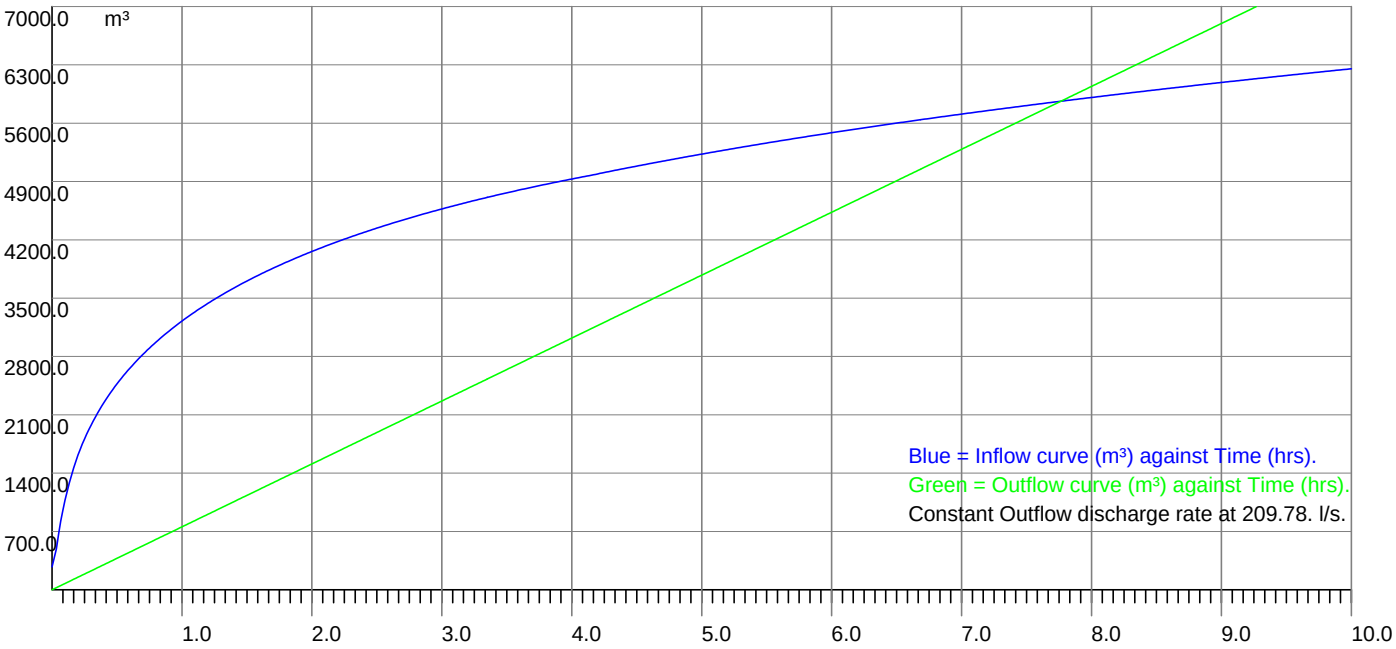
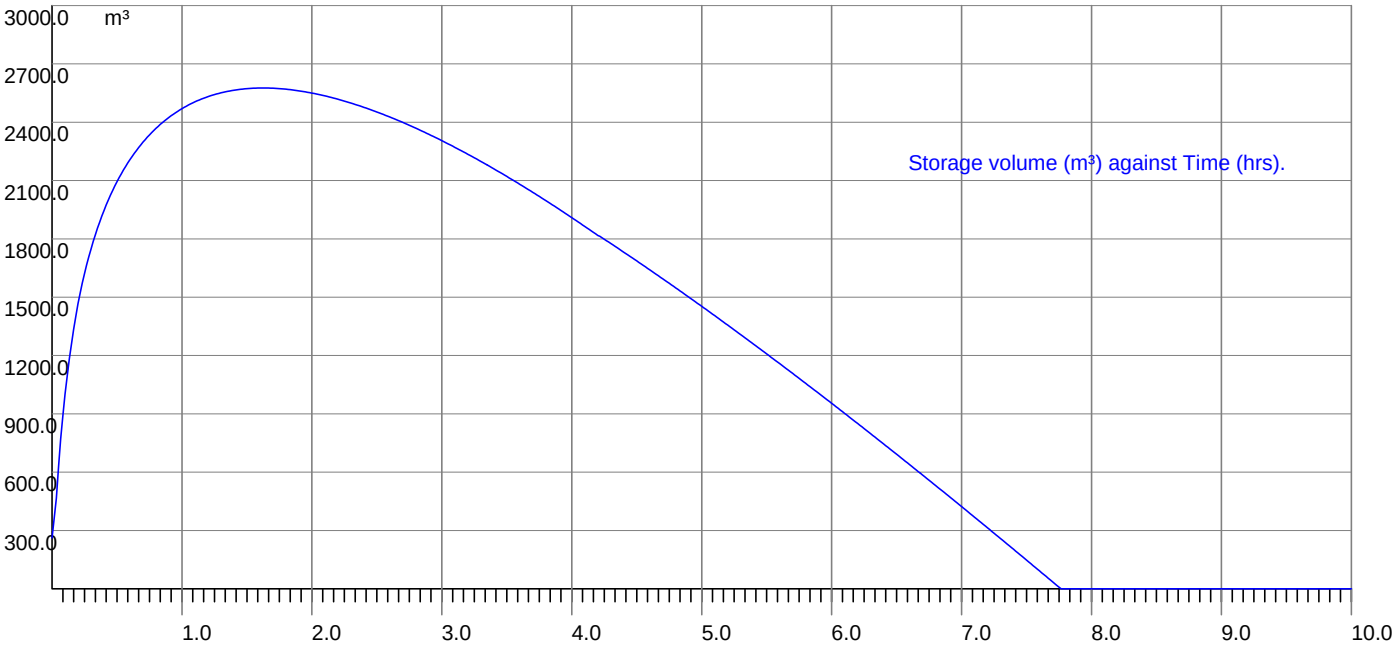
Sheet no.	3
Date	01/08/18

MasterDrain SW

Project	100yr+40% Parcel B	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		







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Job No.			
Sheet no.	1		
Date	31/07/18		
Project	Parcel C	By	Checked / Reviewed
Title	IoH 124 Runoff calcs for Radcliffe		

Hydrological Data:-

FSR Hydrology:-

Location = Radcliffe — Grid reference = SD7808
M5-60 (mm) = 18.9 — r = 0.32
Soil runoff = 0.45 — SAAR (mm/yr) = 1100
WRAP = 4 — Area = England & Wales
Hydrological area = 10 — Hydrological zone = 7

Soil classification for WRAP type 4
Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Design data:-

Area = 0.218 Km² - 21.8 Ha - 218000 m²

Calculation method:-

Runoff is calculated from:-

$$Q_{BAR(rural)} = 0.00108\ AREA^{0.89}\ .\ SAAR^{1.17}\ .\ SOIL^{2.17}$$

where

AREA = Site area in Km²
SAAR = Standard Average Annual Rainfall (mm/yr)
SOIL = Soil value derived from Winter Rainfall Acceptance Potential
$Q_{BAR(rural)}$ = Runoff (cumecs)

$Q_{BAR(rural)}$ is then multiplied by a growth factor - GC(T) - for different storm return periods derived from EA publication W5-074/A.

Calculated data:-

For areas less than 50Ha, a modified calculation which multiplies the 50Ha runoff value by the ratio of the site area to 50Ha is used
Reducing factor used for these calculations is 0.436

Mean Annual Peak Flow $Q_{BAR(rural)}$ = 162.52 l/s

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Job No.			
Sheet no.	2		
Date	31/07/18		
By	Checked	Reviewed	

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Project: Parcel C

Title: IoH 124 Runoff calcs for Radcliffe

Values for $Q_{BAR(rural)}$

Ret. per.	m³/hr	l/s	l/s/ha	Ret. per.	m³/hr	l/s	l/s/ha
1yr	497.296	138.138	6.337	100yr	1228.615	341.282	15.655
2yr	544.101	151.139	6.933	100yr+20%	1474.338	409.538	18.786
5yr	707.916	196.643	9.020	100yr+30%	1597.199	443.666	20.352
10yr	807.375	224.271	10.288	200yr	1404.131	390.036	17.892
30yr	982.892	273.025	12.524	200yr + 30%	1825.370	507.047	23.259
50yr	1082.351	300.653	13.791	500yr	1597.199	443.666	20.352
				1000yr	1778.566	494.046	22.663

Growth factors -

1yr	2yr	5yr	10yr	30yr	50yr	100yr	200yr	500yr	1000yr
0.85	0.93	1.21	1.38	1.68	1.85	2.10	2.40	2.73	3.04

The above is based on the Institute of Hydrology Report 124
to which you are referred for further details (see Sect 7).
Note that the 200 and above year growth curves were taken from W5-074.

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Job No.			
Sheet no.	1		
Date	01/08/18		
Project	30yr Parcel C	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil index	= 0.45	SAAR (mm/yr)	= 1100
Return period	= 30	WRAP	= 4
UCWI	= 113.8	Climate change	= 0

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 30.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 80800 m²	Pervious area	= 137100 m²
Total area (TA)	= 217900 m²	Equiv area	= 65370 m² (TA x RF).
Allowed discharge rate	= 273.030 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s	Climate change factor	= 0

Calculated data:-

Time to max	= 53.0 mins	Calculated storage volume	= 1557.2 m³
Rainfall at max	= 31.50 mm/hr	Allowed discharge rate	= 273.030 l/s
Pipeline storage	= 0.0 m³	Available MH storage	= 0.0 m³
Offline storage	= 0.0 m³		

Fixed 6 hour data:-

Rainfall event	= 6 hours	Calculated storage volume	= 0.0 m³
Rainfall rate	= 8.00 mm/hr	Allowed discharge rate	= 273.030 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	198303.1	1125	1566.8
150	88134.7	1200	1377.1
225	39171.0	1275	1219.9
300	22033.7	1350	1088.1
375	14101.6	1425	976.6
450	9792.7	1500	881.3
525	7194.7	1575	799.4
600	5508.4	1650	728.4
675	4352.3	1725	666.4
750	3525.4	1800	612.0
825	2913.5	1875	564.1
900	2448.2	1950	521.5
975	2086.0	2025	483.6
1050	1798.7	2100	449.7

Ovoid	Len
400 x 600	8651.0
600 x 900	3766.8
800 x 1200	2118.5

Box culvert	Len
500 x 500	6228.7
500 x 750	4152.5
500 x 1000	3114.3
750 x 1000	2076.2
750 x 1200	1730.2
750 x 1500	1384.2
1000 x 1000	1557.2
1000 x 1200	1297.6
1000 x 1500	1038.1
1000 x 1800	865.1
1000 x 2000	778.6
1500 x 1500	692.1
1500 x 1800	576.7
1500 x 2000	519.1

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Job No.	
Sheet no.	2
Date	01/08/18

MasterDrain SW

Project	30yr Parcel C	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	81.0	1178.607	163.818	1014.789
20	57.0	1649.681	327.636	1322.045
30	45.0	1955.292	491.454	1463.838
40	38.0	2186.745	655.272	1531.473
50	33.0	2374.976	819.090	1555.886
60	29.0	2534.574	982.908	1551.666
70	26.0	2673.638	1146.726	1526.912
80	24.0	2797.162	1310.544	1486.618
90	22.0	2908.455	1474.362	1434.093
100	21.0	3009.835	1638.180	1371.655
110	19.0	3102.990	1801.998	1300.992
120	18.0	3189.198	1965.816	1223.382
130	17.0	3269.442	2129.634	1139.808
140	16.0	3344.507	2293.452	1051.055
150	16.0	3415.021	2457.270	957.751
160	15.0	3481.503	2621.088	860.415
170	14.0	3544.381	2784.906	759.475
180	14.0	3604.015	2948.724	655.291
190	13.0	3660.714	3112.542	548.172
200	13.0	3714.742	3276.360	438.382
210	12.0	3766.324	3440.178	326.146
220	12.0	3815.661	3603.996	211.665
230	12.0	3862.926	3767.814	95.112
240	11.0	3908.272	3931.632	0.000
250	11.0	3951.837	4095.450	0.000
260	11.0	3996.645	4259.268	0.000
270	10.0	4039.537	4423.086	0.000
280	10.0	4081.218	4586.904	0.000
290	10.0	4121.759	4750.722	0.000
300	10.0	4161.235	4914.540	0.000
310	9.0	4199.706	5078.358	0.000
320	9.0	4237.227	5242.176	0.000
330	9.0	4273.854	5405.994	0.000
340	9.0	4309.633	5569.812	0.000
350	9.0	4344.607	5733.630	0.000
360	8.0	4378.818	5897.448	0.000
370	8.0	4412.303	6061.266	0.000
380	8.0	4445.095	6225.084	0.000
390	8.0	4477.229	6388.902	0.000
400	8.0	4508.732	6552.720	0.000
410	8.0	4539.633	6716.538	0.000
420	7.0	4569.957	6880.356	0.000
430	7.0	4599.729	7044.174	0.000
440	7.0	4628.972	7207.992	0.000
450	7.0	4657.706	7371.810	0.000
460	7.0	4685.952	7535.628	0.000
470	7.0	4713.728	7699.446	0.000
480	7.0	4741.050	7863.264	0.000
490	7.0	4767.938	8027.082	0.000
500	7.0	4794.405	8190.900	0.000
510	7.0	4820.468	8354.718	0.000
520	6.0	4846.138	8518.536	0.000
530	6.0	4871.430	8682.354	0.000
540	6.0	4896.357	8846.172	0.000
550	6.0	4920.930	9009.990	0.000
560	6.0	4945.161	9173.808	0.000
570	6.0	4969.059	9337.626	0.000
580	6.0	4992.637	9501.444	0.000
590	6.0	5015.903	9665.262	0.000
600	6.0	5038.866	9829.080	0.000

Storage volume (m^3) = 1557.2 m^3

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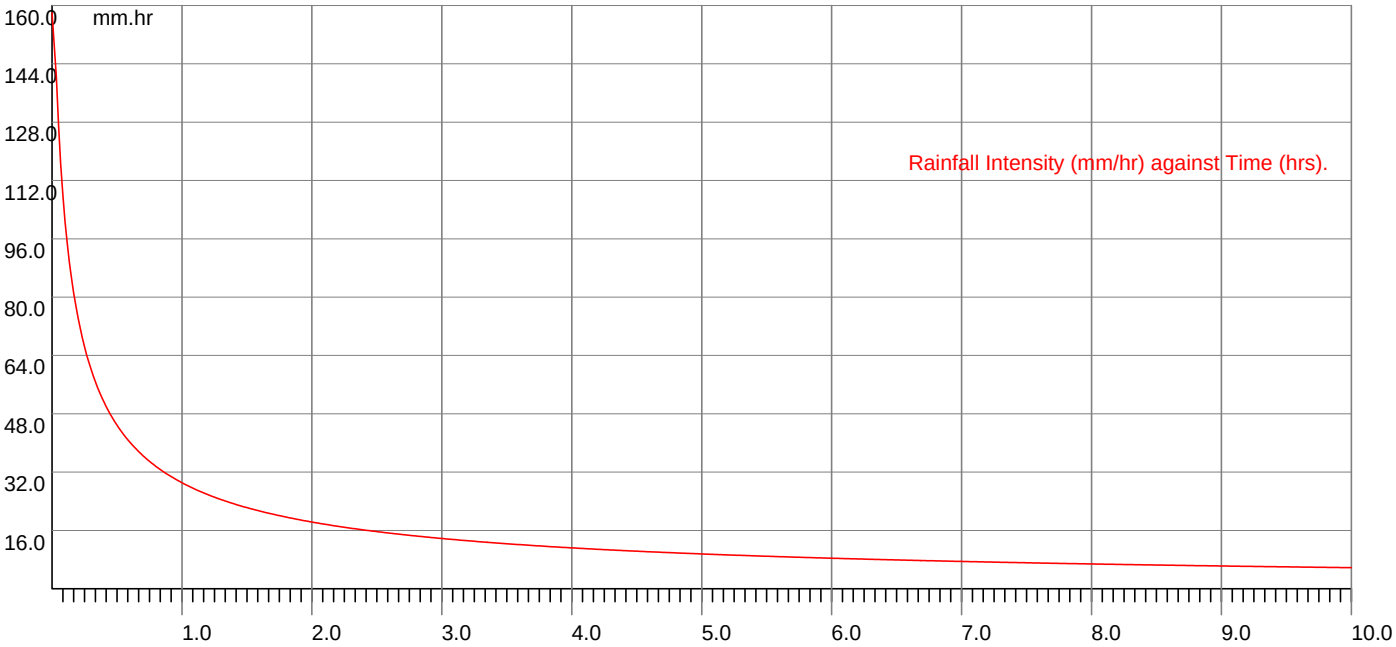
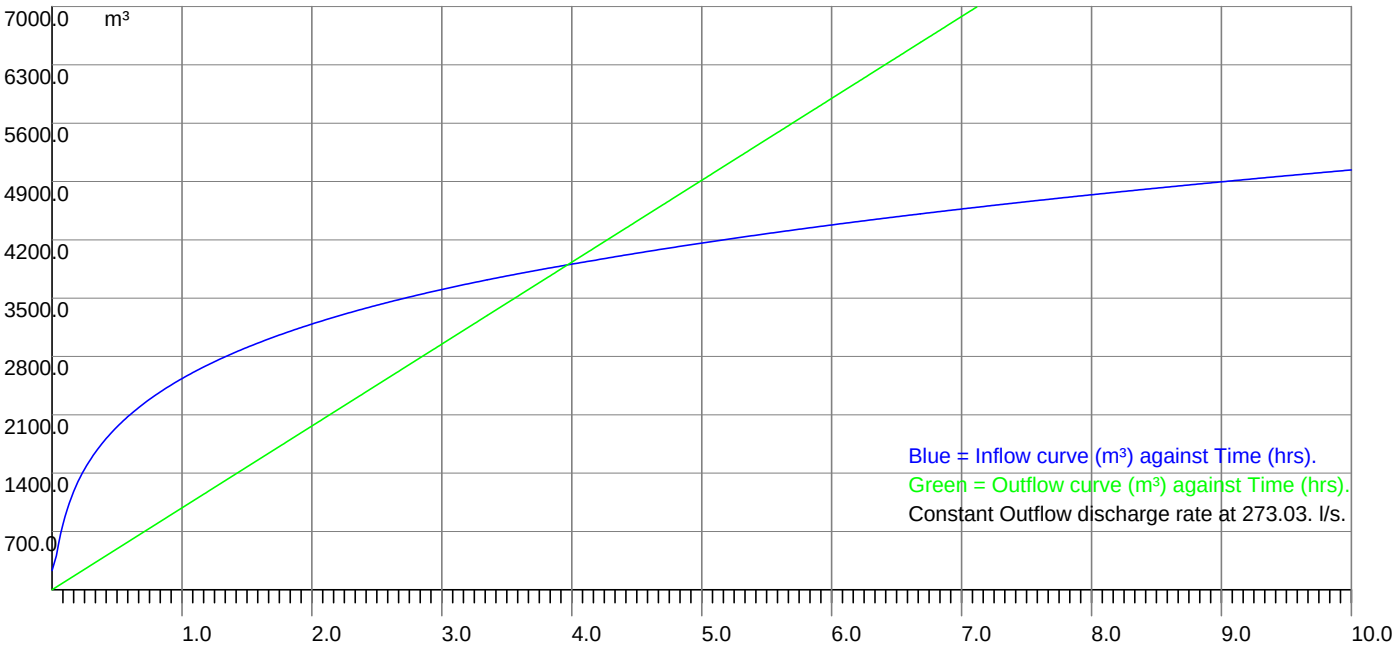
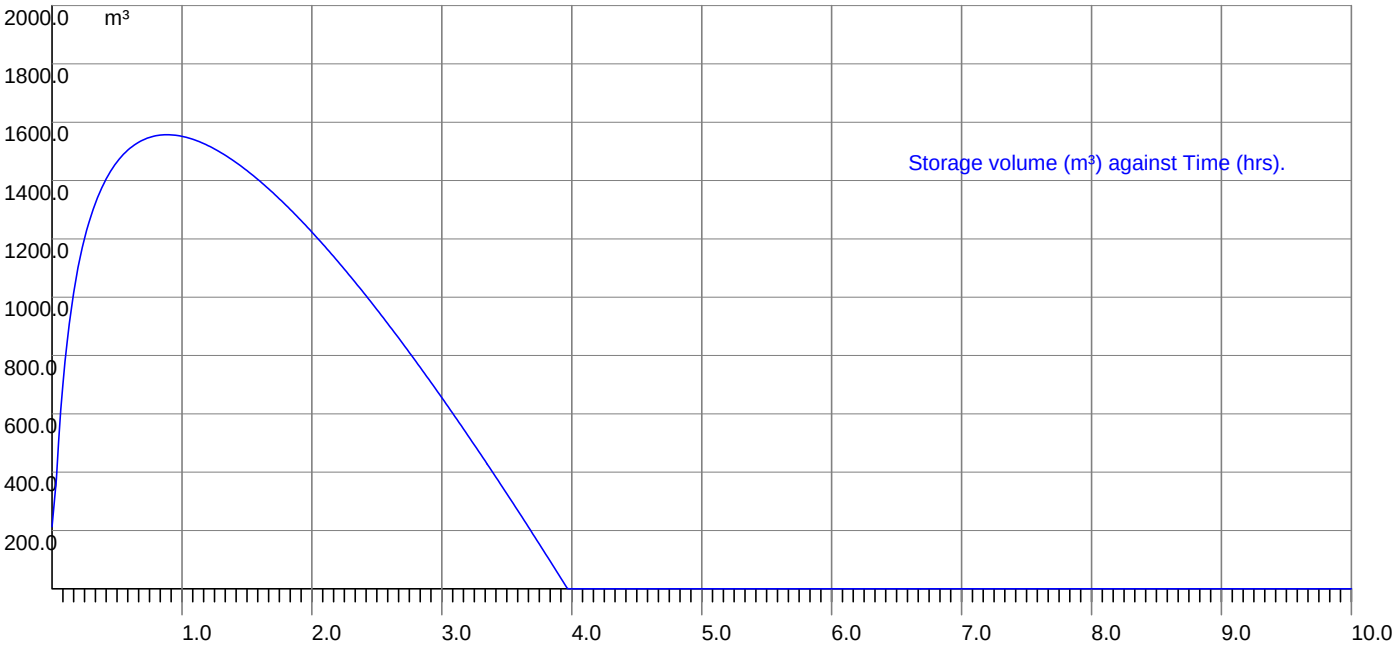
Job No.	
Sheet no.	3
Date	01/08/18

MasterDrain SW

Project	30yr Parcel C	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		







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www.thelkgroup.com		Sheet no.	1	
		Date	01/08/18	
Project 100yr+20% Parcel C		By	Checked	Reviewed
Title Peak flow storage calcs for Radcliffe				

Data:-

FSR Hydrology:-

Location = Radcliffe
M5-60 (mm) = 18.9
Soil index = 0.45
Return period = 100
UCWI = 113.8

Grid reference = SD7808
r = 0.32
SAAR (mm/yr) = 1100
WRAP = 4
Climate change = 20

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 30.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area = 80800 m²
Total area (TA) = 217900 m²
Allowed discharge rate = 341.280 l/s
Additional flow = 0.00 l/s

Pervious area = 137100 m²
Equiv area = 65370 m² (TA x RF).
Areal reduction factor = 1.000
Climate change factor = 20

Calculated data:-

Time to max = 71.0 mins
Rainfall at max = 41.10 mm/hr
Pipeline storage = 0.0 m³
Offline storage = 0.0 m³

Calculated storage volume = 2784.9 m³
Allowed discharge rate = 341.280 l/s
Available MH storage = 0.0 m³

Fixed 6 hour data:-

Rainfall event = 6 hours
Rainfall rate = 13.00 mm/hr

Calculated storage volume = 0.0 m³
Allowed discharge rate = 341.280 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	354654.6	1125	2802.2
150	157624.3	1200	2462.9
225	70055.2	1275	2181.7
300	39406.1	1350	1946.0
375	25219.9	1425	1746.5
450	17513.8	1500	1576.2
525	12867.3	1575	1429.7
600	9851.5	1650	1302.7
675	7783.9	1725	1191.9
750	6305.0	1800	1094.6
825	5210.7	1875	1008.8
900	4378.5	1950	932.7
975	3730.8	2025	864.9
1050	3216.8	2100	804.2

Ovoid	Len
400 x 600	15471.8
600 x 900	6736.6
800 x 1200	3788.8

Box culvert	Len
500 x 500	11139.7
500 x 750	7426.5
500 x 1000	5569.9
750 x 1000	3713.2
750 x 1200	3094.4
750 x 1500	2475.5
1000 x 1000	2784.9
1000 x 1200	2320.8
1000 x 1500	1856.6
1000 x 1800	1547.2
1000 x 2000	1392.5
1500 x 1500	1237.7
1500 x 1800	1031.5
1500 x 2000	928.3

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Job No.	
Sheet no.	2
Date	01/08/18

MasterDrain SW

Project	100yr+20% Parcel C	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	125.0	1810.462	204.768	1605.694
20	88.0	2568.838	409.536	2159.302
30	70.0	3062.182	614.304	2447.878
40	59.0	3435.969	819.072	2616.897
50	51.0	3739.321	1023.840	2715.480
60	46.0	3995.651	1228.608	2767.043
70	41.0	4218.061	1433.376	2784.685
80	38.0	4414.676	1638.144	2776.532
90	35.0	4590.909	1842.912	2747.997
100	33.0	4750.568	2047.680	2702.888
110	31.0	4896.441	2252.448	2643.993
120	29.0	5030.636	2457.216	2573.420
130	27.0	5154.792	2661.984	2492.809
140	26.0	5270.213	2866.752	2403.461
150	25.0	5377.947	3071.520	2306.427
160	24.0	5478.863	3276.288	2202.575
170	23.0	5573.680	3481.056	2092.624
180	22.0	5663.004	3685.824	1977.180
190	21.0	5747.354	3890.592	1856.761
200	20.0	5827.172	4095.360	1731.812
210	19.0	5902.845	4300.128	1602.717
220	19.0	5974.709	4504.896	1469.813
230	18.0	6043.060	4709.664	1333.396
240	18.0	6108.156	4914.432	1193.724
250	17.0	6170.232	5119.200	1051.032
260	17.0	6236.889	5323.968	912.921
270	16.0	6299.980	5528.736	771.245
280	16.0	6361.211	5733.504	627.707
290	15.0	6420.698	5938.272	482.426
300	15.0	6478.550	6143.040	335.510
310	15.0	6534.863	6347.808	187.055
320	14.0	6589.726	6552.576	37.150
330	14.0	6643.221	6757.344	0.000
340	14.0	6695.422	6962.112	0.000
350	13.0	6746.395	7166.880	0.000
360	13.0	6796.203	7371.648	0.000
370	13.0	6844.905	7576.416	0.000
380	12.0	6892.553	7781.184	0.000
390	12.0	6939.198	7985.952	0.000
400	12.0	6984.885	8190.720	0.000
410	12.0	7029.656	8395.488	0.000
420	12.0	7073.553	8600.256	0.000
430	11.0	7116.611	8805.024	0.000
440	11.0	7158.866	9009.792	0.000
450	11.0	7200.349	9214.560	0.000
460	11.0	7241.094	9419.328	0.000
470	11.0	7281.127	9624.096	0.000
480	10.0	7320.474	9828.864	0.000
490	10.0	7359.163	10033.632	0.000
500	10.0	7397.218	10238.400	0.000
510	10.0	7434.659	10443.168	0.000
520	10.0	7471.509	10647.936	0.000
530	10.0	7507.790	10852.704	0.000
540	10.0	7543.520	11057.472	0.000
550	9.0	7578.715	11262.240	0.000
560	9.0	7613.395	11467.008	0.000
570	9.0	7647.575	11671.776	0.000
580	9.0	7681.272	11876.544	0.000
590	9.0	7714.501	12081.312	0.000
600	9.0	7747.274	12286.080	0.000

Storage volume (m^3) = 2784.9 m^3

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Sheet no.	3
Date	01/08/18

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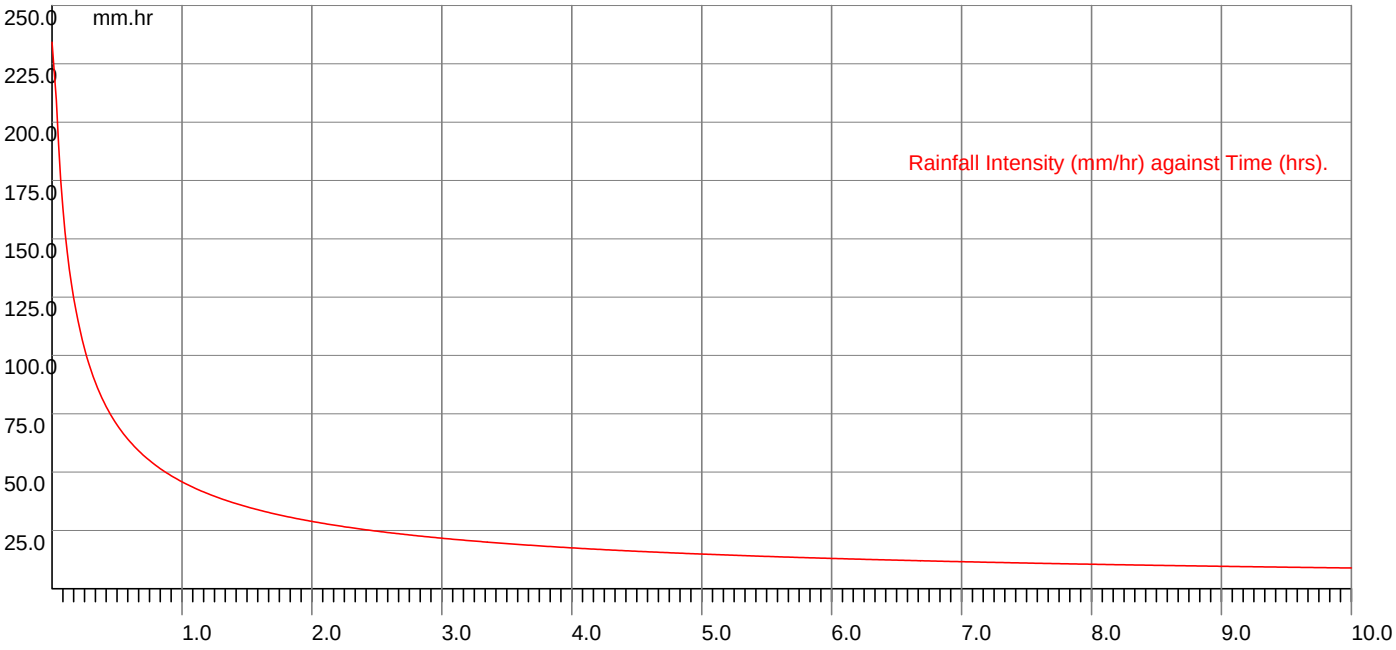
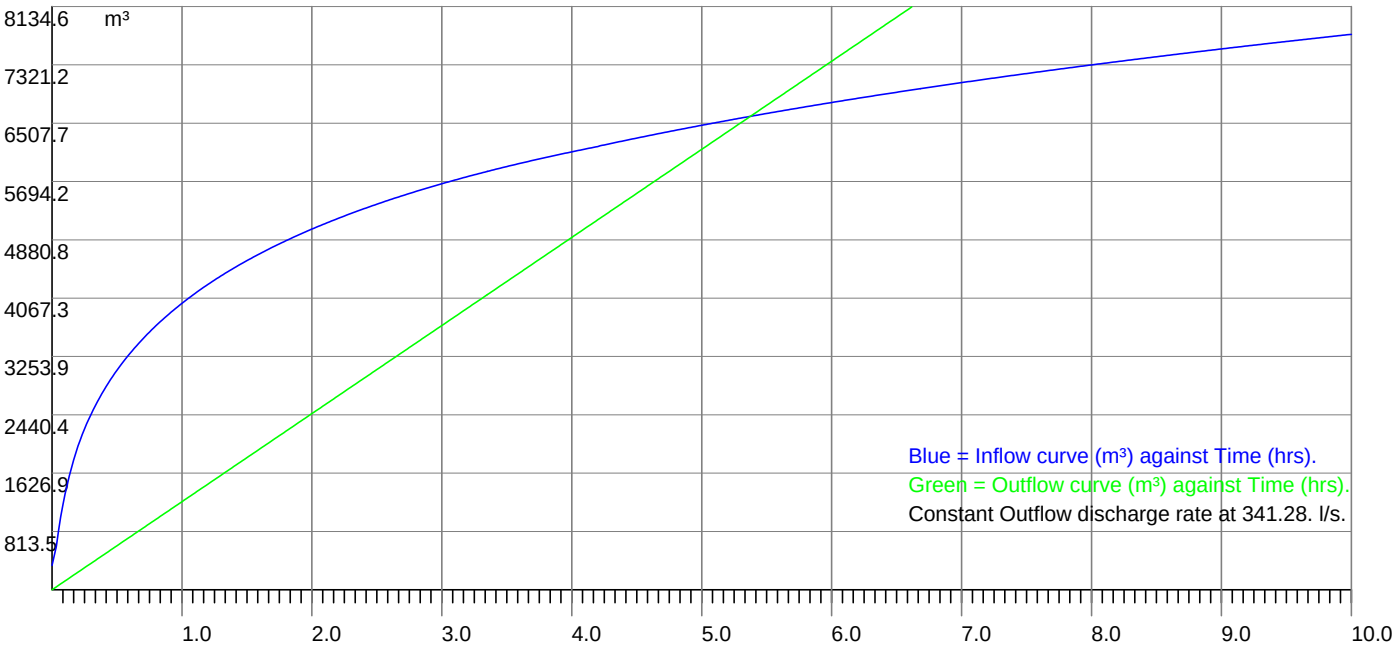
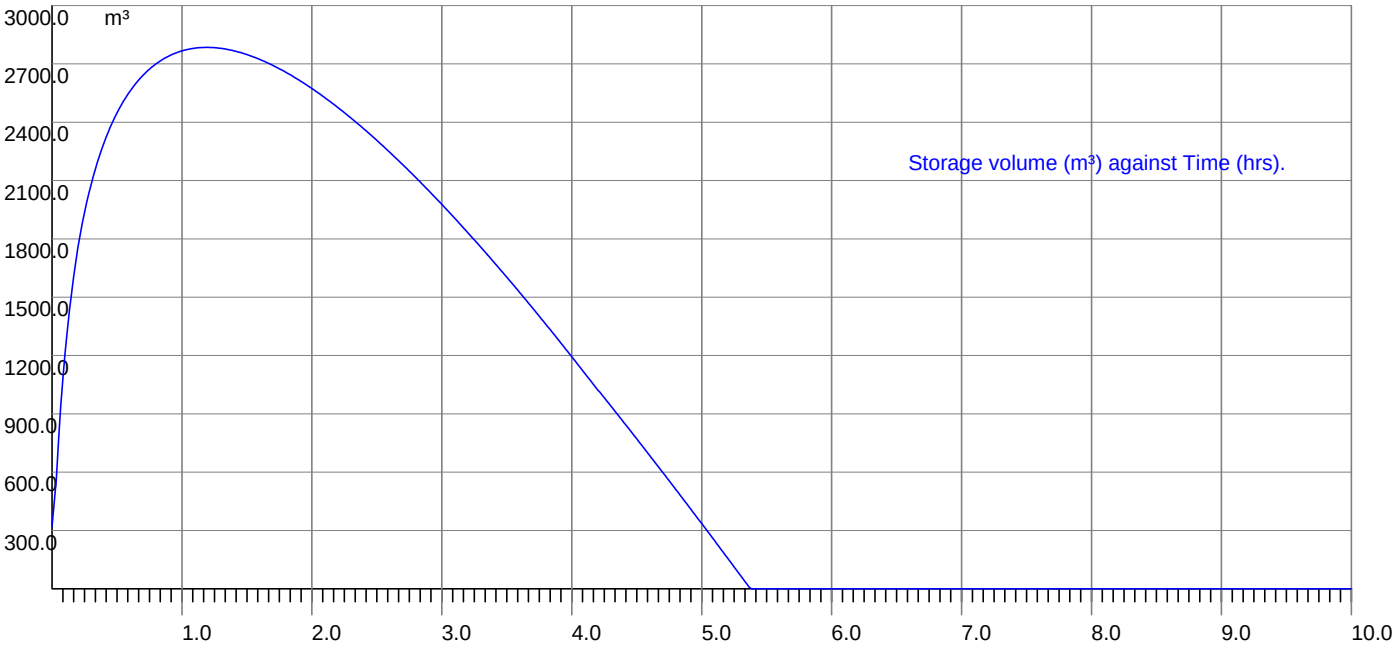
Project	100yr+20% Parcel C	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		







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Job No.			
Sheet no.	1		
Date	01/08/18		
Project	100yr+40% Parcel C	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil index	= 0.45	SAAR (mm/yr)	= 1100
Return period	= 100	WRAP	= 4
UCWI	= 113.8	Climate change	= 40

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 30.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 80800 m²	Pervious area	= 137100 m²
Total area (TA)	= 217900 m²	Equiv area	= 65370 m² (TA x RF).
Allowed discharge rate	= 341.280 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s	Climate change factor	= 40

Calculated data:-

Time to max	= 85.0 mins	Calculated storage volume	= 3515.4 m³
Rainfall at max	= 42.57 mm/hr	Allowed discharge rate	= 341.280 l/s
Pipeline storage	= 0.0 m³	Available MH storage	= 0.0 m³
Offline storage	= 0.0 m³		

Fixed 6 hour data:-

Rainfall event	= 6 hours	Calculated storage volume	= 409.3 m³
Rainfall rate	= 15.00 mm/hr	Allowed discharge rate	= 341.280 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	447677.9	1125	3537.2
150	198968.0	1200	3108.9
225	88430.2	1275	2753.9
300	49742.0	1350	2456.4
375	31834.9	1425	2204.6
450	22107.6	1500	1989.7
525	16242.3	1575	1804.7
600	12435.5	1650	1644.4
675	9825.6	1725	1504.5
750	7958.7	1800	1381.7
825	6577.5	1875	1273.4
900	5526.9	1950	1177.3
975	4709.3	2025	1091.7
1050	4060.6	2100	1015.1

Ovoid	Len
400 x 600	19529.9
600 x 900	8503.6
800 x 1200	4782.6

Box culvert	Len
500 x 500	14061.6
500 x 750	9374.4
500 x 1000	7030.8
750 x 1000	4687.2
750 x 1200	3906.0
750 x 1500	3124.8
1000 x 1000	3515.4
1000 x 1200	2929.5
1000 x 1500	2343.6
1000 x 1800	1953.0
1000 x 2000	1757.7
1500 x 1500	1562.4
1500 x 1800	1302.0
1500 x 2000	1171.8

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Job No.	
Sheet no.	2
Date	01/08/18

MasterDrain SW

Project	100yr+40% Parcel C	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	145.0	2112.206	204.768	1907.438
20	103.0	2996.978	409.536	2587.442
30	82.0	3572.545	614.304	2958.241
40	69.0	4008.631	819.072	3189.559
50	60.0	4362.541	1023.840	3338.701
60	53.0	4661.593	1228.608	3432.985
70	48.0	4921.071	1433.376	3487.695
80	44.0	5150.455	1638.144	3512.311
90	41.0	5356.061	1842.912	3513.149
100	38.0	5542.329	2047.680	3494.649
110	36.0	5712.515	2252.448	3460.067
120	34.0	5869.076	2457.216	3411.860
130	32.0	6013.924	2661.984	3351.940
140	30.0	6148.581	2866.752	3281.829
150	29.0	6274.271	3071.520	3202.751
160	28.0	6392.007	3276.288	3115.719
170	26.0	6502.626	3481.056	3021.570
180	25.0	6606.838	3685.824	2921.014
190	24.0	6705.246	3890.592	2814.654
200	23.0	6798.368	4095.360	2703.008
210	23.0	6886.653	4300.128	2586.525
220	22.0	6970.494	4504.896	2465.598
230	21.0	7050.236	4709.664	2340.572
240	20.0	7126.182	4914.432	2211.750
250	20.0	7198.604	5119.200	2079.404
260	19.0	7276.370	5323.968	1952.402
270	19.0	7349.977	5528.736	1821.241
280	18.0	7421.412	5733.504	1687.908
290	18.0	7490.813	5938.272	1552.541
300	17.0	7558.307	6143.040	1415.267
310	17.0	7624.006	6347.808	1276.198
320	17.0	7688.013	6552.576	1135.437
330	16.0	7750.424	6757.344	993.081
340	16.0	7811.325	6962.112	849.213
350	15.0	7870.793	7166.880	703.913
360	15.0	7928.903	7371.648	557.255
370	15.0	7985.722	7576.416	409.306
380	15.0	8041.311	7781.184	260.127
390	14.0	8095.730	7985.952	109.778
400	14.0	8149.033	8190.720	0.000
410	14.0	8201.266	8395.488	0.000
420	14.0	8252.478	8600.256	0.000
430	13.0	8302.712	8805.024	0.000
440	13.0	8352.010	9009.792	0.000
450	13.0	8400.407	9214.560	0.000
460	13.0	8447.942	9419.328	0.000
470	12.0	8494.647	9624.096	0.000
480	12.0	8540.552	9828.864	0.000
490	12.0	8585.689	10033.632	0.000
500	12.0	8630.087	10238.400	0.000
510	12.0	8673.769	10443.168	0.000
520	12.0	8716.760	10647.936	0.000
530	11.0	8759.088	10852.704	0.000
540	11.0	8800.772	11057.472	0.000
550	11.0	8841.834	11262.240	0.000
560	11.0	8882.294	11467.008	0.000
570	11.0	8922.171	11671.776	0.000
580	11.0	8961.483	11876.544	0.000
590	11.0	9000.251	12081.312	0.000
600	10.0	9038.486	12286.080	0.000

Storage volume (m^3) = 3515.4 m^3

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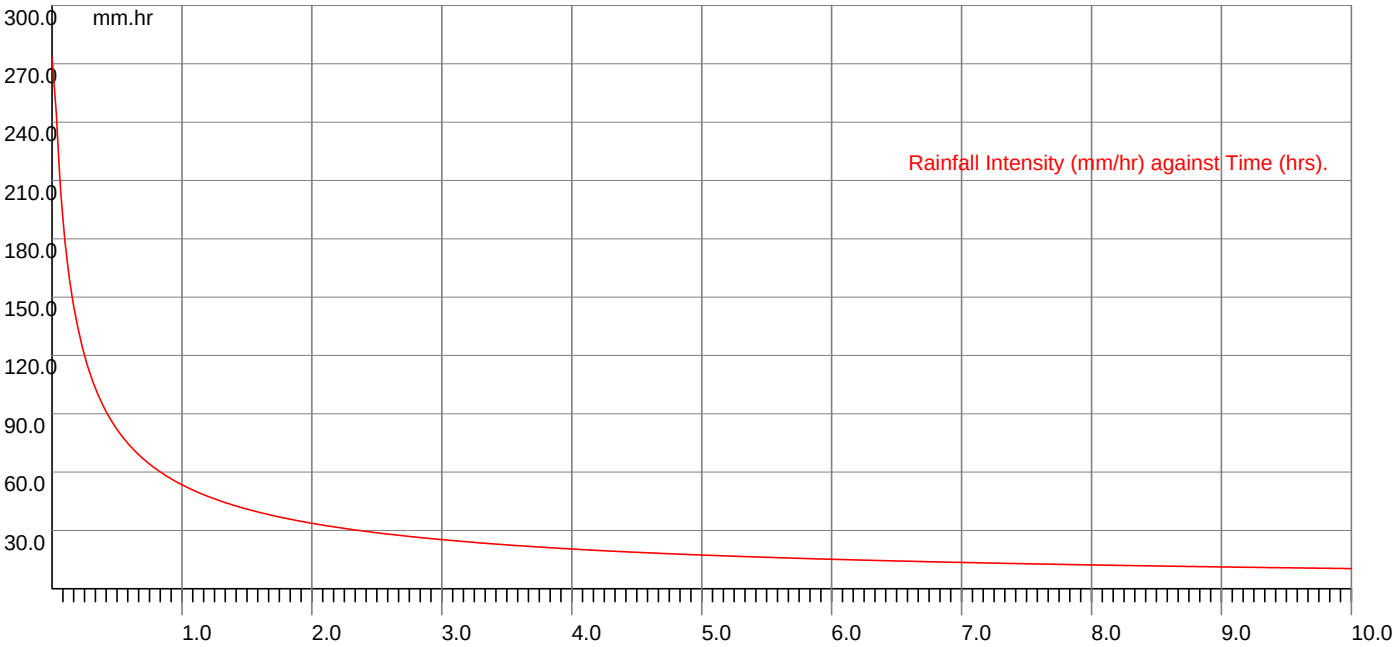
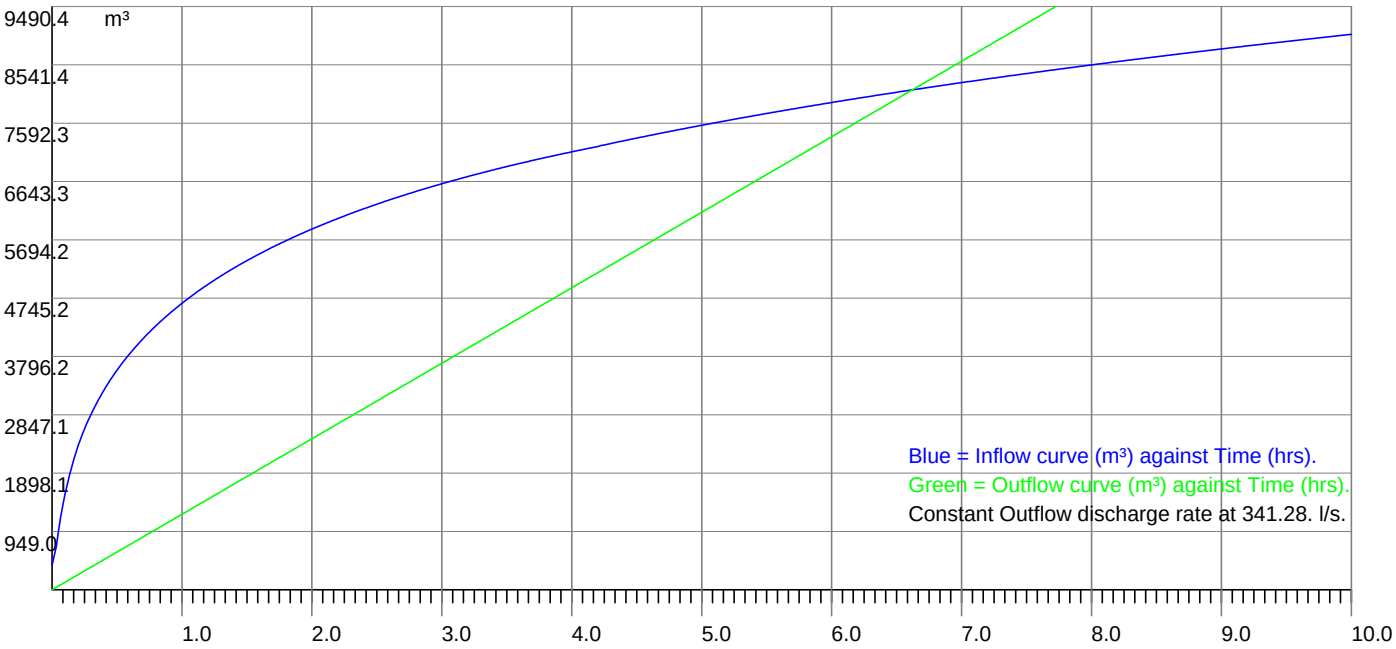
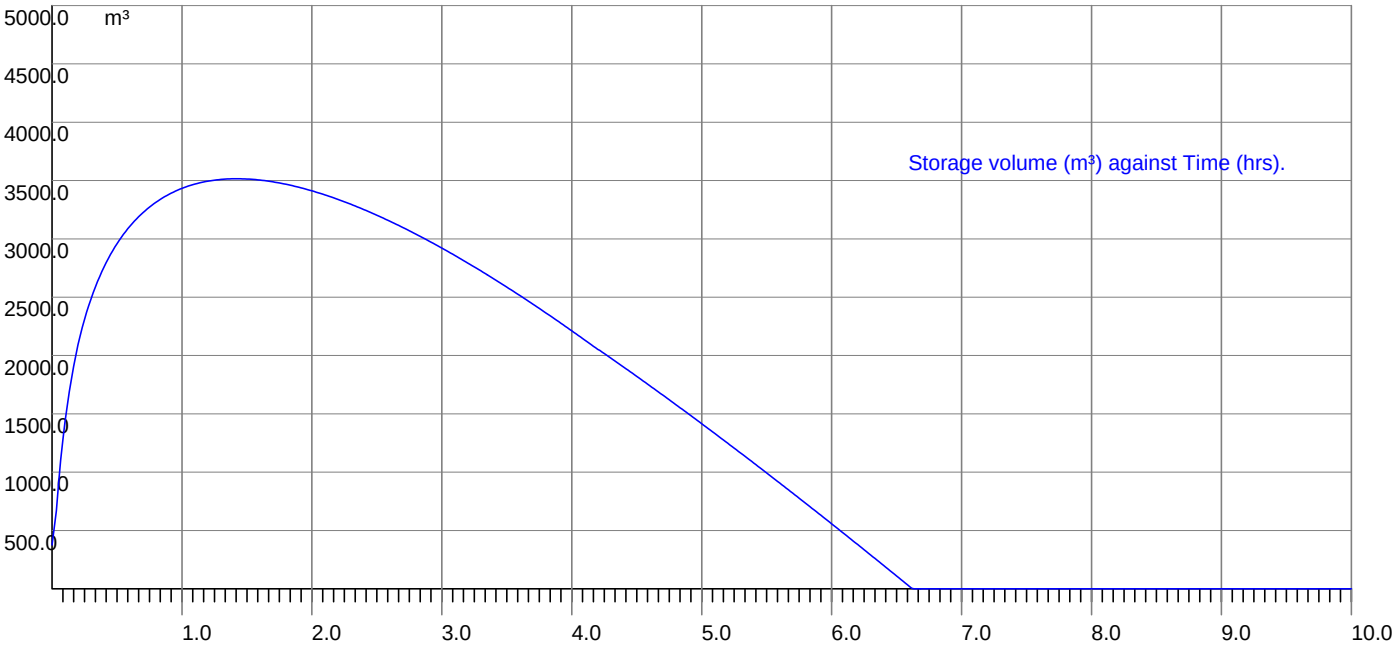
			Sheet no.	3	
			Date	01/08/18	
	Project **100yr+40% Parcel C**		By	Checked	Reviewed
	Title **Peak flow storage calcs for Radcliffe**				







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Job No.			
Sheet no.	1		
Date	14/02/19		
Project	parcel C1	By	Checked / Reviewed
Title	IoH 124 Runoff calcs for Radcliffe		

Hydrological Data:-

FSR Hydrology:-

Location = Radcliffe — Grid reference = SD7808
M5-60 (mm) = 18.9 — r = 0.32
Soil runoff = 0.45 — SAAR (mm/yr) = 1100
WRAP = 4 — Area = England & Wales
Hydrological area = 10 — Hydrological zone = 7

Soil classification for WRAP type 4
Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Design data:-

Area = 0.0145 Km² - 1.45 Ha - 14500 m²

Calculation method:-

Runoff is calculated from:-

$$Q_{BAR(rural)} = 0.00108\ AREA^{0.89} \cdot SAAR^{1.17} \cdot SOIL^{2.17}$$

where

AREA = Site area in Km²
SAAR = Standard Average Annual Rainfall (mm/yr)
SOIL = Soil value derived from Winter Rainfall Acceptance Potential
$Q_{BAR(rural)}$ = Runoff (cumecs)

$Q_{BAR(rural)}$ is then multiplied by a growth factor - GC(T) - for different storm return periods derived from EA publication W5-074/A.

Calculated data:-

For areas less than 50Ha, a modified calculation which multiplies the 50Ha runoff value by the ratio of the site area to 50Ha is used
Reducing factor used for these calculations is 0.029

Mean Annual Peak Flow $Q_{BAR(rural)}$ = 10.81 l/s

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Job No.			
Sheet no.	2		
Date	14/02/19		
Project	parcel C1	By	Checked / Reviewed
Title	IoH 124 Runoff calcs for Radcliffe		

Values for $Q_{BAR(rural)}$

Ret. per.	m³/hr	l/s	l/s/ha	Ret. per.	m³/hr	l/s	l/s/ha
1yr	33.077	9.188	6.337	100yr	81.720	22.700	15.655
2yr	36.190	10.053	6.933	100yr+20%	98.064	27.240	18.786
5yr	47.086	13.079	9.020	100yr+30%	106.236	29.510	20.352
10yr	53.702	14.917	10.288	200yr	93.394	25.943	17.892
30yr	65.376	18.160	12.524	200yr + 30%	121.412	33.726	23.259
50yr	71.991	19.998	13.791	500yr	106.236	29.510	20.352
				1000yr	118.299	32.861	22.663

Growth factors -

1yr	2yr	5yr	10yr	30yr	50yr	100yr	200yr	500yr	1000yr
0.85	0.93	1.21	1.38	1.68	1.85	2.10	2.40	2.73	3.04

The above is based on the Institute of Hydrology Report 124
to which you are referred for further details (see Sect 7).
Note that the 200 and above year growth curves were taken from W5-074.

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Job No.	
Sheet no.	1
Date	14/02/19
Project	30 yr event
Title	Peak flow storage calcs for Radcliffe

By	Checked	Reviewed

Data:-

FSR Hydrology:-

Location = Radcliffe
M5-60 (mm) = 18.9
Soil index = 0.45
Return period = 30
UCWI = 113.8

Grid reference = SD7808
r = 0.32
SAAR (mm/yr) = 1100
WRAP = 4
Climate change = 0

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 11.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7

where

PIMP = Impervious Area*100/(Impervious Area+Pervious Area)

UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area = 2000 m²
Total area (TA) = 14500 m²
Allowed discharge rate = 18.160 l/s
Additional flow = 0.00 l/s

Pervious area = 12500 m²
Equiv area = 1595 m² (TA x RF).
Areal reduction factor = 1.000
Climate change factor = 0

Calculated data:-

Time to max = 53.0 mins
Rainfall at max = 31.50 mm/hr
Pipeline storage = 0.0 m³
Offline storage = 0.0 m³

Calculated storage volume = 103.6 m³
Allowed discharge rate = 18.160 l/s
Available MH storage = 0.0 m³

Fixed 6 hour data:-

Rainfall event = 6 hours
Rainfall rate = 8.00 mm/hr

Calculated storage volume = 0.0 m³
Allowed discharge rate = 18.160 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	13199.4	1125	104.3
150	5866.4	1200	91.7
225	2607.3	1275	81.2
300	1466.6	1350	72.4
375	938.6	1425	65.0
450	651.8	1500	58.7
525	478.9	1575	53.2
600	366.7	1650	48.5
675	289.7	1725	44.4
750	234.7	1800	40.7
825	193.9	1875	37.5
900	163.0	1950	34.7
975	138.8	2025	32.2
1050	119.7	2100	29.9

Ovoid	Len
400 x 600	575.8
600 x 900	250.7
800 x 1200	141.0

Box culvert	Len
500 x 500	414.6
500 x 750	276.4
500 x 1000	207.3
750 x 1000	138.2
750 x 1200	115.2
750 x 1500	92.1
1000 x 1000	103.6
1000 x 1200	86.4
1000 x 1500	69.1
1000 x 1800	57.6
1000 x 2000	51.8
1500 x 1500	46.1
1500 x 1800	38.4
1500 x 2000	34.5

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Job No.		
Sheet no.	2	
Date	14/02/19	
By	Checked	Reviewed

MasterDrain SW

Project 30 yr event

Title Peak flow storage calcs for Radcliffe

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	81.0	78.430	10.896	67.534
20	57.0	109.777	21.792	87.985
30	45.0	130.113	32.688	97.425
40	38.0	145.515	43.584	101.931
50	33.0	158.041	54.480	103.561
60	29.0	168.661	65.376	103.285
70	26.0	177.915	76.272	101.643
80	24.0	186.135	87.168	98.967
90	22.0	193.541	98.064	95.477
100	21.0	200.287	108.960	91.327
110	19.0	206.486	119.856	86.630
120	18.0	212.223	130.752	81.471
130	17.0	217.563	141.648	75.915
140	16.0	222.558	152.544	70.014
150	16.0	227.250	163.440	63.810
160	15.0	231.674	174.336	57.338
170	14.0	235.858	185.232	50.626
180	14.0	239.827	196.128	43.699
190	13.0	243.600	207.024	36.576
200	13.0	247.195	217.920	29.275
210	12.0	250.627	228.816	21.811
220	12.0	253.910	239.712	14.198
230	12.0	257.056	250.608	6.448
240	11.0	260.073	261.504	0.000
250	11.0	262.972	272.400	0.000
260	11.0	265.954	283.296	0.000
270	10.0	268.808	294.192	0.000
280	10.0	271.582	305.088	0.000
290	10.0	274.280	315.984	0.000
300	10.0	276.906	326.880	0.000
310	9.0	279.466	337.776	0.000
320	9.0	281.963	348.672	0.000
330	9.0	284.401	359.568	0.000
340	9.0	286.781	370.464	0.000
350	9.0	289.109	381.360	0.000
360	8.0	291.385	392.256	0.000
370	8.0	293.614	403.152	0.000
380	8.0	295.796	414.048	0.000
390	8.0	297.934	424.944	0.000
400	8.0	300.030	435.840	0.000
410	8.0	302.087	446.736	0.000
420	7.0	304.105	457.632	0.000
430	7.0	306.086	468.528	0.000
440	7.0	308.032	479.424	0.000
450	7.0	309.944	490.320	0.000
460	7.0	311.823	501.216	0.000
470	7.0	313.672	512.112	0.000
480	7.0	315.490	523.008	0.000
490	7.0	317.279	533.904	0.000
500	7.0	319.040	544.800	0.000
510	7.0	320.775	555.696	0.000
520	6.0	322.483	566.592	0.000
530	6.0	324.166	577.488	0.000
540	6.0	325.825	588.384	0.000
550	6.0	327.460	599.280	0.000
560	6.0	329.072	610.176	0.000
570	6.0	330.663	621.072	0.000
580	6.0	332.231	631.968	0.000
590	6.0	333.780	642.864	0.000
600	6.0	335.308	653.760	0.000

Storage volume (m^3) = 103.6 m^3

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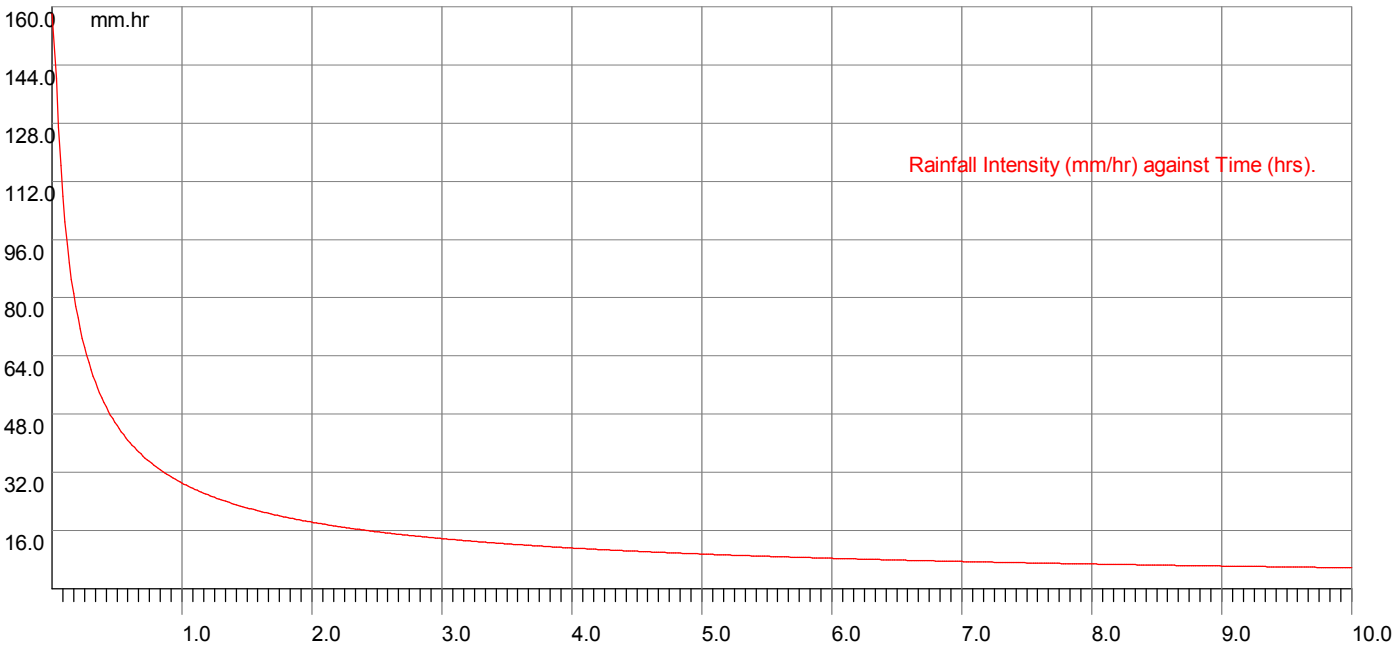
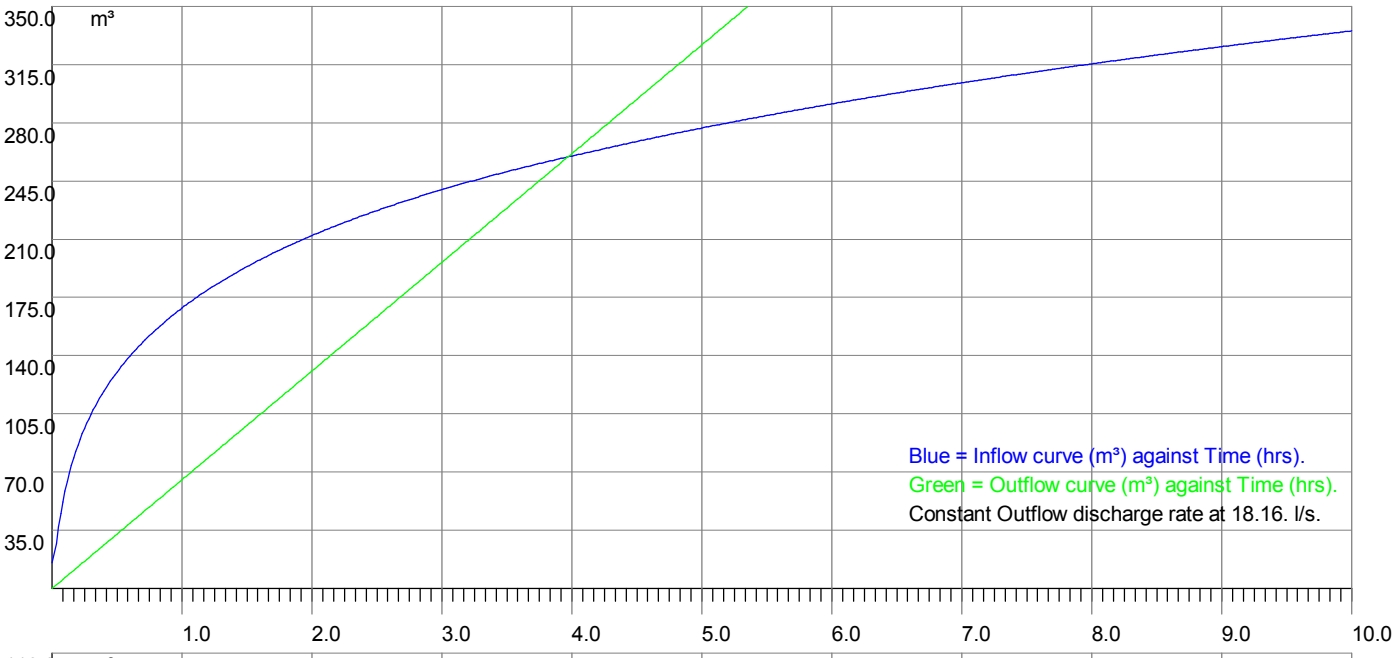
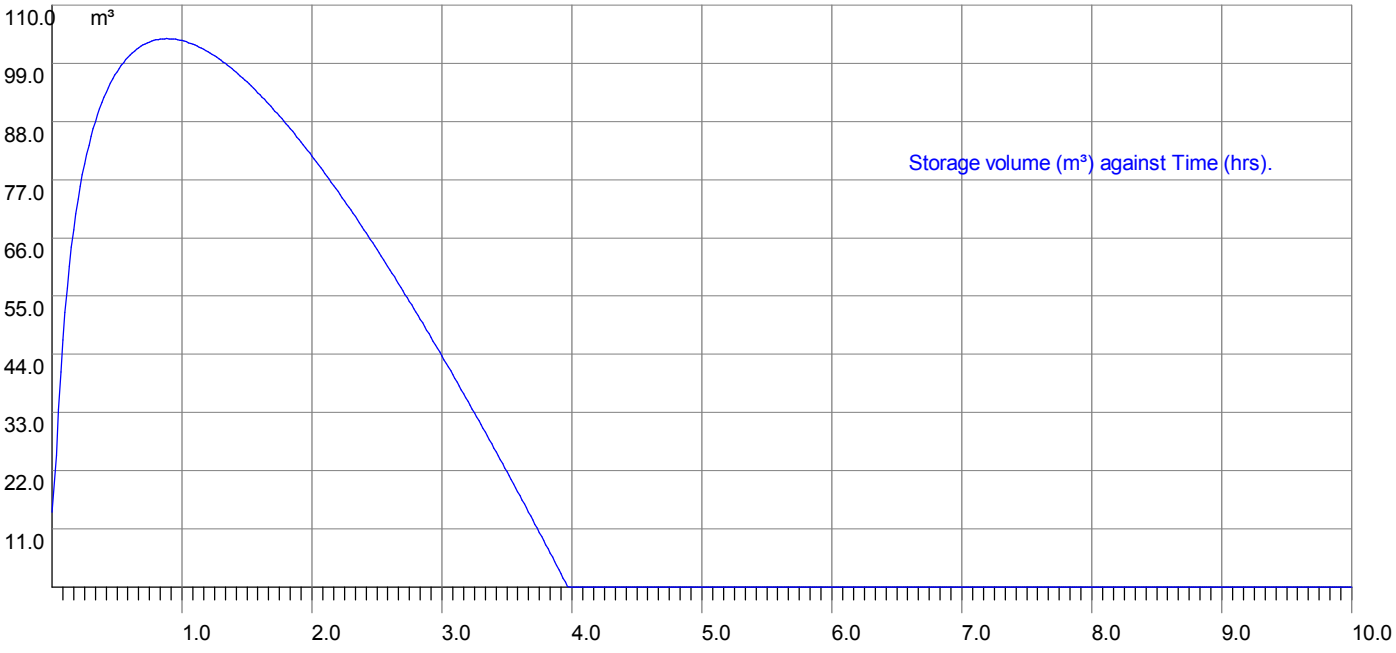
Job No.	
Sheet no.	3
Date	14/02/19

MasterDrain SW

Project	30 yr event	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		







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Job No.	
Sheet no.	1
Date	14/02/19

MasterDrain SW

Project	100 yr + 20% event	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

FSR Hydrology:-

Location = Radcliffe
M5-60 (mm) = 18.9
Soil index = 0.45
Return period = 100
UCWI = 113.8

Grid reference = SD7808
r = 0.32
SAAR (mm/yr) = 1100
WRAP = 4
Climate change = 20

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 11.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7

where

PIMP = Impervious Area*100/(Impervious Area+Pervious Area)

UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area = 2000 m²
Total area (TA) = 14500 m²
Allowed discharge rate = 22.700 l/s
Additional flow = 0.00 l/s

Pervious area = 12500 m²
Equiv area = 1595 m² (TA x RF).
Areal reduction factor = 1.000
Climate change factor = 20

Calculated data:-

Time to max = 71.0 mins
Rainfall at max = 41.10 mm/hr
Pipeline storage = 0.0 m³
Offline storage = 0.0 m³

Calculated storage volume = 185.4 m³
Allowed discharge rate = 22.700 l/s
Available MH storage = 0.0 m³

Fixed 6 hour data:-

Rainfall event = 6 hours
Rainfall rate = 13.00 mm/hr

Calculated storage volume = 0.0 m³
Allowed discharge rate = 22.700 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	23605.8	1125	186.5
150	10491.5	1200	163.9
225	4662.9	1275	145.2
300	2622.9	1350	129.5
375	1678.6	1425	116.2
450	1165.7	1500	104.9
525	856.4	1575	95.2
600	655.7	1650	86.7
675	518.1	1725	79.3
750	419.7	1800	72.9
825	346.8	1875	67.1
900	291.4	1950	62.1
975	248.3	2025	57.6
1050	214.1	2100	53.5

Ovoid	Len
400 x 600	1029.8
600 x 900	448.4
800 x 1200	252.2

Box culvert	Len
500 x 500	741.5
500 x 750	494.3
500 x 1000	370.7
750 x 1000	247.2
750 x 1200	206.0
750 x 1500	164.8
1000 x 1000	185.4
1000 x 1200	154.5
1000 x 1500	123.6
1000 x 1800	103.0
1000 x 2000	92.7
1500 x 1500	82.4
1500 x 1800	68.7
1500 x 2000	61.8

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Job No.		
Sheet no.	2	
Date	14/02/19	
By	Checked	Reviewed

MasterDrain SW

Project: 100 yr + 20% event

Title: Peak flow storage calcs for Radcliffe

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	125.0	120.476	13.620	106.856
20	88.0	170.942	27.240	143.702
30	70.0	203.771	40.860	162.911
40	59.0	228.644	54.480	174.164
50	51.0	248.830	68.100	180.730
60	46.0	265.888	81.720	184.168
70	41.0	280.688	95.340	185.348
80	38.0	293.771	108.960	184.811
90	35.0	305.499	122.580	182.919
100	33.0	316.123	136.200	179.923
110	31.0	325.830	149.820	176.010
120	29.0	334.760	163.440	171.320
130	27.0	343.022	177.060	165.962
140	26.0	350.703	190.680	160.023
150	25.0	357.872	204.300	153.572
160	24.0	364.587	217.920	146.667
170	23.0	370.897	231.540	139.357
180	22.0	376.841	245.160	131.681
190	21.0	382.454	258.780	123.674
200	20.0	387.765	272.400	115.365
210	19.0	392.801	286.020	106.781
220	19.0	397.583	299.640	97.943
230	18.0	402.131	313.260	88.871
240	18.0	406.463	326.880	79.583
250	17.0	410.594	340.500	70.094
260	17.0	415.029	354.120	60.909
270	16.0	419.228	367.740	51.488
280	16.0	423.302	381.360	41.942
290	15.0	427.261	394.980	32.281
300	15.0	431.110	408.600	22.510
310	15.0	434.858	422.220	12.638
320	14.0	438.509	435.840	2.669
330	14.0	442.068	449.460	0.000
340	14.0	445.542	463.080	0.000
350	13.0	448.934	476.700	0.000
360	13.0	452.248	490.320	0.000
370	13.0	455.489	503.940	0.000
380	12.0	458.660	517.560	0.000
390	12.0	461.764	531.180	0.000
400	12.0	464.804	544.800	0.000
410	12.0	467.783	558.420	0.000
420	12.0	470.705	572.040	0.000
430	11.0	473.570	585.660	0.000
440	11.0	476.382	599.280	0.000
450	11.0	479.142	612.900	0.000
460	11.0	481.853	626.520	0.000
470	11.0	484.517	640.140	0.000
480	10.0	487.136	653.760	0.000
490	10.0	489.710	667.380	0.000
500	10.0	492.243	681.000	0.000
510	10.0	494.734	694.620	0.000
520	10.0	497.186	708.240	0.000
530	10.0	499.601	721.860	0.000
540	10.0	501.978	735.480	0.000
550	9.0	504.320	749.100	0.000
560	9.0	506.628	762.720	0.000
570	9.0	508.902	776.340	0.000
580	9.0	511.145	789.960	0.000
590	9.0	513.356	803.580	0.000
600	9.0	515.537	817.200	0.000

Storage volume (m^3) = 185.4 m^3

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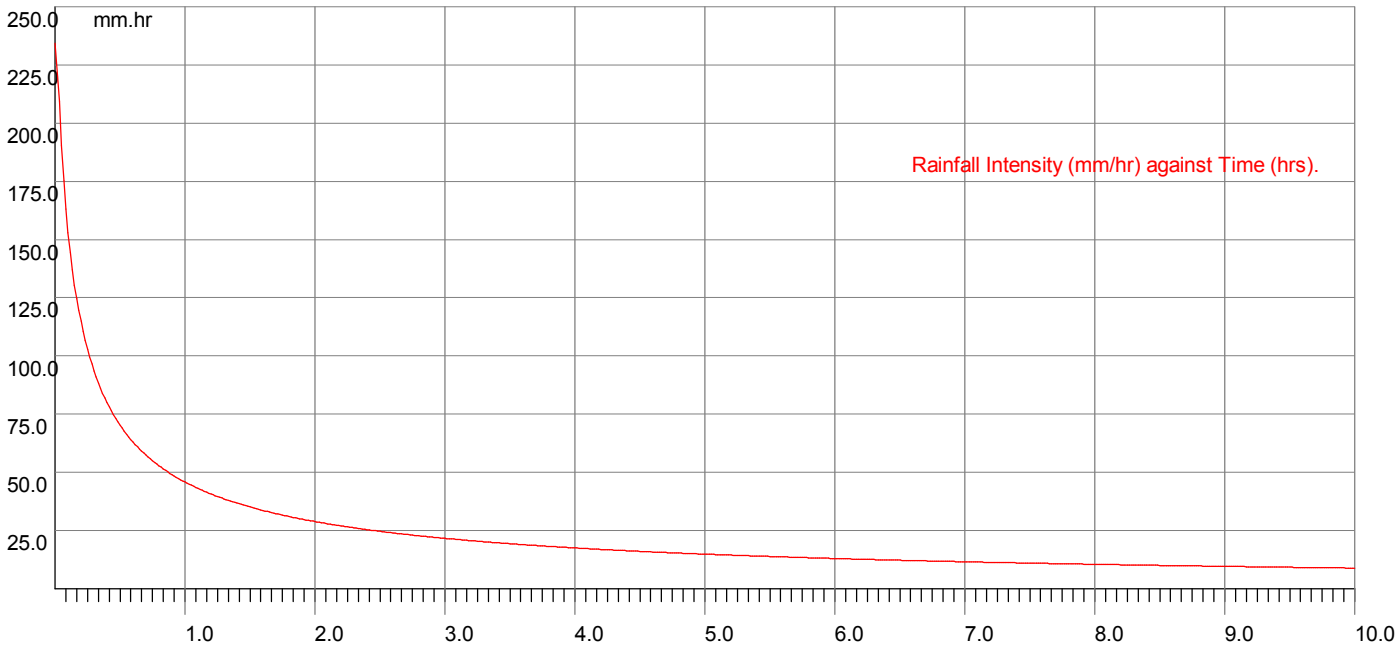
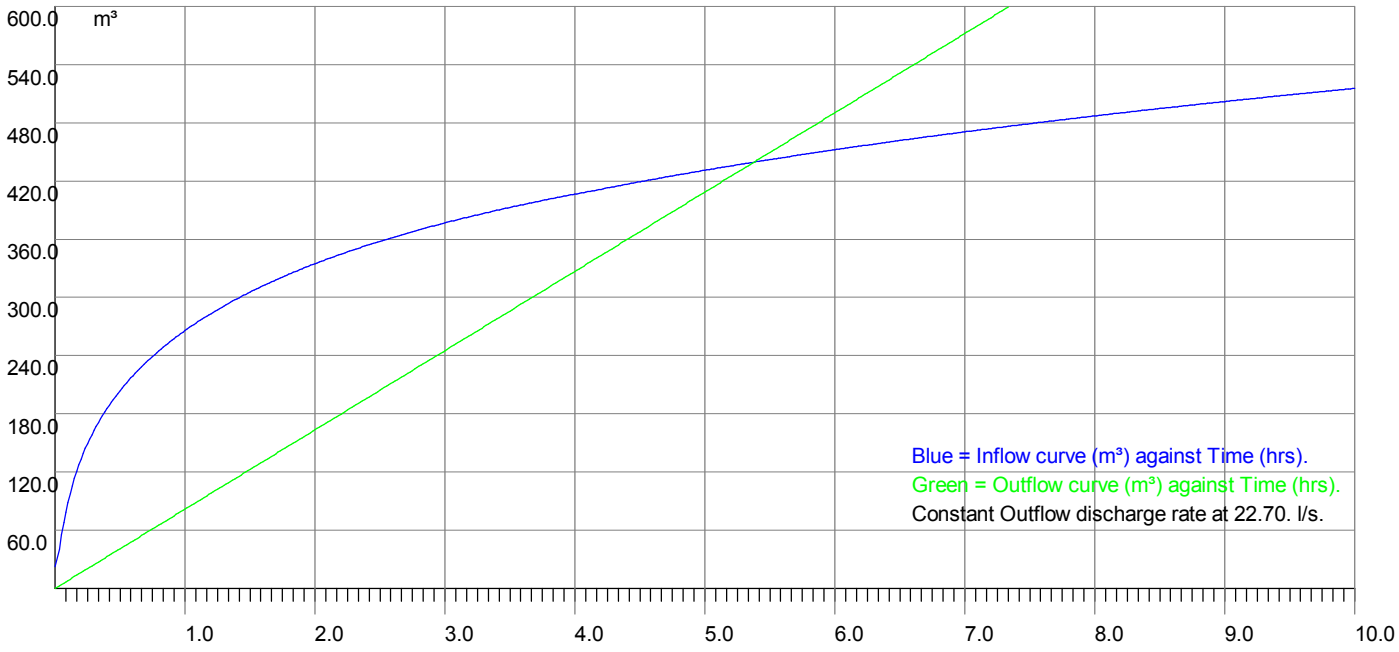
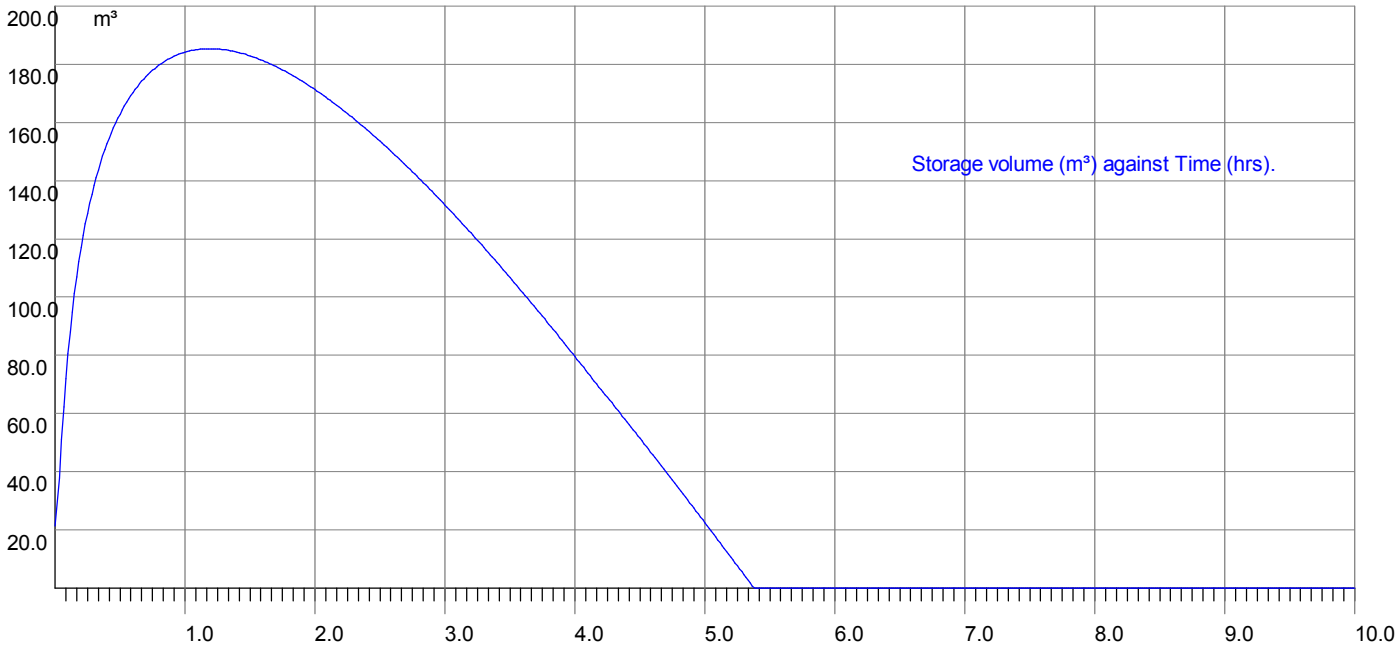
Job No.	
Sheet no.	3
Date	14/02/19

MasterDrain SW

Project	100 yr + 20% event	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		







MasterDrain SW

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Job No.	
Sheet no.	1
Date	14/02/19
Project	100 yr + 40% event
Title	Peak flow storage calcs for Radcliffe

By	Checked	Reviewed

Data:-

FSR Hydrology:-

Location = Radcliffe
M5-60 (mm) = 18.9
Soil index = 0.45
Return period = 100
UCWI = 113.8

Grid reference = SD7808
r = 0.32
SAAR (mm/yr) = 1100
WRAP = 4
Climate change = 40

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 11.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7

where

PIMP = Impervious Area*100/(Impervious Area+Pervious Area)

UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area = 2000 m²
Total area (TA) = 14500 m²
Allowed discharge rate = 22.700 l/s
Additional flow = 0.00 l/s

Pervious area = 12500 m²
Equiv area = 1595 m² (TA x RF).
Areal reduction factor = 1.000
Climate change factor = 40

Calculated data:-

Time to max = 85.0 mins
Rainfall at max = 42.57 mm/hr
Pipeline storage = 0.0 m³
Offline storage = 0.0 m³

Calculated storage volume = 234.0 m³
Allowed discharge rate = 22.700 l/s
Available MH storage = 0.0 m³

Fixed 6 hour data:-

Rainfall event = 6 hours
Rainfall rate = 15.00 mm/hr

Calculated storage volume = 27.5 m³
Allowed discharge rate = 22.700 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	29797.0	1125	235.4
150	13243.1	1200	206.9
225	5885.8	1275	183.3
300	3310.8	1350	163.5
375	2118.9	1425	146.7
450	1471.5	1500	132.4
525	1081.1	1575	120.1
600	827.7	1650	109.4
675	654.0	1725	100.1
750	529.7	1800	92.0
825	437.8	1875	84.8
900	367.9	1950	78.4
975	313.4	2025	72.7
1050	270.3	2100	67.6

Ovoid	Len
400 x 600	1299.9
600 x 900	566.0
800 x 1200	318.3

Box culvert	Len
500 x 500	935.9
500 x 750	624.0
500 x 1000	468.0
750 x 1000	312.0
750 x 1200	260.0
750 x 1500	208.0
1000 x 1000	234.0
1000 x 1200	195.0
1000 x 1500	156.0
1000 x 1800	130.0
1000 x 2000	117.0
1500 x 1500	104.0
1500 x 1800	86.7
1500 x 2000	78.0

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Job No.		
Sheet no.	2	
Date	14/02/19	
By	Checked	Reviewed

MasterDrain SW

Project: 100 yr + 40% event

Title: Peak flow storage calcs for Radcliffe

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	145.0	140.555	13.620	126.935
20	103.0	199.432	27.240	172.192
30	82.0	237.732	40.860	196.872
40	69.0	266.751	54.480	212.271
50	60.0	290.302	68.100	222.202
60	53.0	310.202	81.720	228.482
70	48.0	327.469	95.340	232.129
80	44.0	342.733	108.960	233.773
90	41.0	356.415	122.580	233.835
100	38.0	368.810	136.200	232.610
110	36.0	380.135	149.820	230.315
120	34.0	390.553	163.440	227.113
130	32.0	400.192	177.060	223.132
140	30.0	409.153	190.680	218.473
150	29.0	417.517	204.300	213.217
160	28.0	425.352	217.920	207.432
170	26.0	432.713	231.540	201.173
180	25.0	439.647	245.160	194.487
190	24.0	446.196	258.780	187.416
200	23.0	452.393	272.400	179.993
210	23.0	458.267	286.020	172.247
220	22.0	463.847	299.640	164.207
230	21.0	469.153	313.260	155.893
240	20.0	474.207	326.880	147.327
250	20.0	479.026	340.500	138.526
260	19.0	484.201	354.120	130.081
270	19.0	489.099	367.740	121.359
280	18.0	493.853	381.360	112.493
290	18.0	498.471	394.980	103.491
300	17.0	502.962	408.600	94.362
310	17.0	507.334	422.220	85.114
320	17.0	511.593	435.840	75.753
330	16.0	515.746	449.460	66.286
340	16.0	519.799	463.080	56.719
350	15.0	523.756	476.700	47.056
360	15.0	527.623	490.320	37.303
370	15.0	531.404	503.940	27.464
380	15.0	535.103	517.560	17.543
390	14.0	538.725	531.180	7.545
400	14.0	542.272	544.800	0.000
410	14.0	545.747	558.420	0.000
420	14.0	549.155	572.040	0.000
430	13.0	552.498	585.660	0.000
440	13.0	555.779	599.280	0.000
450	13.0	558.999	612.900	0.000
460	13.0	562.162	626.520	0.000
470	12.0	565.270	640.140	0.000
480	12.0	568.325	653.760	0.000
490	12.0	571.329	667.380	0.000
500	12.0	574.283	681.000	0.000
510	12.0	577.190	694.620	0.000
520	12.0	580.051	708.240	0.000
530	11.0	582.867	721.860	0.000
540	11.0	585.641	735.480	0.000
550	11.0	588.374	749.100	0.000
560	11.0	591.066	762.720	0.000
570	11.0	593.719	776.340	0.000
580	11.0	596.336	789.960	0.000
590	11.0	598.915	803.580	0.000
600	10.0	601.460	817.200	0.000

Storage volume (m^3) = 234.0 m^3

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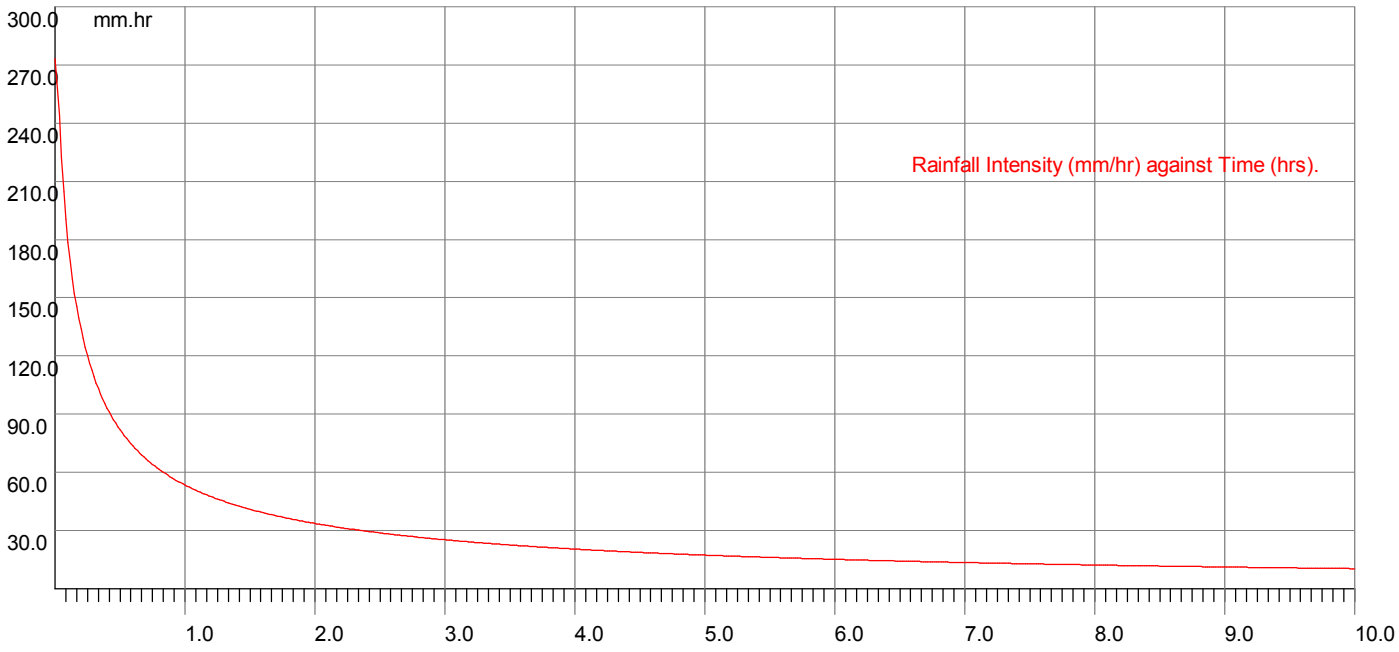
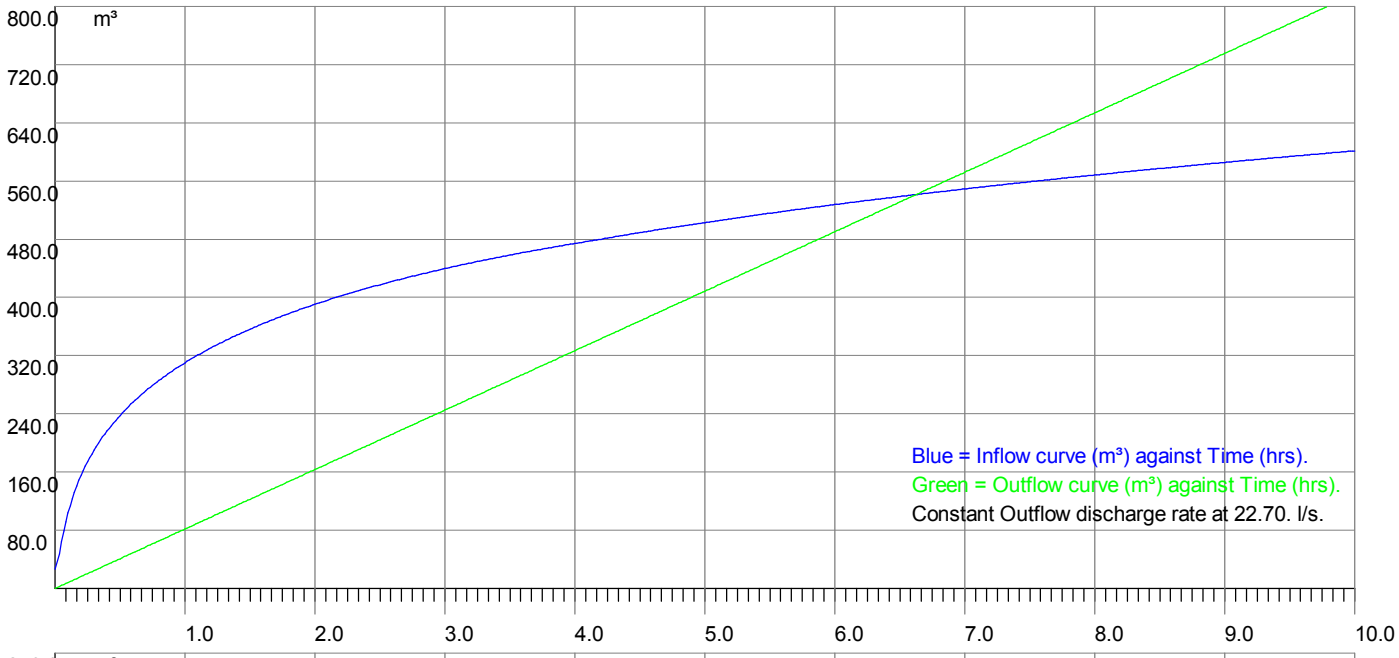
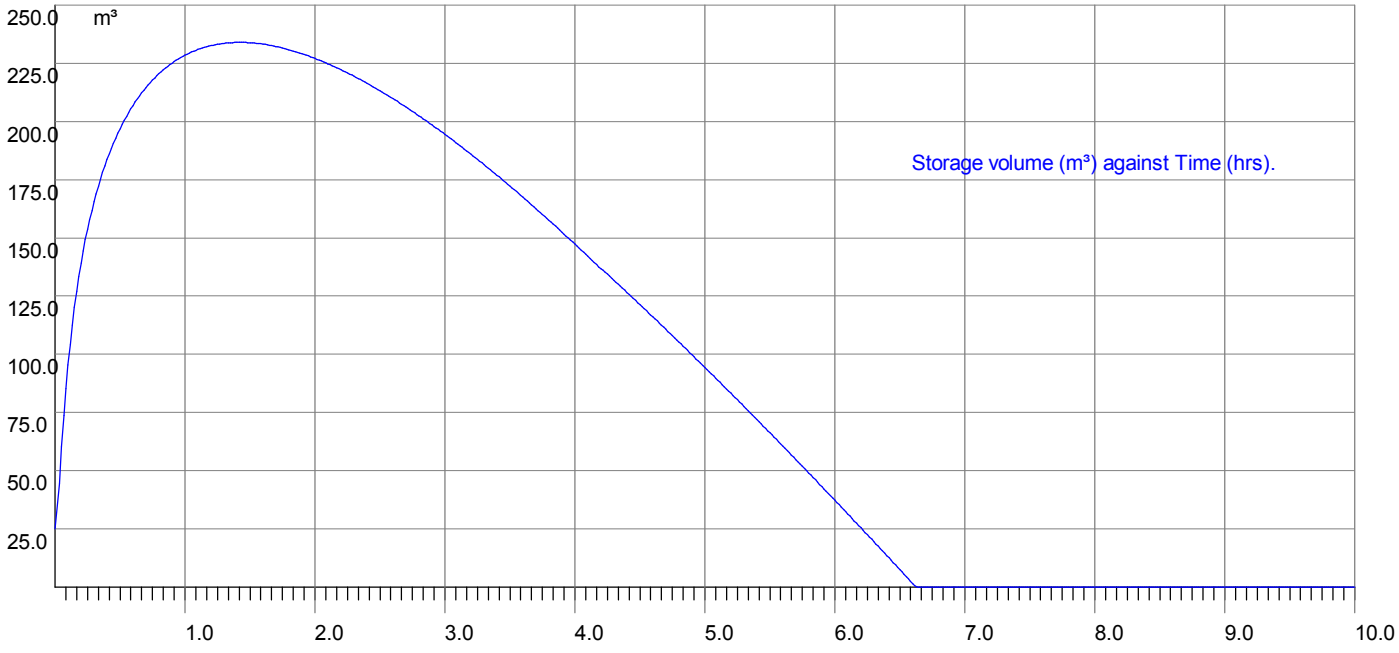
Job No.	
Sheet no.	3
Date	14/02/19

MasterDrain SW

Project	100 yr + 40% event	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		







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Job No.			
Sheet no.	1		
Date	31/07/18		
Project	Parcel D	By	Checked / Reviewed
Title	IoH 124 Runoff calcs for Radcliffe		

Hydrological Data:-

FSR Hydrology:-

Location = Radcliffe — Grid reference = SD7808
M5-60 (mm) = 18.9 — r = 0.32
Soil runoff = 0.45 — SAAR (mm/yr) = 1100
WRAP = 4 — Area = England & Wales
Hydrological area = 10 — Hydrological zone = 7

Soil classification for WRAP type 4
Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Design data:-

Area = 0.176 Km² - 17.6 Ha - 176000 m²

Calculation method:-

Runoff is calculated from:-

$$Q_{BAR(rural)} = 0.00108\ AREA^{0.89}\ .\ SAAR^{1.17}\ .\ SOIL^{2.17}$$

where

AREA = Site area in Km²
SAAR = Standard Average Annual Rainfall (mm/yr)
SOIL = Soil value derived from Winter Rainfall Acceptance Potential
$Q_{BAR(rural)}$ = Runoff (cumecs)

$Q_{BAR(rural)}$ is then multiplied by a growth factor - GC(T) - for different storm return periods derived from EA publication W5-074/A.

Calculated data:-

For areas less than 50Ha, a modified calculation which multiplies the 50Ha runoff value by the ratio of the site area to 50Ha is used
Reducing factor used for these calculations is 0.352

Mean Annual Peak Flow $Q_{BAR(rural)}$ = 131.20 l/s

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MasterDrain
HY 9.36

Project: Parcel D

Title: IoH 124 Runoff calcs for Radcliffe

Values for $Q_{BAR(rural)}$

Ret. per.	m³/hr	l/s	l/s/ha	Ret. per.	m³/hr	l/s	l/s/ha
1yr	401.487	111.524	6.337	100yr	991.909	275.530	15.655
2yr	439.274	122.021	6.933	100yr+20%	1190.291	330.636	18.786
5yr	571.529	158.758	9.020	100yr+30%	1289.482	358.189	20.352
10yr	651.826	181.063	10.288	200yr	1133.611	314.892	17.892
30yr	793.527	220.424	12.524	200yr + 30%	1473.694	409.359	23.259
50yr	873.825	242.729	13.791	500yr	1289.482	358.189	20.352
				1000yr	1435.907	398.863	22.663

Growth factors -

1yr	2yr	5yr	10yr	30yr	50yr	100yr	200yr	500yr	1000yr
0.85	0.93	1.21	1.38	1.68	1.85	2.10	2.40	2.73	3.04

The above is based on the Institute of Hydrology Report 124
to which you are referred for further details (see Sect 7).
Note that the 200 and above year growth curves were taken from W5-074.

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Job No.			
Sheet no.	1		
Date	01/08/18		
Project	30yr parcel D	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil index	= 0.45	SAAR (mm/yr)	= 1100
Return period	= 30	WRAP	= 4
UCWI	= 113.8	Climate change	= 0

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 44.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 94700 m²	Pervious area	= 81300 m²
Total area (TA)	= 176000 m²	Equiv area	= 77440 m² (TA x RF).
Allowed discharge rate	= 220.420 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s	Climate change factor	= 0

Calculated data:-

Time to max	= 60.0 mins	Calculated storage volume	= 1458.4 m³
Rainfall at max	= 29.08 mm/hr	Allowed discharge rate	= 220.420 l/s
Pipeline storage	= 0.0 m³	Available MH storage	= 0.0 m³
Offline storage	= 0.0 m³		

Fixed 6 hour data:-

Rainfall event	= 6 hours	Calculated storage volume	= 0.0 m³
Rainfall rate	= 8.00 mm/hr	Allowed discharge rate	= 220.420 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	185725.4	1125	1467.5
150	82544.6	1200	1289.8
225	36686.5	1275	1142.5
300	20636.2	1350	1019.1
375	13207.1	1425	914.6
450	9171.6	1500	825.4
525	6738.3	1575	748.7
600	5159.0	1650	682.2
675	4076.3	1725	624.2
750	3301.8	1800	573.2
825	2728.7	1875	528.3
900	2292.9	1950	488.4
975	1953.7	2025	452.9
1050	1684.6	2100	421.1

Ovoid	Len
400 x 600	8102.3
600 x 900	3527.8
800 x 1200	1984.1

Box culvert	Len
500 x 500	5833.6
500 x 750	3889.1
500 x 1000	2916.8
750 x 1000	1944.5
750 x 1200	1620.5
750 x 1500	1296.4
1000 x 1000	1458.4
1000 x 1200	1215.3
1000 x 1500	972.3
1000 x 1800	810.2
1000 x 2000	729.2
1500 x 1500	648.2
1500 x 1800	540.2
1500 x 2000	486.1

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Sheet no.	2
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By	Checked	Reviewed

MasterDrain SW

Project: 30yr parcel D

Title: Peak flow storage calcs for Radcliffe

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	81.0	1047.170	132.252	914.918
20	57.0	1465.710	264.504	1201.206
30	45.0	1737.239	396.756	1340.483
40	38.0	1942.881	529.008	1413.873
50	33.0	2110.121	661.260	1448.861
60	29.0	2251.921	793.512	1458.409
70	26.0	2375.476	925.764	1449.712
80	24.0	2485.225	1058.016	1427.209
90	22.0	2584.107	1190.268	1393.839
100	21.0	2674.181	1322.520	1351.661
110	19.0	2756.948	1454.772	1302.176
120	18.0	2833.542	1587.024	1246.518
130	17.0	2904.837	1719.276	1185.561
140	16.0	2971.531	1851.528	1120.003
150	16.0	3034.181	1983.780	1050.401
160	15.0	3093.249	2116.032	977.217
170	14.0	3149.115	2248.284	900.831
180	14.0	3202.099	2380.536	821.563
190	13.0	3252.475	2512.788	739.687
200	13.0	3300.477	2645.040	655.437
210	12.0	3346.308	2777.292	569.016
220	12.0	3390.142	2909.544	480.598
230	12.0	3432.136	3041.796	390.340
240	11.0	3472.426	3174.048	298.378
250	11.0	3511.132	3306.300	204.832
260	11.0	3550.943	3438.552	112.391
270	10.0	3589.052	3570.804	18.248
280	10.0	3626.084	3703.056	0.000
290	10.0	3662.105	3835.308	0.000
300	10.0	3697.178	3967.560	0.000
310	9.0	3731.358	4099.812	0.000
320	9.0	3764.696	4232.064	0.000
330	9.0	3797.238	4364.316	0.000
340	9.0	3829.027	4496.568	0.000
350	9.0	3860.101	4628.820	0.000
360	8.0	3890.496	4761.072	0.000
370	8.0	3920.247	4893.324	0.000
380	8.0	3949.382	5025.576	0.000
390	8.0	3977.932	5157.828	0.000
400	8.0	4005.922	5290.080	0.000
410	8.0	4033.377	5422.332	0.000
420	7.0	4060.320	5554.584	0.000
430	7.0	4086.772	5686.836	0.000
440	7.0	4112.753	5819.088	0.000
450	7.0	4138.283	5951.340	0.000
460	7.0	4163.379	6083.592	0.000
470	7.0	4188.057	6215.844	0.000
480	7.0	4212.333	6348.096	0.000
490	7.0	4236.222	6480.348	0.000
500	7.0	4259.738	6612.600	0.000
510	7.0	4282.894	6744.852	0.000
520	6.0	4305.701	6877.104	0.000
530	6.0	4328.173	7009.356	0.000
540	6.0	4350.320	7141.608	0.000
550	6.0	4372.152	7273.860	0.000
560	6.0	4393.681	7406.112	0.000
570	6.0	4414.915	7538.364	0.000
580	6.0	4435.863	7670.616	0.000
590	6.0	4456.534	7802.868	0.000
600	6.0	4476.937	7935.120	0.000

Storage volume (m^3) = 1458.4 m^3

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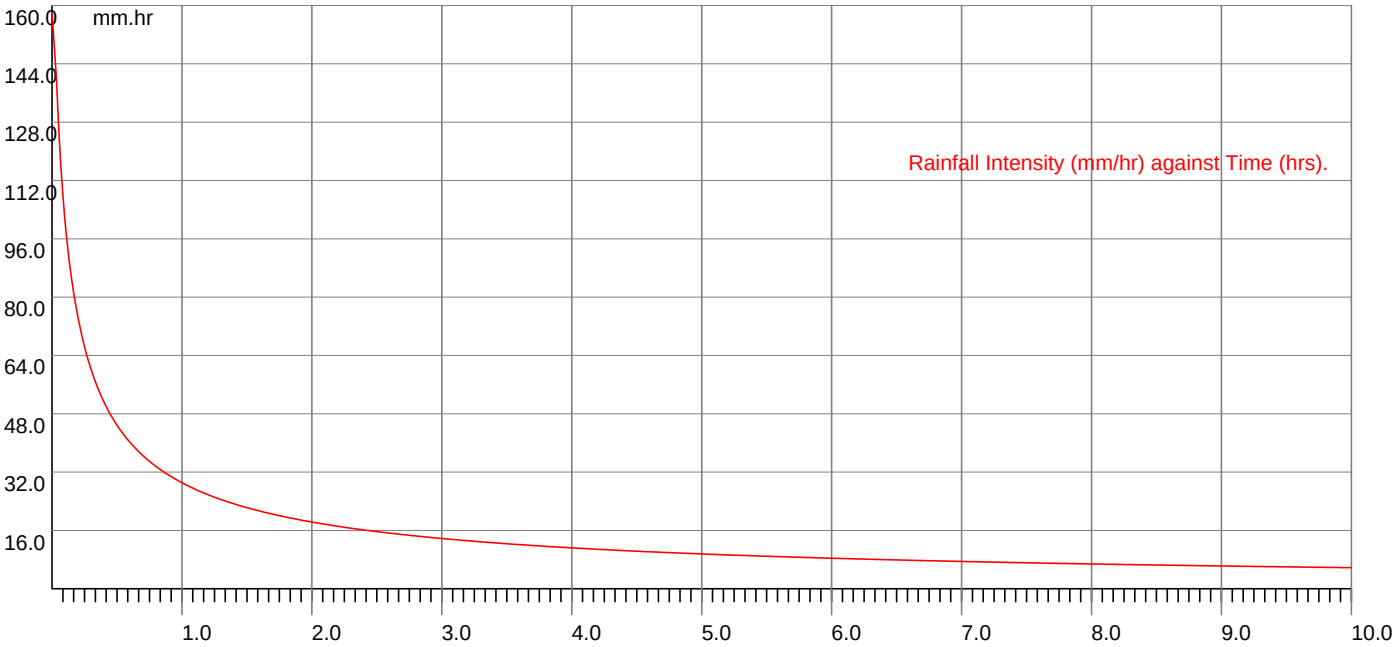
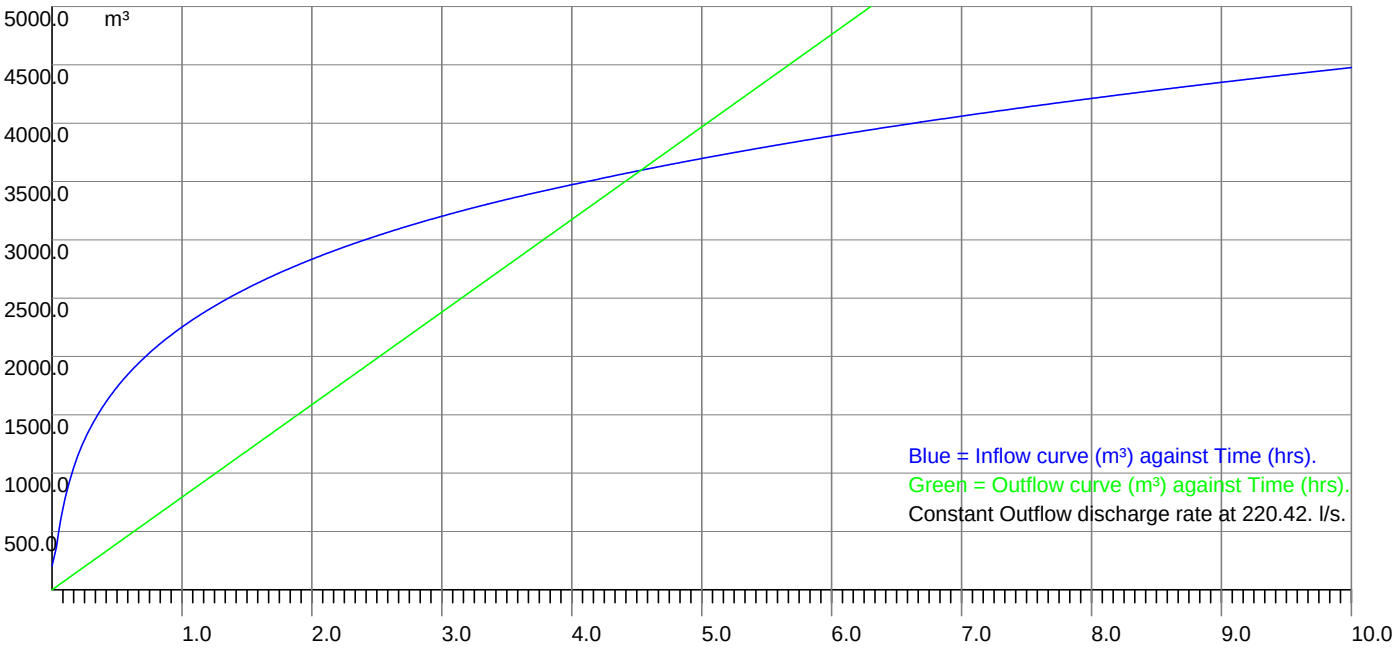
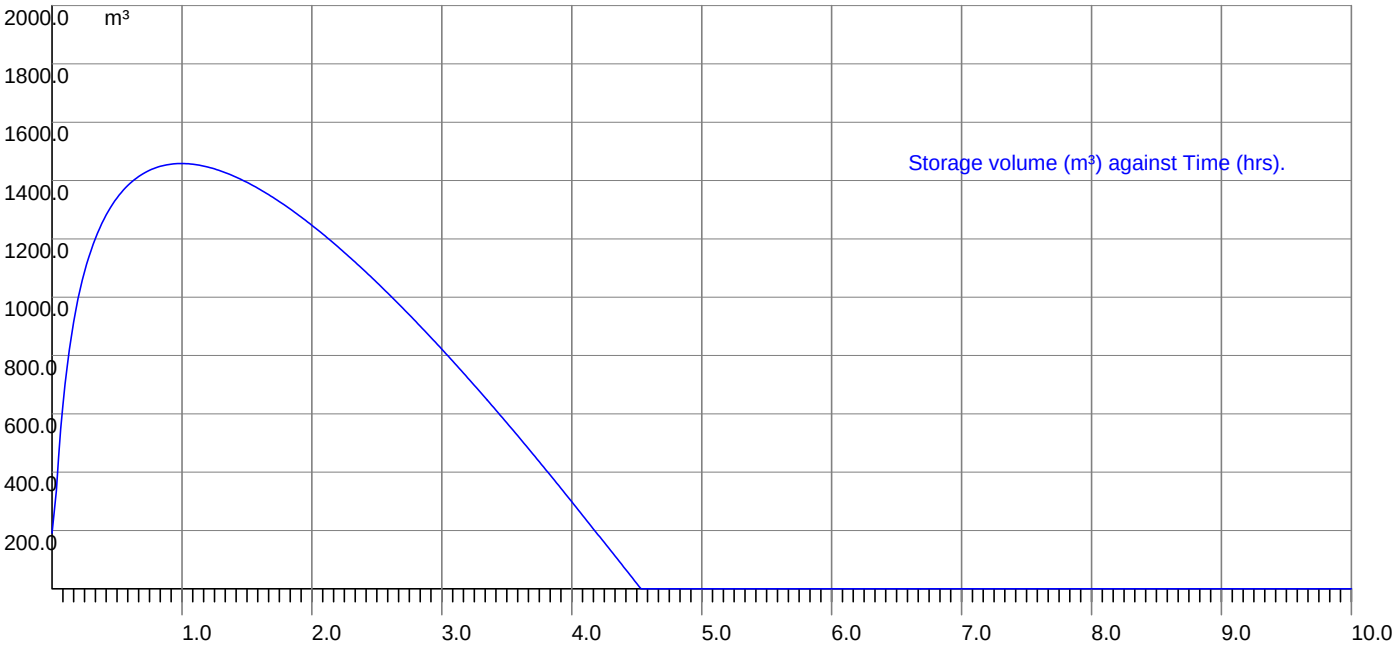
		Sheet no.	3
		Date	01/08/18
Project: **30yr parcel D**		By	Checked / Reviewed
Title: **Peak flow storage calcs for Radcliffe**			







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www.thelkgroup.com		Sheet no.	1	
		Date	01/08/18	
Project 100yr +20% parcel D		By	Checked	Reviewed
Title Peak flow storage calcs for Radcliffe				

Data:-

FSR Hydrology:-

Location = Radcliffe
M5-60 (mm) = 18.9
Soil index = 0.45
Return period = 100
UCWI = 113.8

Grid reference = SD7808
r = 0.32
SAAR (mm/yr) = 1100
WRAP = 4
Climate change = 20

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 44.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area = 94700 m²
Total area (TA) = 176000 m²
Allowed discharge rate = 257.530 l/s
Additional flow = 0.00 l/s

Pervious area = 81300 m²
Equiv area = 77440 m² (TA x RF).
Areal reduction factor = 1.000
Climate change factor = 20

Calculated data:-

Time to max = 86.0 mins
Rainfall at max = 36.20 mm/hr
Pipeline storage = 0.0 m³
Offline storage = 0.0 m³

Calculated storage volume = 2689.4 m³
Allowed discharge rate = 257.530 l/s
Available MH storage = 0.0 m³

Fixed 6 hour data:-

Rainfall event = 6 hours
Rainfall rate = 13.00 mm/hr

Calculated storage volume = 364.4 m³
Allowed discharge rate = 257.530 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	342487.2	1125	2706.1
150	152216.6	1200	2378.4
225	67651.8	1275	2106.8
300	38054.1	1350	1879.2
375	24354.7	1425	1686.6
450	16913.0	1500	1522.2
525	12425.8	1575	1380.6
600	9513.5	1650	1258.0
675	7516.9	1725	1151.0
750	6088.7	1800	1057.1
825	5032.0	1875	974.2
900	4228.2	1950	900.7
975	3602.8	2025	835.2
1050	3106.5	2100	776.6

Ovoid	Len
400 x 600	14941.0
600 x 900	6505.5
800 x 1200	3658.8

Box culvert	Len
500 x 500	10757.5
500 x 750	7171.7
500 x 1000	5378.8
750 x 1000	3585.8
750 x 1200	2988.2
750 x 1500	2390.6
1000 x 1000	2689.4
1000 x 1200	2241.2
1000 x 1500	1792.9
1000 x 1800	1494.1
1000 x 2000	1344.7
1500 x 1500	1195.3
1500 x 1800	996.1
1500 x 2000	896.5

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Sheet no.	2
Date	01/08/18

MasterDrain SW

Project	100yr +20% parcel D	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	125.0	1608.561	154.518	1454.043
20	88.0	2282.364	309.036	1973.328
30	70.0	2720.690	463.554	2257.136
40	59.0	3052.793	618.072	2434.721
50	51.0	3322.315	772.590	2549.725
60	46.0	3550.060	927.108	2622.952
70	41.0	3747.667	1081.626	2666.041
80	38.0	3922.356	1236.144	2686.212
90	35.0	4078.936	1390.662	2688.273
100	33.0	4220.789	1545.180	2675.609
110	31.0	4350.395	1699.698	2650.697
120	29.0	4469.625	1854.216	2615.409
130	27.0	4579.935	2008.734	2571.201
140	26.0	4682.484	2163.252	2519.232
150	25.0	4778.204	2317.770	2460.434
160	24.0	4867.865	2472.288	2395.577
170	23.0	4952.108	2626.806	2325.302
180	22.0	5031.471	2781.324	2250.147
190	21.0	5106.414	2935.842	2170.572
200	20.0	5177.332	3090.360	2086.972
210	19.0	5244.566	3244.878	1999.688
220	19.0	5308.416	3399.396	1909.020
230	18.0	5369.143	3553.914	1815.229
240	18.0	5426.980	3708.432	1718.549
250	17.0	5482.134	3862.950	1619.184
260	17.0	5541.357	4017.468	1523.889
270	16.0	5597.413	4171.986	1425.427
280	16.0	5651.814	4326.504	1325.311
290	15.0	5704.667	4481.022	1223.646
300	15.0	5756.068	4635.540	1120.528
310	15.0	5806.102	4790.058	1016.043
320	14.0	5854.846	4944.576	910.270
330	14.0	5902.375	5099.094	803.282
340	14.0	5948.755	5253.612	695.143
350	13.0	5994.043	5408.130	585.913
360	13.0	6038.297	5562.648	475.649
370	13.0	6081.567	5717.166	364.401
380	12.0	6123.902	5871.684	252.218
390	12.0	6165.345	6026.202	139.143
400	12.0	6205.938	6180.720	25.218
410	12.0	6245.715	6335.238	0.000
420	12.0	6284.717	6489.756	0.000
430	11.0	6322.974	6644.274	0.000
440	11.0	6360.516	6798.792	0.000
450	11.0	6397.373	6953.310	0.000
460	11.0	6433.574	7107.828	0.000
470	11.0	6469.143	7262.346	0.000
480	10.0	6504.102	7416.864	0.000
490	10.0	6538.476	7571.382	0.000
500	10.0	6572.287	7725.900	0.000
510	10.0	6605.553	7880.418	0.000
520	10.0	6638.293	8034.936	0.000
530	10.0	6670.528	8189.454	0.000
540	10.0	6702.273	8343.972	0.000
550	9.0	6733.544	8498.490	0.000
560	9.0	6764.356	8653.008	0.000
570	9.0	6794.725	8807.526	0.000
580	9.0	6824.664	8962.044	0.000
590	9.0	6854.188	9116.562	0.000
600	9.0	6883.306	9271.080	0.000

Storage volume (m^3) = 2689.4 m^3

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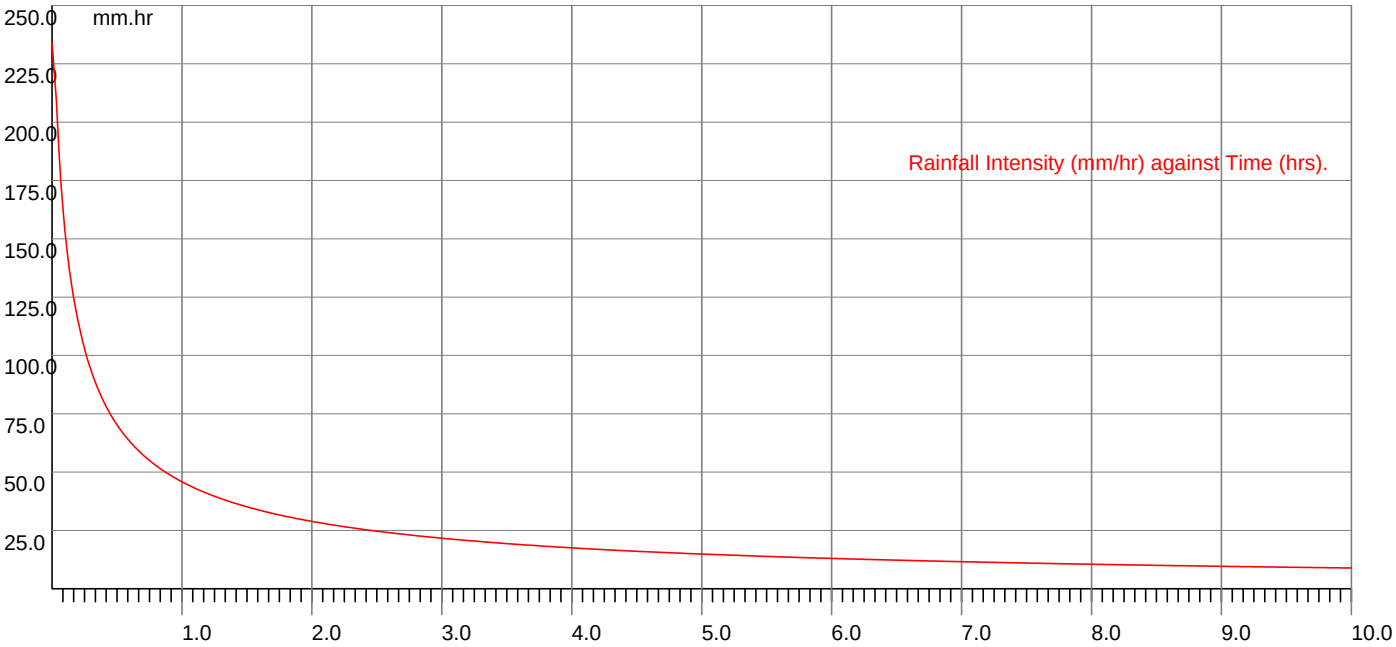
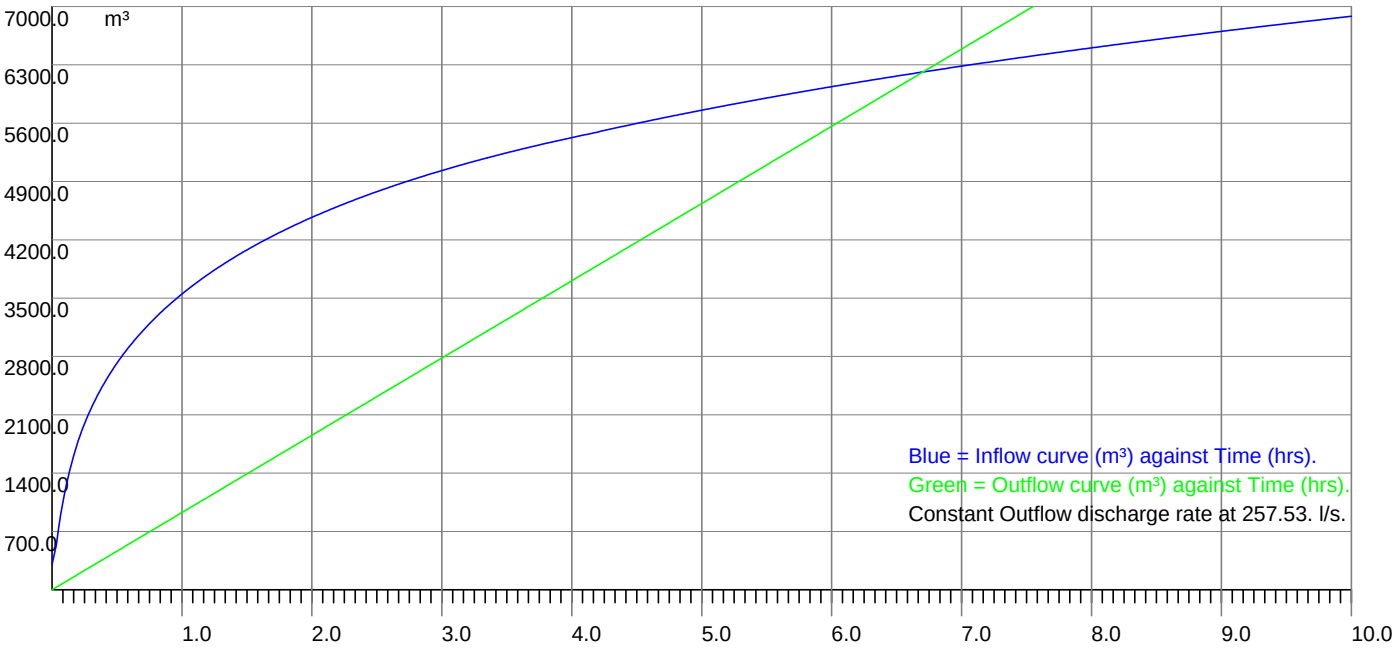
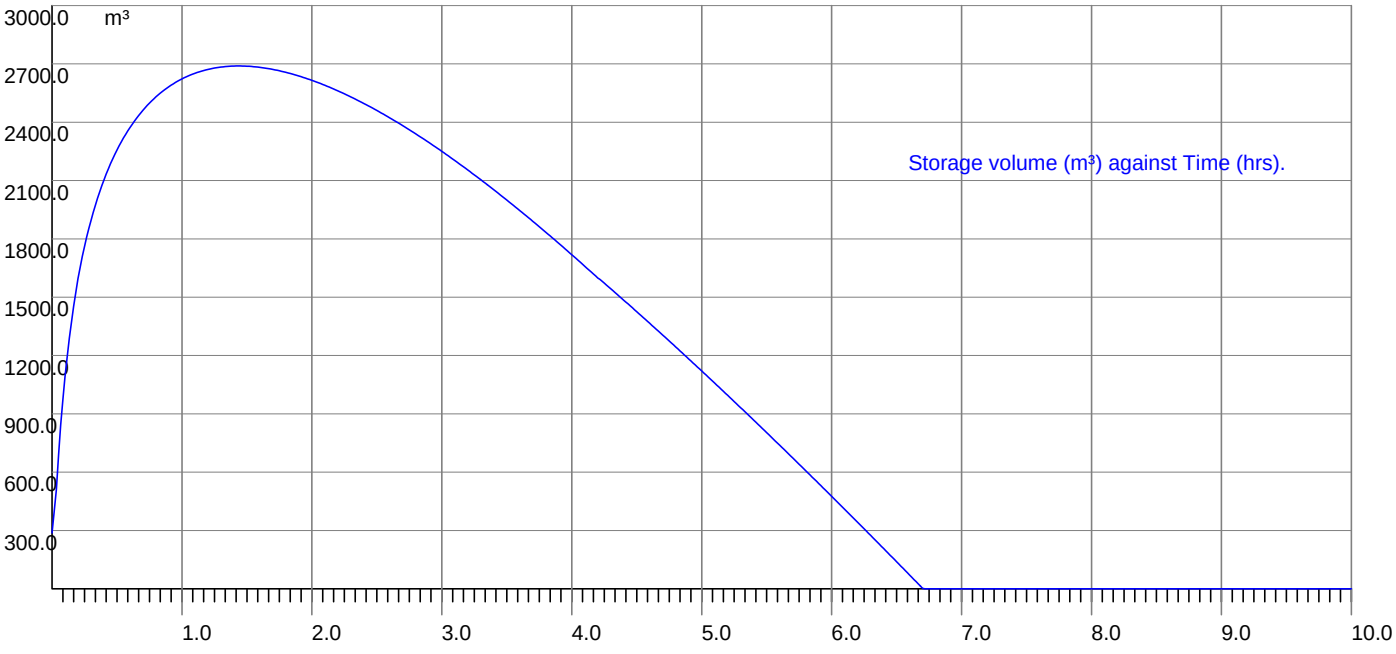
	Project **100yr +20% parcel D**		By / Checked / Reviewed
	Title **Peak flow storage calcs for Radcliffe**		







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Job No.	
Sheet no.	1
Date	01/08/18

MasterDrain SW

Project	100yr +40% parcel D	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil index	= 0.45	SAAR (mm/yr)	= 1100
Return period	= 100	WRAP	= 4
UCWI	= 113.8	Climate change	= 40

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 44.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 94700 m²	Pervious area	= 81300 m²
Total area (TA)	= 176000 m²	Equiv area	= 77440 m² (TA x RF).
Allowed discharge rate	= 257.530 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s	Climate change factor	= 40

Calculated data:-

Time to max	= 102.0 mins	Calculated storage volume	= 3379.5 m³
Rainfall at max	= 37.64 mm/hr	Allowed discharge rate	= 257.530 l/s
Pipeline storage	= 0.0 m³	Available MH storage	= 0.0 m³
Offline storage	= 0.0 m³		

Fixed 6 hour data:-

Rainfall event	= 6 hours	Calculated storage volume	= 1378.0 m³
Rainfall rate	= 15.00 mm/hr	Allowed discharge rate	= 257.530 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	430369.5	1125	3400.5
150	191275.3	1200	2988.7
225	85011.3	1275	2647.4
300	47818.8	1350	2361.4
375	30604.1	1425	2119.4
450	21252.8	1500	1912.8
525	15614.3	1575	1734.9
600	11954.7	1650	1580.8
675	9445.7	1725	1446.3
750	7651.0	1800	1328.3
825	6323.2	1875	1224.2
900	5313.2	1950	1131.8
975	4527.2	2025	1049.5
1050	3903.6	2100	975.9

Ovoid	Len
400 x 600	18774.9
600 x 900	8174.8
800 x 1200	4597.7

Box culvert	Len
500 x 500	13517.9
500 x 750	9011.9
500 x 1000	6759.0
750 x 1000	4506.0
750 x 1200	3755.0
750 x 1500	3004.0
1000 x 1000	3379.5
1000 x 1200	2816.2
1000 x 1500	2253.0
1000 x 1800	1877.5
1000 x 2000	1689.7
1500 x 1500	1502.0
1500 x 1800	1251.7
1500 x 2000	1126.5

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Sheet no.	2
Date	01/08/18
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MasterDrain SW

Project: 100yr +40% parcel D

Title: Peak flow storage calcs for Radcliffe

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	145.0	1876.655	154.518	1722.137
20	103.0	2662.758	309.036	2353.722
30	82.0	3174.138	463.554	2710.584
40	69.0	3561.592	618.072	2943.520
50	60.0	3876.034	772.590	3103.444
60	53.0	4141.736	927.108	3214.628
70	48.0	4372.278	1081.626	3290.652
80	44.0	4576.082	1236.144	3339.938
90	41.0	4758.758	1390.662	3368.096
100	38.0	4924.254	1545.180	3379.074
110	36.0	5075.460	1699.698	3375.762
120	34.0	5214.562	1854.216	3360.346
130	32.0	5343.257	2008.734	3334.523
140	30.0	5462.897	2163.252	3299.646
150	29.0	5574.571	2317.770	3256.801
160	28.0	5679.176	2472.288	3206.888
170	26.0	5777.459	2626.806	3150.654
180	25.0	5870.049	2781.324	3088.725
190	24.0	5957.483	2935.842	3021.641
200	23.0	6040.220	3090.360	2949.860
210	23.0	6118.660	3244.878	2873.782
220	22.0	6193.151	3399.396	2793.755
230	21.0	6264.000	3553.914	2710.086
240	20.0	6331.477	3708.432	2623.045
250	20.0	6395.823	3862.950	2532.873
260	19.0	6464.916	4017.468	2447.448
270	19.0	6530.314	4171.986	2358.329
280	18.0	6593.783	4326.504	2267.279
290	18.0	6655.445	4481.022	2174.423
300	17.0	6715.412	4635.540	2079.872
310	17.0	6773.785	4790.058	1983.727
320	17.0	6830.653	4944.576	1886.077
330	16.0	6886.104	5099.094	1787.011
340	16.0	6940.213	5253.612	1686.602
350	15.0	6993.050	5408.130	1584.920
360	15.0	7044.679	5562.648	1482.031
370	15.0	7095.162	5717.166	1377.996
380	15.0	7144.552	5871.684	1272.868
390	14.0	7192.902	6026.202	1166.700
400	14.0	7240.260	6180.720	1059.541
410	14.0	7286.668	6335.238	951.430
420	14.0	7332.169	6489.756	842.414
430	13.0	7376.802	6644.274	732.528
440	13.0	7420.601	6798.792	621.809
450	13.0	7463.602	6953.310	510.292
460	13.0	7505.836	7107.828	398.008
470	12.0	7547.333	7262.346	284.986
480	12.0	7588.118	7416.864	171.254
490	12.0	7628.222	7571.382	56.840
500	12.0	7667.668	7725.900	0.000
510	12.0	7706.478	7880.418	0.000
520	12.0	7744.675	8034.936	0.000
530	11.0	7782.283	8189.454	0.000
540	11.0	7819.318	8343.972	0.000
550	11.0	7855.801	8498.490	0.000
560	11.0	7891.749	8653.008	0.000
570	11.0	7927.179	8807.526	0.000
580	11.0	7962.107	8962.044	0.000
590	11.0	7996.551	9116.562	0.000
600	10.0	8030.523	9271.080	0.000

Storage volume (m^3) = 3379.5 m^3

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Sheet no.	3
Date	01/08/18

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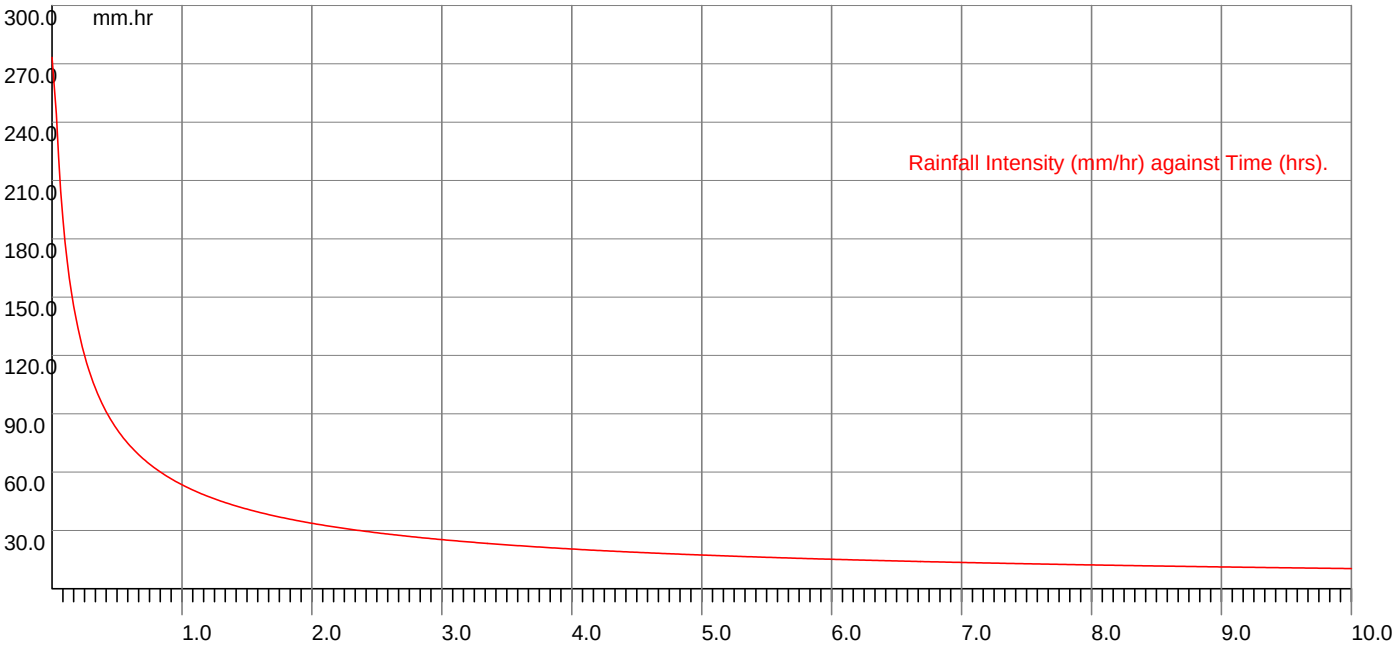
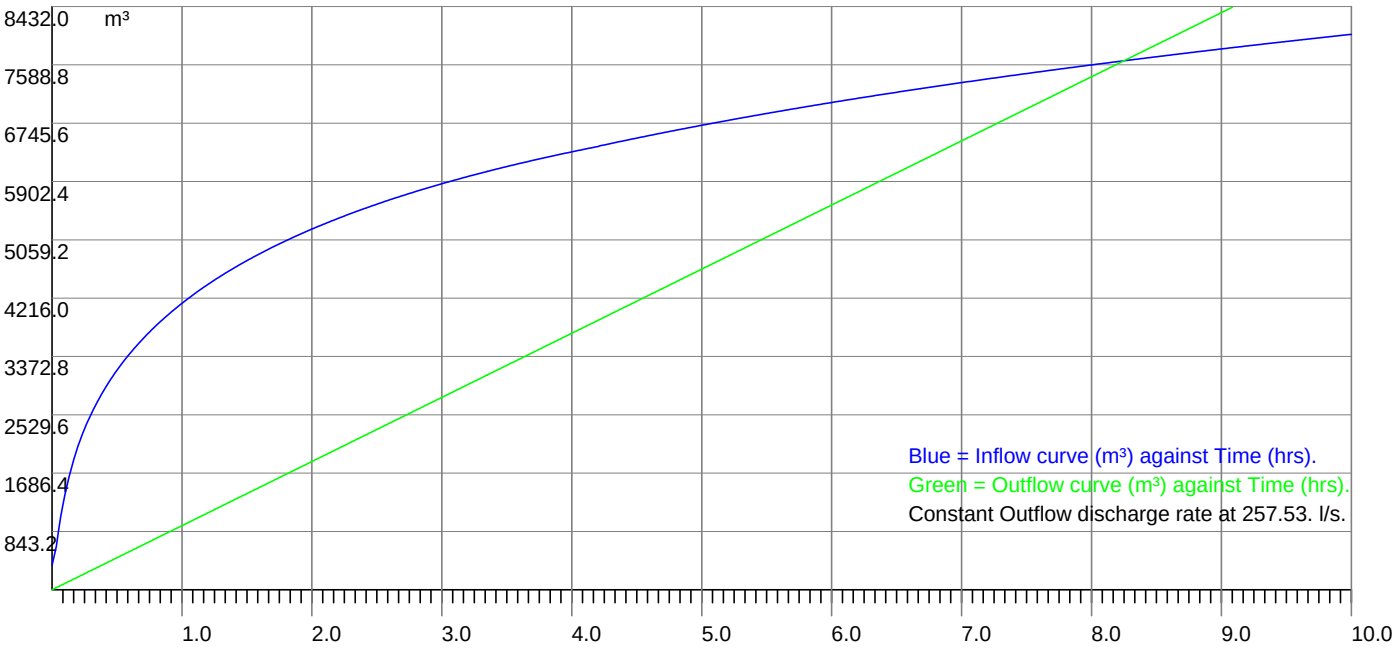
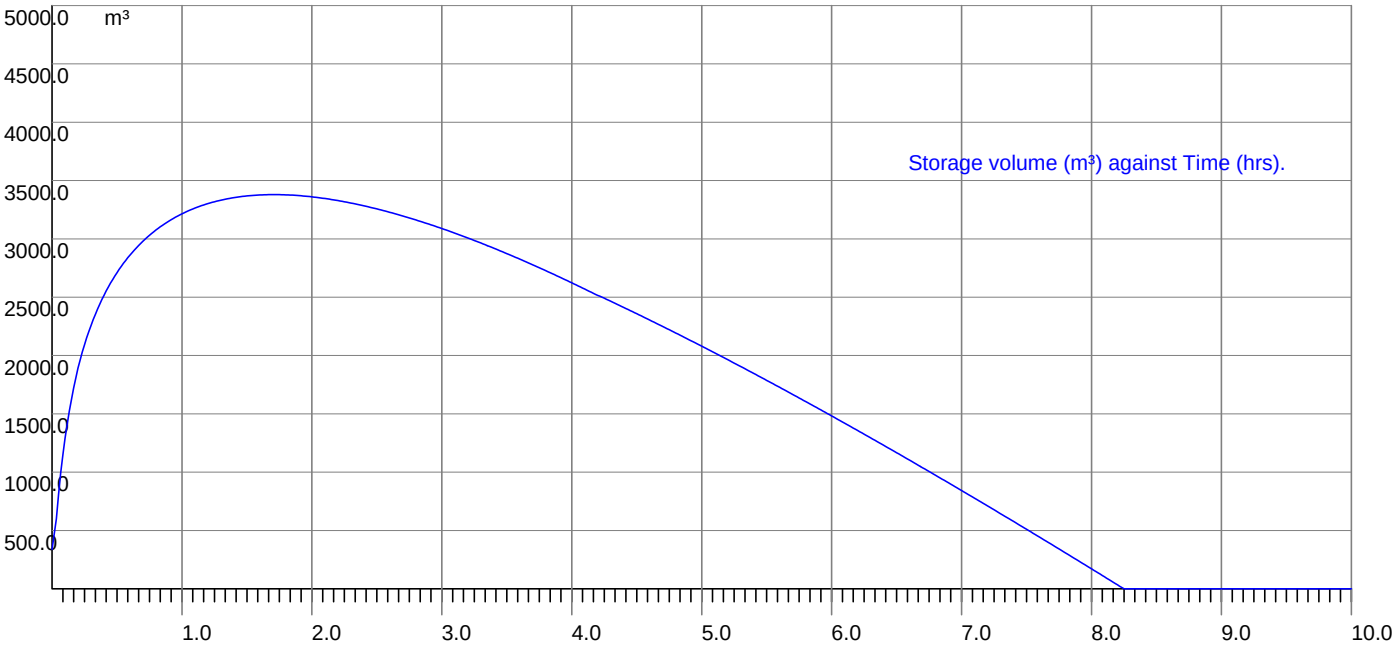
Project	100yr +40% parcel D	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		







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Job No.			
Sheet no.	1		
Date	31/07/18		
Project	Parcel E north	By	Checked / Reviewed
Title	IoH 124 Runoff calcs for Radcliffe		

Hydrological Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil runoff	= 0.45	SAAR (mm/yr)	= 1100
WRAP	= 4	Area	= England & Wales
Hydrological area	= 10	Hydrological zone	= 7

Soil classification for WRAP type 4
Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Design data:-

Area = 0.1337 Km² - 13.37 Ha - 133700 m²

Calculation method:-

Runoff is calculated from:-

$$Q_{BAR(rural)} = 0.00108\ AREA^{0.89}\ .\ SAAR^{1.17}\ .\ SOIL^{2.17}$$

where

AREA = Site area in Km²
SAAR = Standard Average Annual Rainfall (mm/yr)
SOIL = Soil value derived from Winter Rainfall Acceptance Potential
$Q_{BAR(rural)}$ = Runoff (cumecs)

$Q_{BAR(rural)}$ is then multiplied by a growth factor - GC(T) - for different storm return periods derived from EA publication W5-074/A.

Calculated data:-

For areas less than 50Ha, a modified calculation which multiplies the 50Ha runoff value by the ratio of the site area to 50Ha is used
Reducing factor used for these calculations is 0.267

Mean Annual Peak Flow $Q_{BAR(rural)}$ = 99.67 l/s

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Date	31/07/18

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Project: Parcel E north

Title: IoH 124 Runoff calcs for Radcliffe

Values for $Q_{BAR(rural)}$

Ret. per.	m³/hr	l/s	l/s/ha	Ret. per.	m³/hr	l/s	l/s/ha
1yr	304.993	84.720	6.337	100yr	753.513	209.309	15.655
2yr	333.699	92.694	6.933	100yr+20%	904.215	251.171	18.786
5yr	434.167	120.602	9.020	100yr+30%	979.567	272.102	20.352
10yr	495.166	137.546	10.288	200yr	861.158	239.210	17.892
30yr	602.810	167.447	12.524	200yr + 30%	1119.505	310.974	23.259
50yr	663.809	184.391	13.791	500yr	979.567	272.102	20.352
				1000yr	1090.799	303.000	22.663

Growth factors -

1yr	2yr	5yr	10yr	30yr	50yr	100yr	200yr	500yr	1000yr
0.85	0.93	1.21	1.38	1.68	1.85	2.10	2.40	2.73	3.04

The above is based on the Institute of Hydrology Report 124
to which you are referred for further details (see Sect 7).
Note that the 200 and above year growth curves were taken from W5-074.

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Job No.			
Sheet no.	1		
Date	01/08/18		
Project	30yr Parcel E north	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil index	= 0.45	SAAR (mm/yr)	= 1100
Return period	= 30	WRAP	= 4
UCWI	= 113.8	Climate change	= 0

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 41.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 66400 m²	Pervious area	= 67300 m²
Total area (TA)	= 133700 m²	Equiv area	= 54817 m² (TA x RF).
Allowed discharge rate	= 167.450 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s	Climate change factor	= 0

Calculated data:-

Time to max	= 53.0 mins	Calculated storage volume	= 955.7 m³
Rainfall at max	= 31.50 mm/hr	Allowed discharge rate	= 167.450 l/s
Pipeline storage	= 0.0 m³	Available MH storage	= 0.0 m³
Offline storage	= 0.0 m³		

Fixed 6 hour data:-

Rainfall event	= 6 hours	Calculated storage volume	= 0.0 m³
Rainfall rate	= 8.00 mm/hr	Allowed discharge rate	= 167.450 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	121706.8	1125	961.6
150	54091.9	1200	845.2
225	24040.8	1275	748.7
300	13523.0	1350	667.8
375	8654.7	1425	599.4
450	6010.2	1500	540.9
525	4415.7	1575	490.6
600	3380.7	1650	447.0
675	2671.2	1725	409.0
750	2163.7	1800	375.6
825	1788.2	1875	346.2
900	1502.6	1950	320.1
975	1280.3	2025	296.8
1050	1103.9	2100	276.0

Ovoid	Len
400 x 600	5309.5
600 x 900	2311.8
800 x 1200	1300.2

Box culvert	Len
500 x 500	3822.8
500 x 750	2548.5
500 x 1000	1911.4
750 x 1000	1274.3
750 x 1200	1061.9
750 x 1500	849.5
1000 x 1000	955.7
1000 x 1200	796.4
1000 x 1500	637.1
1000 x 1800	530.9
1000 x 2000	477.9
1500 x 1500	424.8
1500 x 1800	354.0
1500 x 2000	318.6

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Date	01/08/18
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Project: 30yr Parcel E north

Title: Peak flow storage calcs for Radcliffe

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	81.0	723.174	100.470	622.704
20	57.0	1012.218	200.940	811.278
30	45.0	1199.736	301.410	898.326
40	38.0	1341.752	401.880	939.872
50	33.0	1457.248	502.350	954.898
60	29.0	1555.175	602.820	952.355
70	26.0	1640.502	703.290	937.212
80	24.0	1716.295	803.760	912.535
90	22.0	1784.582	904.230	880.352
100	21.0	1846.787	1004.700	842.087
110	19.0	1903.946	1105.170	798.776
120	18.0	1956.841	1205.640	751.201
130	17.0	2006.078	1306.110	699.968
140	16.0	2052.137	1406.580	645.557
150	16.0	2095.403	1507.050	588.353
160	15.0	2136.195	1607.520	528.675
170	14.0	2174.776	1707.990	466.786
180	14.0	2211.367	1808.460	402.907
190	13.0	2246.156	1908.930	337.227
200	13.0	2279.307	2009.400	269.907
210	12.0	2310.957	2109.870	201.087
220	12.0	2341.229	2210.340	130.889
230	12.0	2370.230	2310.810	59.420
240	11.0	2398.054	2411.280	0.000
250	11.0	2424.785	2511.750	0.000
260	11.0	2452.278	2612.220	0.000
270	10.0	2478.596	2712.690	0.000
280	10.0	2504.171	2813.160	0.000
290	10.0	2529.046	2913.630	0.000
300	10.0	2553.268	3014.100	0.000
310	9.0	2576.873	3114.570	0.000
320	9.0	2599.896	3215.040	0.000
330	9.0	2622.369	3315.510	0.000
340	9.0	2644.323	3415.980	0.000
350	9.0	2665.782	3516.450	0.000
360	8.0	2686.774	3616.920	0.000
370	8.0	2707.319	3717.390	0.000
380	8.0	2727.440	3817.860	0.000
390	8.0	2747.157	3918.330	0.000
400	8.0	2766.487	4018.800	0.000
410	8.0	2785.447	4119.270	0.000
420	7.0	2804.054	4219.740	0.000
430	7.0	2822.321	4320.210	0.000
440	7.0	2840.264	4420.680	0.000
450	7.0	2857.895	4521.150	0.000
460	7.0	2875.226	4621.620	0.000
470	7.0	2892.269	4722.090	0.000
480	7.0	2909.034	4822.560	0.000
490	7.0	2925.531	4923.030	0.000
500	7.0	2941.771	5023.500	0.000
510	7.0	2957.763	5123.970	0.000
520	6.0	2973.513	5224.440	0.000
530	6.0	2989.033	5324.910	0.000
540	6.0	3004.327	5425.380	0.000
550	6.0	3019.405	5525.850	0.000
560	6.0	3034.272	5626.320	0.000
570	6.0	3048.936	5726.790	0.000
580	6.0	3063.403	5827.260	0.000
590	6.0	3077.679	5927.730	0.000
600	6.0	3091.769	6028.200	0.000

Storage volume (m^3) = 955.7 m^3

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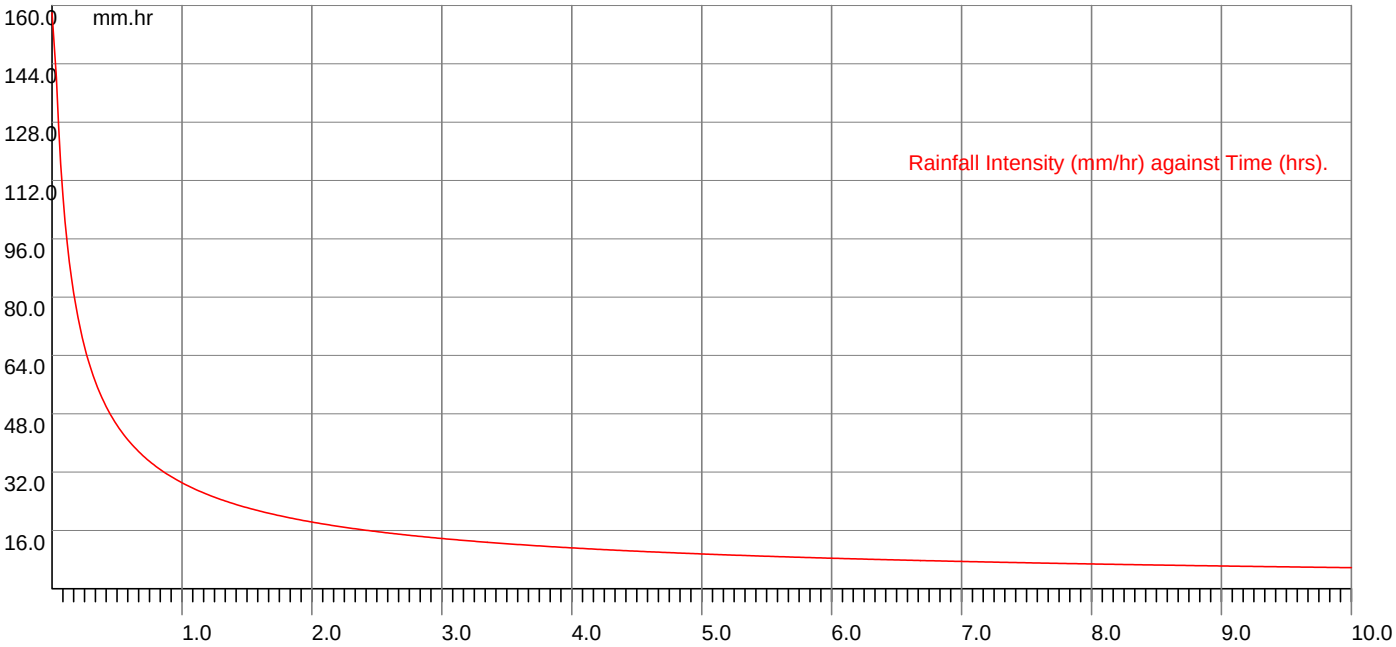
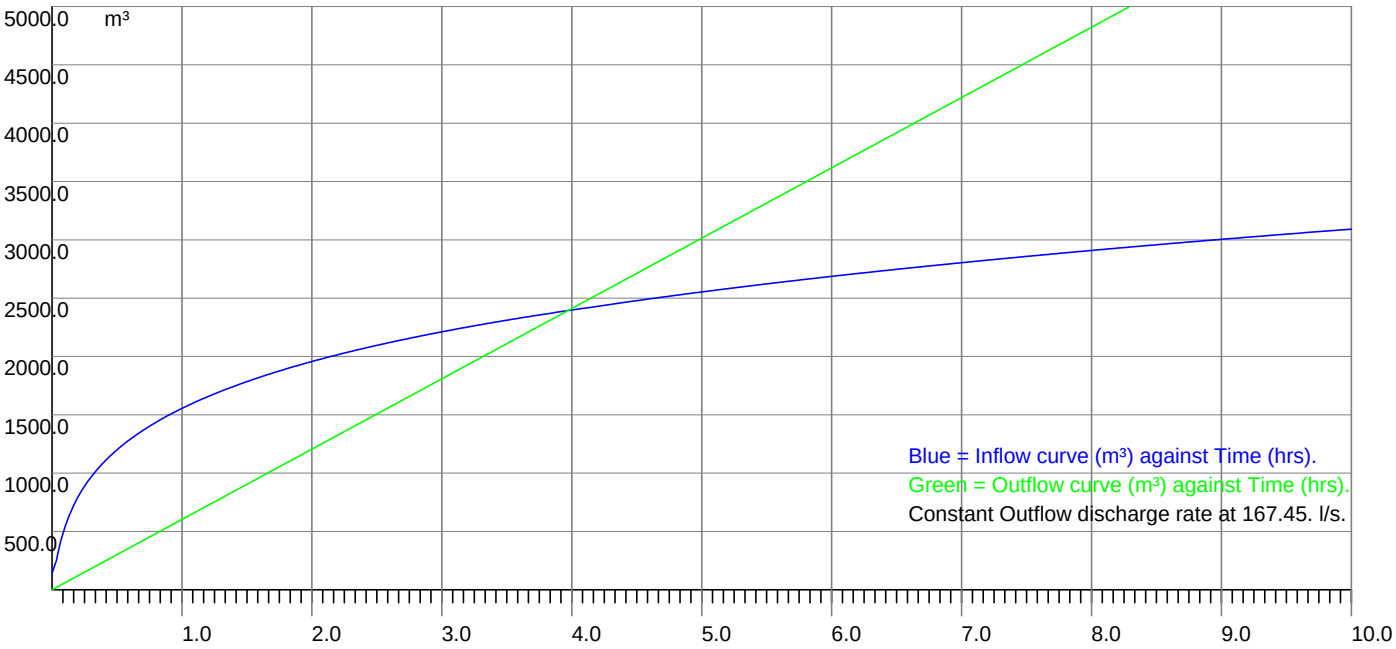
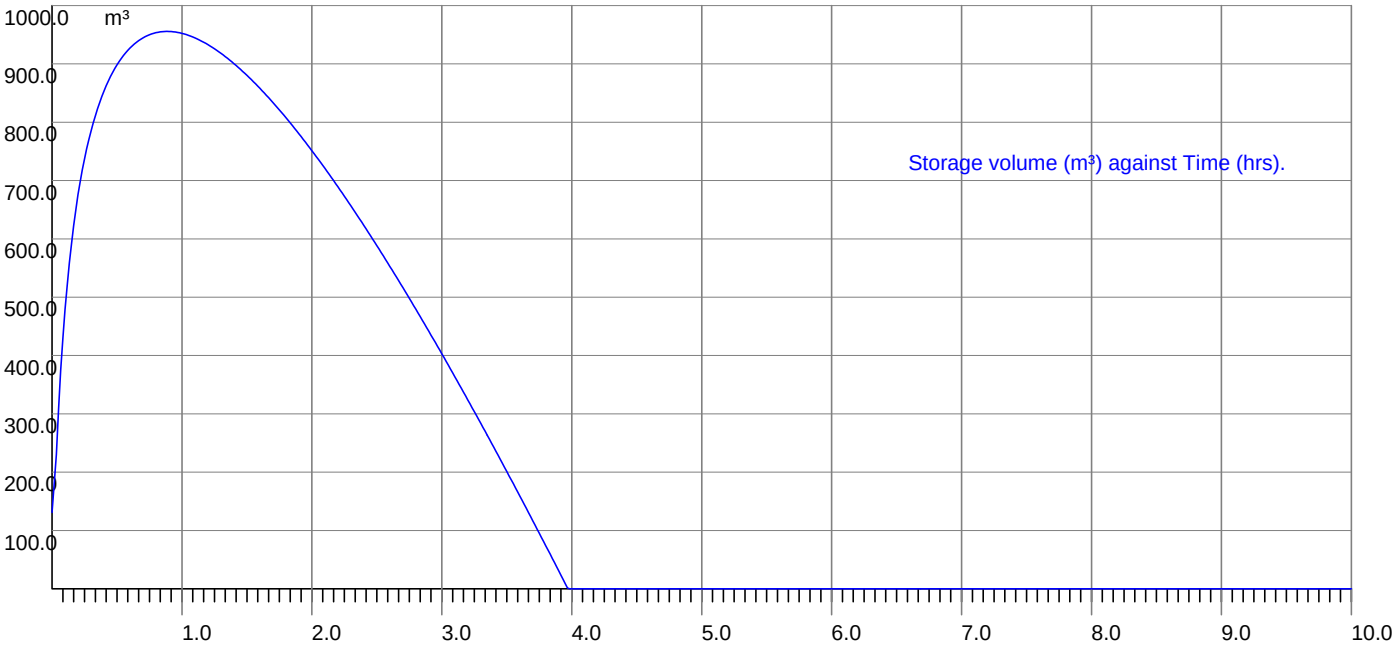
		Sheet no.	3
		Date	01/08/18
Project: **30yr Parcel E north**		By	Checked / Reviewed
Title: **Peak flow storage calcs for Radcliffe**			







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		Date	01/08/18	
Project 100yr+20% Parcel E north		By	Checked	Reviewed
Title Peak flow storage calcs for Radcliffe				

Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil index	= 0.45	SAAR (mm/yr)	= 1100
Return period	= 100	WRAP	= 4
UCWI	= 113.8	Climate change	= 20

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 41.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 66400 m²	Pervious area	= 67300 m²
Total area (TA)	= 133700 m²	Equiv area	= 54817 m² (TA x RF).
Allowed discharge rate	= 209.310 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s	Climate change factor	= 20

Calculated data:-

Time to max	= 71.0 mins	Calculated storage volume	= 1709.2 m³
Rainfall at max	= 41.10 mm/hr	Allowed discharge rate	= 209.310 l/s
Pipeline storage	= 0.0 m³	Available MH storage	= 0.0 m³
Offline storage	= 0.0 m³		

Fixed 6 hour data:-

Rainfall event	= 6 hours	Calculated storage volume	= 0.0 m³
Rainfall rate	= 13.00 mm/hr	Allowed discharge rate	= 209.310 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	217661.4	1125	1719.8
150	96738.4	1200	1511.5
225	42994.9	1275	1338.9
300	24184.6	1350	1194.3
375	15478.1	1425	1071.9
450	10748.7	1500	967.4
525	7897.0	1575	877.4
600	6046.2	1650	799.5
675	4777.2	1725	731.5
750	3869.5	1800	671.8
825	3198.0	1875	619.1
900	2687.2	1950	572.4
975	2289.7	2025	530.8
1050	1974.3	2100	493.6

Ovoid	Len
400 x 600	9495.5
600 x 900	4134.5
800 x 1200	2325.3

Box culvert	Len
500 x 500	6836.7
500 x 750	4557.8
500 x 1000	3418.4
750 x 1000	2278.9
750 x 1200	1899.1
750 x 1500	1519.3
1000 x 1000	1709.2
1000 x 1200	1424.3
1000 x 1500	1139.5
1000 x 1800	949.5
1000 x 2000	854.6
1500 x 1500	759.6
1500 x 1800	633.0
1500 x 2000	569.7

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Project: 100yr+20% Parcel E north

Title: Peak flow storage calcs for Radcliffe

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	125.0	1110.871	125.586	985.285
20	88.0	1576.199	251.172	1325.027
30	70.0	1878.906	376.758	1502.148
40	59.0	2108.256	502.344	1605.912
50	51.0	2294.388	627.930	1666.458
60	46.0	2451.668	753.516	1698.152
70	41.0	2588.136	879.102	1709.034
80	38.0	2708.776	1004.688	1704.088
90	35.0	2816.909	1130.274	1686.635
100	33.0	2914.874	1255.860	1659.014
110	31.0	3004.379	1381.446	1622.933
120	29.0	3086.719	1507.032	1579.687
130	27.0	3162.899	1632.618	1530.281
140	26.0	3233.719	1758.204	1475.516
150	25.0	3299.823	1883.790	1416.033
160	24.0	3361.744	2009.376	1352.368
170	23.0	3419.922	2134.962	1284.960
180	22.0	3474.730	2260.548	1214.182
190	21.0	3526.486	2386.134	1140.352
200	20.0	3575.461	2511.720	1063.741
210	19.0	3621.893	2637.306	984.587
220	19.0	3665.987	2762.892	903.095
230	18.0	3707.926	2888.478	819.448
240	18.0	3747.868	3014.064	733.804
250	17.0	3785.957	3139.650	646.307
260	17.0	3826.857	3265.236	561.621
270	16.0	3865.569	3390.822	474.747
280	16.0	3903.138	3516.408	386.730
290	15.0	3939.639	3641.994	297.645
300	15.0	3975.136	3767.580	207.556
310	15.0	4009.689	3893.166	116.523
320	14.0	4043.352	4018.752	24.600
330	14.0	4076.176	4144.338	0.000
340	14.0	4108.205	4269.924	0.000
350	13.0	4139.481	4395.510	0.000
360	13.0	4170.043	4521.096	0.000
370	13.0	4199.925	4646.682	0.000
380	12.0	4229.162	4772.268	0.000
390	12.0	4257.782	4897.854	0.000
400	12.0	4285.815	5023.440	0.000
410	12.0	4313.286	5149.026	0.000
420	12.0	4340.221	5274.612	0.000
430	11.0	4366.640	5400.198	0.000
440	11.0	4392.567	5525.784	0.000
450	11.0	4418.021	5651.370	0.000
460	11.0	4443.021	5776.956	0.000
470	11.0	4467.584	5902.542	0.000
480	10.0	4491.727	6028.128	0.000
490	10.0	4515.466	6153.714	0.000
500	10.0	4538.816	6279.300	0.000
510	10.0	4561.790	6404.886	0.000
520	10.0	4584.400	6530.472	0.000
530	10.0	4606.662	6656.058	0.000
540	10.0	4628.584	6781.644	0.000
550	9.0	4650.180	6907.230	0.000
560	9.0	4671.459	7032.816	0.000
570	9.0	4692.432	7158.402	0.000
580	9.0	4713.107	7283.988	0.000
590	9.0	4733.496	7409.574	0.000
600	9.0	4753.605	7535.160	0.000

Storage volume (m^3) = 1709.2 m^3

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Sheet no.	3
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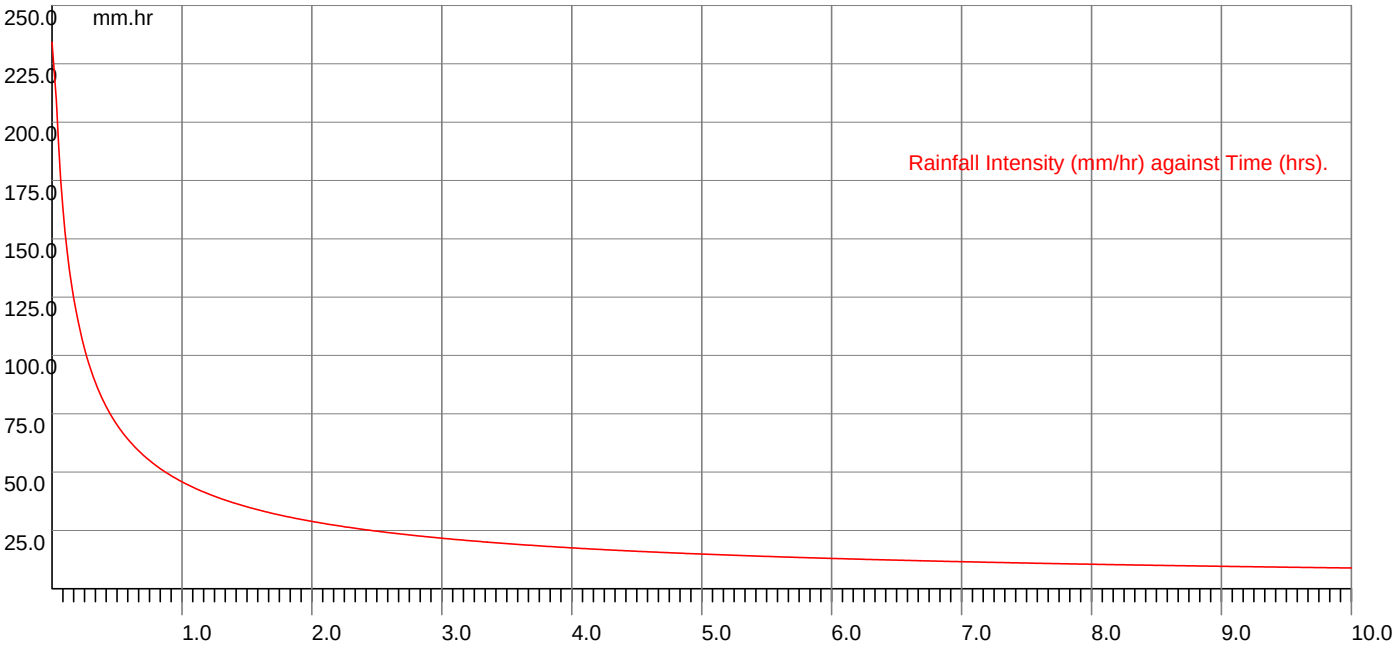
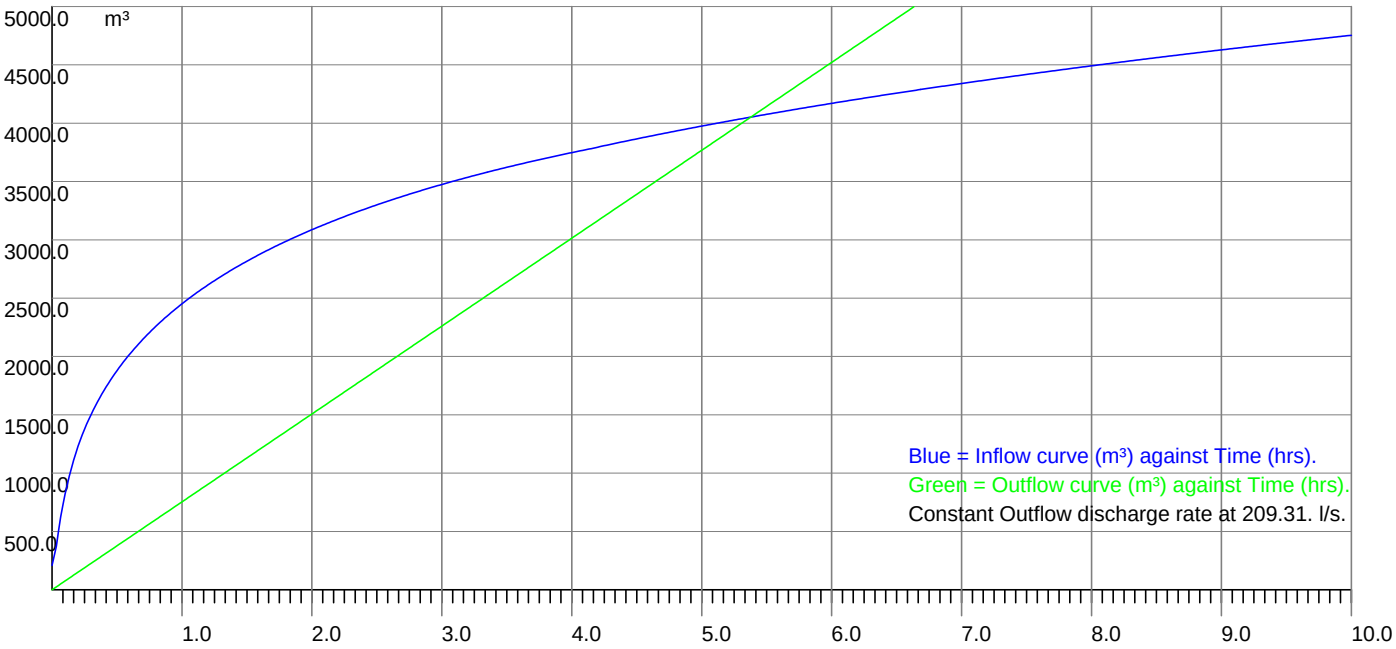
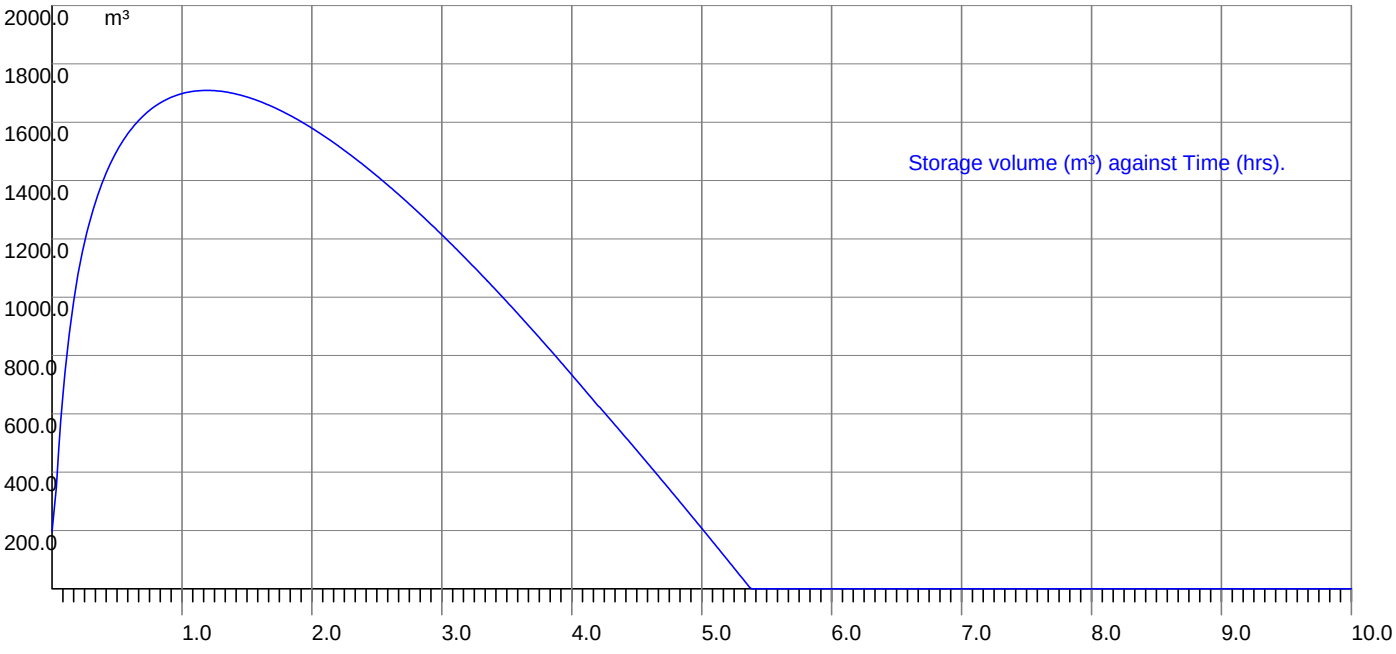
Project	100yr+20% Parcel E north	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		







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Sheet no.	1		
Date	01/08/18		
Project	100yr+40% Parcel E north	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil index	= 0.45	SAAR (mm/yr)	= 1100
Return period	= 100	WRAP	= 4
UCWI	= 113.8	Climate change	= 40

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 41.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 66400 m²	Pervious area	= 67300 m²
Total area (TA)	= 133700 m²	Equiv area	= 54817 m² (TA x RF).
Allowed discharge rate	= 209.310 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s	Climate change factor	= 40

Calculated data:-

Time to max	= 85.0 mins	Calculated storage volume	= 2157.5 m³
Rainfall at max	= 42.57 mm/hr	Allowed discharge rate	= 209.310 l/s
Pipeline storage	= 0.0 m³	Available MH storage	= 0.0 m³
Offline storage	= 0.0 m³		

Fixed 6 hour data:-

Rainfall event	= 6 hours	Calculated storage volume	= 253.2 m³
Rainfall rate	= 15.00 mm/hr	Allowed discharge rate	= 209.310 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	274749.1	1125	2170.9
150	122110.7	1200	1908.0
225	54271.4	1275	1690.1
300	30527.7	1350	1507.5
375	19537.7	1425	1353.0
450	13567.9	1500	1221.1
525	9968.2	1575	1107.6
600	7631.9	1650	1009.2
675	6030.2	1725	923.3
750	4884.4	1800	848.0
825	4036.7	1875	781.5
900	3392.0	1950	722.5
975	2890.2	2025	670.0
1050	2492.1	2100	623.0

Ovoid	Len
400 x 600	11985.9
600 x 900	5218.8
800 x 1200	2935.2

Box culvert	Len
500 x 500	8629.9
500 x 750	5753.2
500 x 1000	4314.9
750 x 1000	2876.6
750 x 1200	2397.2
750 x 1500	1917.7
1000 x 1000	2157.5
1000 x 1200	1797.9
1000 x 1500	1438.3
1000 x 1800	1198.6
1000 x 2000	1078.7
1500 x 1500	958.9
1500 x 1800	799.1
1500 x 2000	719.2

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MasterDrain SW

Project: 100yr+40% Parcel E north

Title: Peak flow storage calcs for Radcliffe

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	145.0	1296.016	125.586	1170.430
20	103.0	1838.898	251.172	1587.726
30	82.0	2192.057	376.758	1815.299
40	69.0	2459.633	502.344	1957.289
50	60.0	2676.786	627.930	2048.856
60	53.0	2860.280	753.516	2106.764
70	48.0	3019.492	879.102	2140.390
80	44.0	3160.238	1004.688	2155.550
90	41.0	3286.394	1130.274	2156.120
100	38.0	3400.686	1255.860	2144.826
110	36.0	3505.109	1381.446	2123.663
120	34.0	3601.172	1507.032	2094.140
130	32.0	3690.049	1632.618	2057.431
140	30.0	3772.672	1758.204	2014.468
150	29.0	3849.794	1883.790	1966.004
160	28.0	3922.034	2009.376	1912.658
170	26.0	3989.909	2134.962	1854.947
180	25.0	4053.851	2260.548	1793.303
190	24.0	4114.233	2386.134	1728.099
200	23.0	4171.371	2511.720	1659.651
210	23.0	4225.542	2637.306	1588.236
220	22.0	4276.985	2762.892	1514.093
230	21.0	4325.913	2888.478	1437.435
240	20.0	4372.513	3014.064	1358.449
250	20.0	4416.950	3139.650	1277.300
260	19.0	4464.666	3265.236	1199.430
270	19.0	4509.830	3390.822	1119.008
280	18.0	4553.661	3516.408	1037.253
290	18.0	4596.245	3641.994	954.251
300	17.0	4637.658	3767.580	870.078
310	17.0	4677.970	3893.166	784.804
320	17.0	4717.244	4018.752	698.492
330	16.0	4755.538	4144.338	611.200
340	16.0	4792.906	4269.924	522.982
350	15.0	4829.395	4395.510	433.885
360	15.0	4865.050	4521.096	343.954
370	15.0	4899.913	4646.682	253.231
380	15.0	4934.021	4772.268	161.753
390	14.0	4967.413	4897.854	69.559
400	14.0	5000.118	5023.440	0.000
410	14.0	5032.167	5149.026	0.000
420	14.0	5063.590	5274.612	0.000
430	13.0	5094.413	5400.198	0.000
440	13.0	5124.661	5525.784	0.000
450	13.0	5154.357	5651.370	0.000
460	13.0	5183.524	5776.956	0.000
470	12.0	5212.182	5902.542	0.000
480	12.0	5240.348	6028.128	0.000
490	12.0	5268.043	6153.714	0.000
500	12.0	5295.285	6279.300	0.000
510	12.0	5322.087	6404.886	0.000
520	12.0	5348.466	6530.472	0.000
530	11.0	5374.438	6656.058	0.000
540	11.0	5400.015	6781.644	0.000
550	11.0	5425.209	6907.230	0.000
560	11.0	5450.035	7032.816	0.000
570	11.0	5474.503	7158.402	0.000
580	11.0	5498.625	7283.988	0.000
590	11.0	5522.412	7409.574	0.000
600	10.0	5545.873	7535.160	0.000

Storage volume (m^3) = 2157.5 m^3

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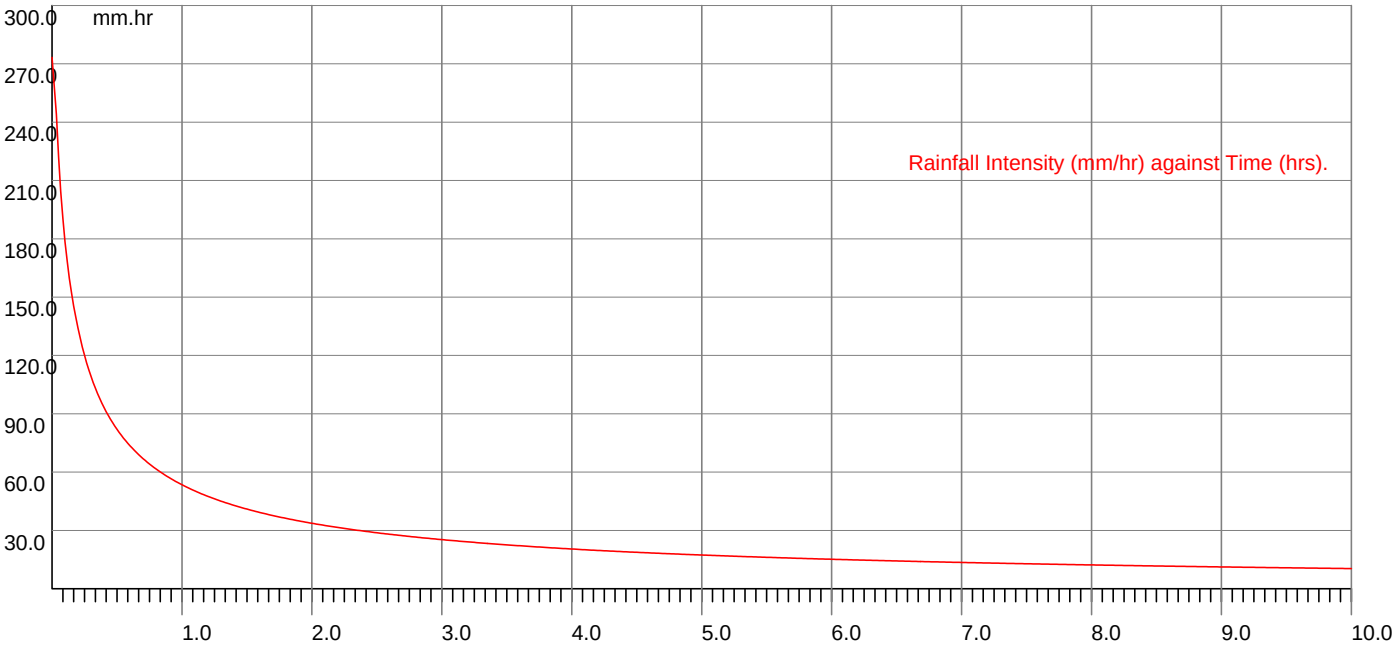
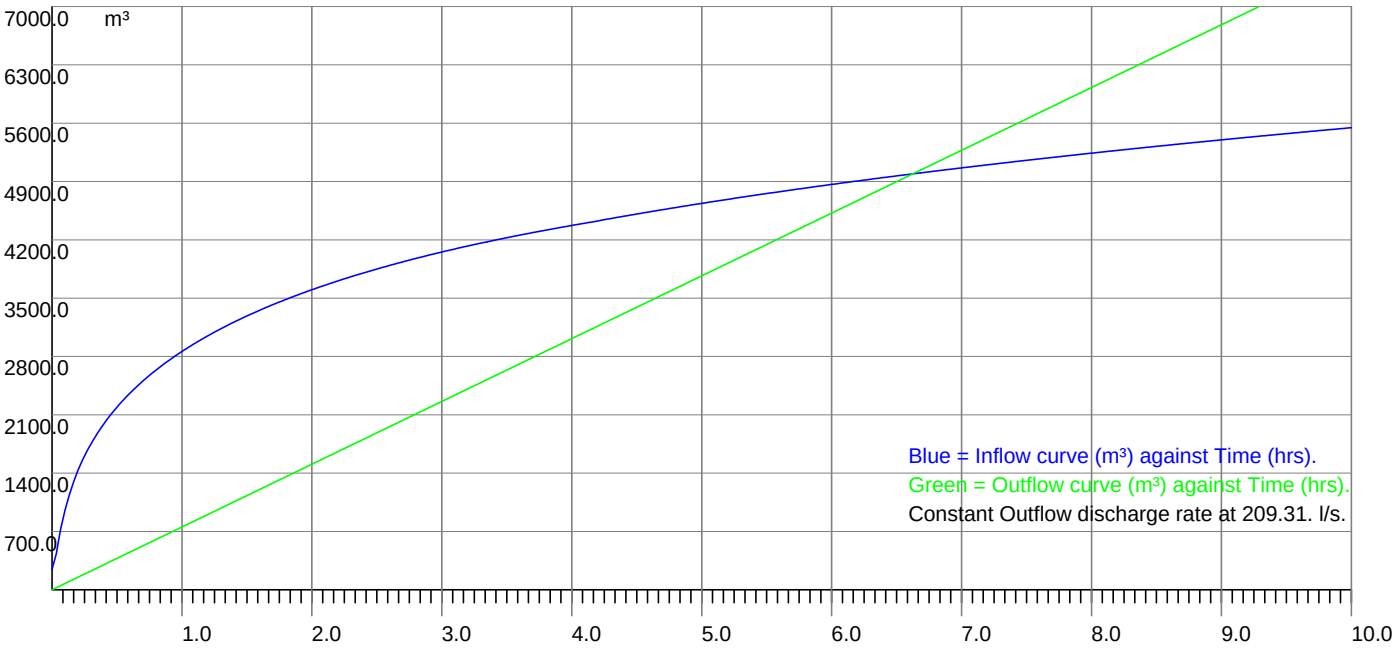
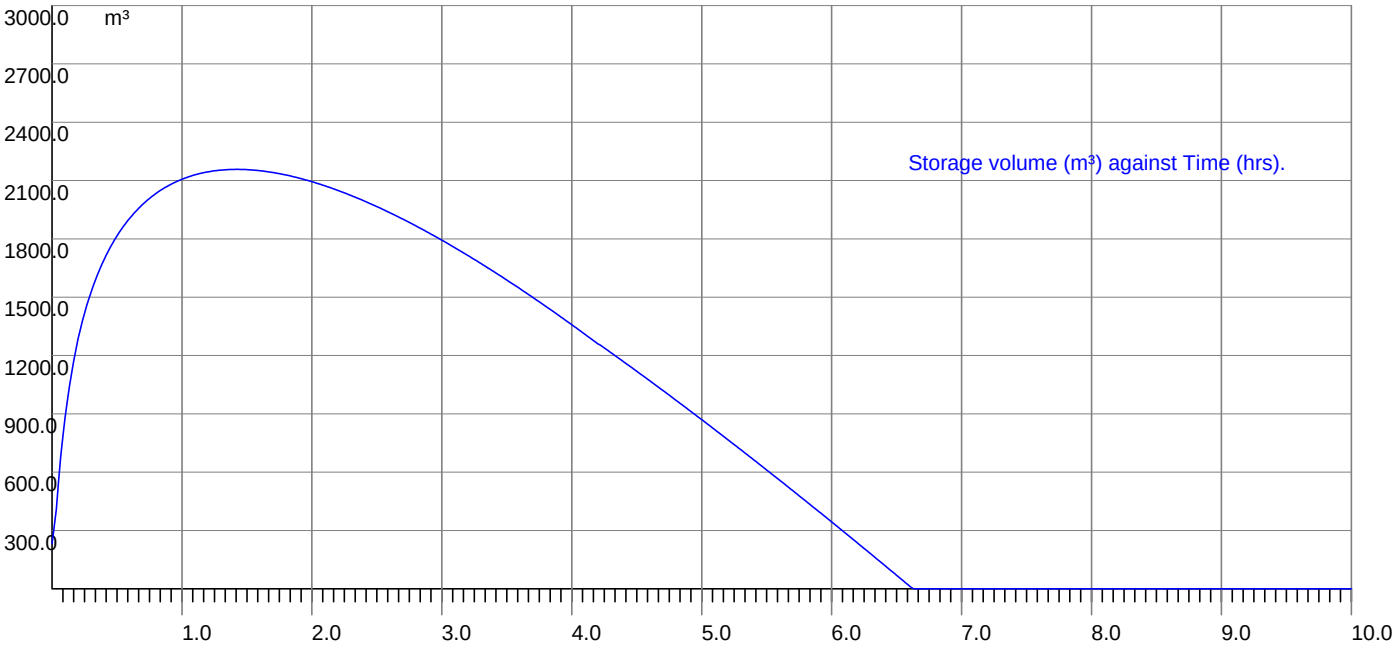
Project	100yr+40% Parcel E north	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		







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Job No.			
Sheet no.	1		
Date	31/07/18		
Project	Parcel E south	By	Checked / Reviewed
Title	IoH 124 Runoff calcs for Radcliffe		

Hydrological Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil runoff	= 0.45	SAAR (mm/yr)	= 1100
WRAP	= 4	Area	= England & Wales
Hydrological area	= 10	Hydrological zone	= 7

Soil classification for WRAP type 4
Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Design data:-

Area = 0.0423 Km² - 4.23 Ha - 42300 m²

Calculation method:-

Runoff is calculated from:-

$$Q_{BAR(rural)} = 0.00108\ AREA^{0.89}\ .\ SAAR^{1.17}\ .\ SOIL^{2.17}$$

where

AREA = Site area in Km²
SAAR = Standard Average Annual Rainfall (mm/yr)
SOIL = Soil value derived from Winter Rainfall Acceptance Potential
$Q_{BAR(rural)}$ = Runoff (cumecs)

$Q_{BAR(rural)}$ is then multiplied by a growth factor - GC(T) - for different storm return periods derived from EA publication W5-074/A.

Calculated data:-

For areas less than 50Ha, a modified calculation which multiplies the 50Ha runoff value by the ratio of the site area to 50Ha is used
Reducing factor used for these calculations is 0.085

Mean Annual Peak Flow $Q_{BAR(rural)}$ = 31.53 l/s

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Project: **Parcel E south**

Title: **IoH 124 Runoff calcs for Radcliffe**

Values for $Q_{BAR(rural)}$

Ret. per.	m³/hr	l/s	l/s/ha	Ret. per.	m³/hr	l/s	l/s/ha
1yr	96.494	26.804	6.337	100yr	238.396	66.221	15.655
2yr	105.576	29.327	6.933	100yr+20%	286.076	79.465	18.786
5yr	137.362	38.156	9.020	100yr+30%	309.915	86.088	20.352
10yr	156.660	43.517	10.288	200yr	272.453	75.681	17.892
30yr	190.717	52.977	12.524	200yr + 30%	354.189	98.386	23.259
50yr	210.016	58.338	13.791	500yr	309.915	86.088	20.352
				1000yr	345.107	95.863	22.663

Growth factors -

1yr	2yr	5yr	10yr	30yr	50yr	100yr	200yr	500yr	1000yr
0.85	0.93	1.21	1.38	1.68	1.85	2.10	2.40	2.73	3.04

The above is based on the Institute of Hydrology Report 124
to which you are referred for further details (see Sect 7).
Note that the 200 and above year growth curves were taken from W5-074.

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Job No.			
Sheet no.	1		
Date	01/08/18		
Project	30yr Parcel E south	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil index	= 0.45	SAAR (mm/yr)	= 1100
Return period	= 30	WRAP	= 4
UCWI	= 113.8	Climate change	= 0

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 31.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 16100 m²	Pervious area	= 26200 m²
Total area (TA)	= 42300 m²	Equiv area	= 13113 m² (TA x RF).
Allowed discharge rate	= 52.980 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s	Climate change factor	= 0

Calculated data:-

Time to max	= 53.0 mins	Calculated storage volume	= 302.4 m³
Rainfall at max	= 31.50 mm/hr	Allowed discharge rate	= 52.980 l/s
Pipeline storage	= 0.0 m³	Available MH storage	= 0.0 m³
Offline storage	= 0.0 m³		

Fixed 6 hour data:-

Rainfall event	= 6 hours	Calculated storage volume	= 0.0 m³
Rainfall rate	= 8.00 mm/hr	Allowed discharge rate	= 52.980 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	38504.7	1125	304.2
150	17113.2	1200	267.4
225	7605.9	1275	236.9
300	4278.3	1350	211.3
375	2738.1	1425	189.6
450	1901.5	1500	171.1
525	1397.0	1575	155.2
600	1069.6	1650	141.4
675	845.1	1725	129.4
750	684.5	1800	118.8
825	565.7	1875	109.5
900	475.4	1950	101.3
975	405.0	2025	93.9
1050	349.2	2100	87.3

Ovoid	Len
400 x 600	1679.8
600 x 900	731.4
800 x 1200	411.3

Box culvert	Len
500 x 500	1209.4
500 x 750	806.3
500 x 1000	604.7
750 x 1000	403.1
750 x 1200	336.0
750 x 1500	268.8
1000 x 1000	302.4
1000 x 1200	252.0
1000 x 1500	201.6
1000 x 1800	168.0
1000 x 2000	151.2
1500 x 1500	134.4
1500 x 1800	112.0
1500 x 2000	100.8

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Sheet no. 2
Date 01/08/18

MasterDrain SW

Project 30yr Parcel E south

Title Peak flow storage calcs for Radcliffe

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Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	81.0	228.798	31.788	197.010
20	57.0	320.245	63.576	256.669
30	45.0	379.572	95.364	284.208
40	38.0	424.504	127.152	297.352
50	33.0	461.044	158.940	302.104
60	29.0	492.026	190.728	301.298
70	26.0	519.022	222.516	296.506
80	24.0	543.001	254.304	288.697
90	22.0	564.606	286.092	278.514
100	21.0	584.286	317.880	266.406
110	19.0	602.370	349.668	252.702
120	18.0	619.105	381.456	237.649
130	17.0	634.683	413.244	221.439
140	16.0	649.255	445.032	204.223
150	16.0	662.944	476.820	186.124
160	15.0	675.849	508.608	167.241
170	14.0	688.055	540.396	147.659
180	14.0	699.632	572.184	127.448
190	13.0	710.639	603.972	106.667
200	13.0	721.127	635.760	85.367
210	12.0	731.141	667.548	63.593
220	12.0	740.718	699.336	41.382
230	12.0	749.893	731.124	18.769
240	11.0	758.696	762.912	0.000
250	11.0	767.153	794.700	0.000
260	11.0	775.852	826.488	0.000
270	10.0	784.178	858.276	0.000
280	10.0	792.269	890.064	0.000
290	10.0	800.140	921.852	0.000
300	10.0	807.803	953.640	0.000
310	9.0	815.271	985.428	0.000
320	9.0	822.555	1017.216	0.000
330	9.0	829.665	1049.004	0.000
340	9.0	836.611	1080.792	0.000
350	9.0	843.400	1112.580	0.000
360	8.0	850.041	1144.368	0.000
370	8.0	856.542	1176.156	0.000
380	8.0	862.907	1207.944	0.000
390	8.0	869.145	1239.732	0.000
400	8.0	875.261	1271.520	0.000
410	8.0	881.260	1303.308	0.000
420	7.0	887.146	1335.096	0.000
430	7.0	892.926	1366.884	0.000
440	7.0	898.603	1398.672	0.000
450	7.0	904.181	1430.460	0.000
460	7.0	909.664	1462.248	0.000
470	7.0	915.056	1494.036	0.000
480	7.0	920.360	1525.824	0.000
490	7.0	925.579	1557.612	0.000
500	7.0	930.718	1589.400	0.000
510	7.0	935.777	1621.188	0.000
520	6.0	940.760	1652.976	0.000
530	6.0	945.670	1684.764	0.000
540	6.0	950.509	1716.552	0.000
550	6.0	955.279	1748.340	0.000
560	6.0	959.983	1780.128	0.000
570	6.0	964.622	1811.916	0.000
580	6.0	969.199	1843.704	0.000
590	6.0	973.716	1875.492	0.000
600	6.0	978.174	1907.280	0.000

Storage volume (m³) = 302.4 m³

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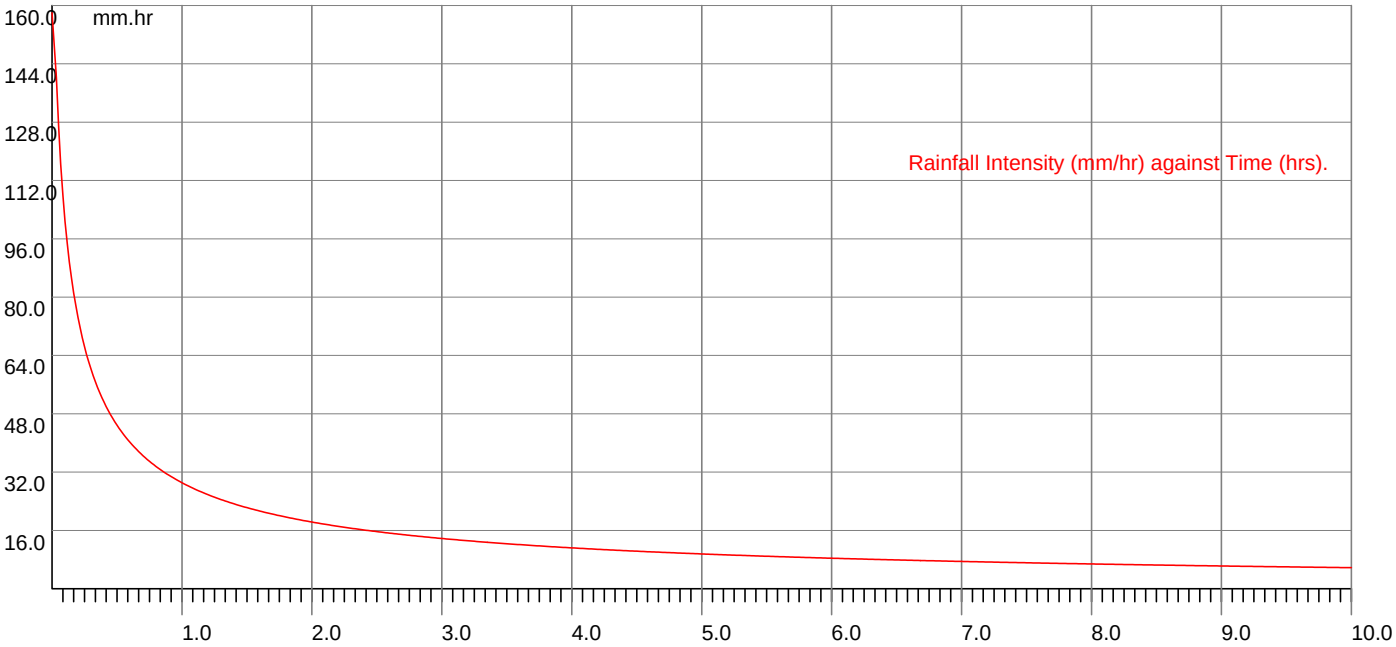
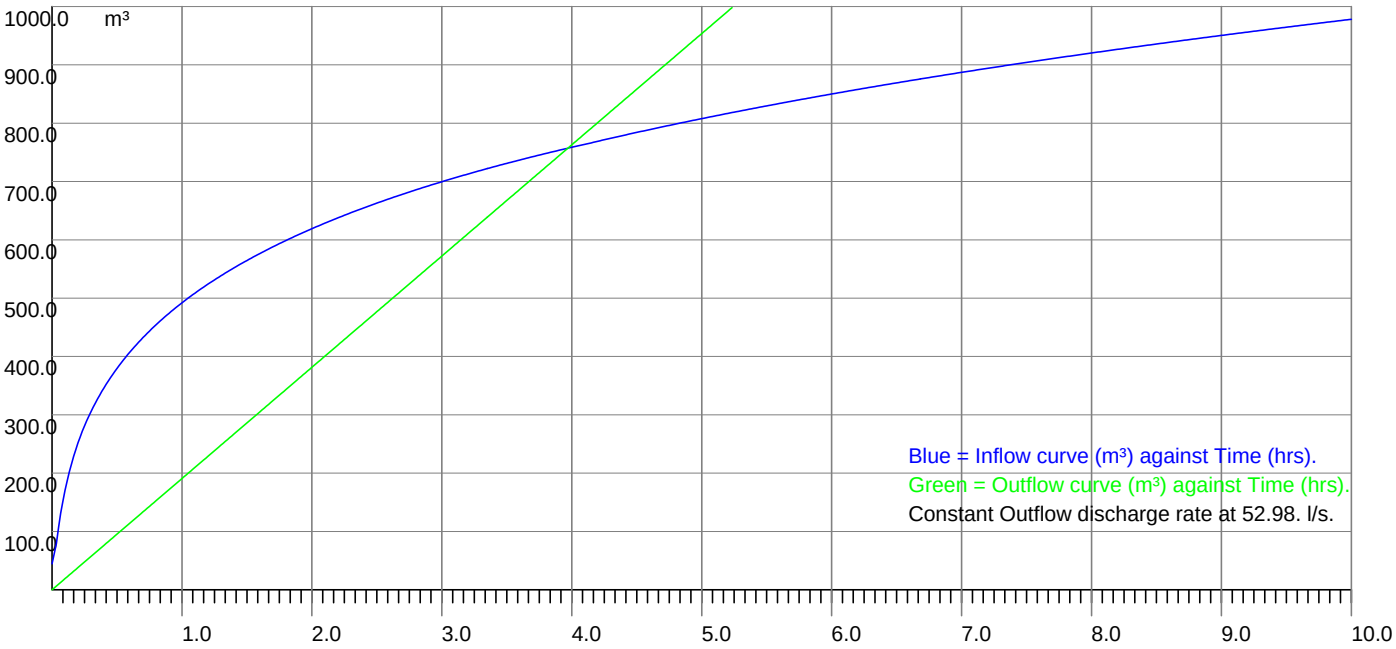
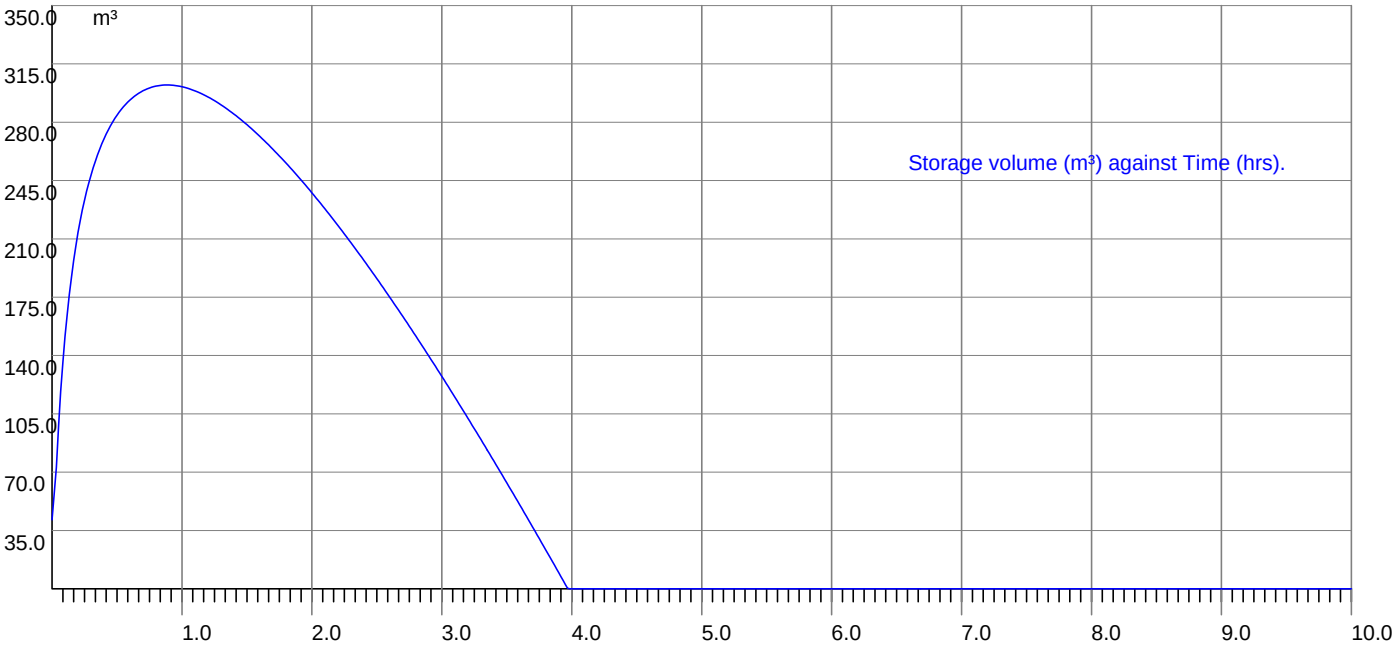
Project	30yr Parcel E south	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		







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		Date	01/08/18	
Project 100yr+20% Parcel E south		By	Checked	Reviewed
Title Peak flow storage calcs for Radcliffe				

Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil index	= 0.45	SAAR (mm/yr)	= 1100
Return period	= 100	WRAP	= 4
UCWI	= 113.8	Climate change	= 20

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 31.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 16100 m²	Pervious area	= 26200 m²
Total area (TA)	= 42300 m²	Equiv area	= 13113 m² (TA x RF).
Allowed discharge rate	= 66.220 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s	Climate change factor	= 20

Calculated data:-

Time to max	= 71.0 mins	Calculated storage volume	= 540.8 m³
Rainfall at max	= 41.10 mm/hr	Allowed discharge rate	= 66.220 l/s
Pipeline storage	= 0.0 m³	Available MH storage	= 0.0 m³
Offline storage	= 0.0 m³		

Fixed 6 hour data:-

Rainfall event	= 6 hours	Calculated storage volume	= 0.0 m³
Rainfall rate	= 13.00 mm/hr	Allowed discharge rate	= 66.220 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	68864.5	1125	544.1
150	30606.5	1200	478.2
225	13602.9	1275	423.6
300	7651.6	1350	377.9
375	4897.0	1425	339.1
450	3400.7	1500	306.1
525	2498.5	1575	277.6
600	1912.9	1650	252.9
675	1511.4	1725	231.4
750	1224.3	1800	212.5
825	1011.8	1875	195.9
900	850.2	1950	181.1
975	724.4	2025	167.9
1050	624.6	2100	156.2

Ovoid	Len
400 x 600	3004.2
600 x 900	1308.1
800 x 1200	735.7

Box culvert	Len
500 x 500	2163.0
500 x 750	1442.0
500 x 1000	1081.5
750 x 1000	721.0
750 x 1200	600.8
750 x 1500	480.7
1000 x 1000	540.8
1000 x 1200	450.6
1000 x 1500	360.5
1000 x 1800	300.4
1000 x 2000	270.4
1500 x 1500	240.3
1500 x 1800	200.3
1500 x 2000	180.3

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MasterDrain SW

Project	100yr+20% Parcel E south	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	125.0	351.457	39.732	311.725
20	88.0	498.678	79.464	419.214
30	70.0	594.448	119.196	475.252
40	59.0	667.010	158.928	508.082
50	51.0	725.898	198.660	527.238
60	46.0	775.659	238.392	537.267
70	41.0	818.834	278.124	540.710
80	38.0	857.002	317.856	539.146
90	35.0	891.214	357.588	533.626
100	33.0	922.208	397.320	524.888
110	31.0	950.525	437.052	513.473
120	29.0	976.576	476.784	499.792
130	27.0	1000.678	516.516	484.162
140	26.0	1023.084	556.248	466.836
150	25.0	1043.998	595.980	448.018
160	24.0	1063.588	635.712	427.876
170	23.0	1081.995	675.444	406.551
180	22.0	1099.335	715.176	384.159
190	21.0	1115.709	754.908	360.801
200	20.0	1131.204	794.640	336.564
210	19.0	1145.894	834.372	311.522
220	19.0	1159.845	874.104	285.741
230	18.0	1173.113	913.836	259.277
240	18.0	1185.750	953.568	232.182
250	17.0	1197.801	993.300	204.501
260	17.0	1210.741	1033.032	177.709
270	16.0	1222.988	1072.764	150.224
280	16.0	1234.875	1112.496	122.379
290	15.0	1246.423	1152.228	94.195
300	15.0	1257.653	1191.960	65.693
310	15.0	1268.585	1231.692	36.893
320	14.0	1279.235	1271.424	7.811
330	14.0	1289.620	1311.156	0.000
340	14.0	1299.754	1350.888	0.000
350	13.0	1309.649	1390.620	0.000
360	13.0	1319.318	1430.352	0.000
370	13.0	1328.772	1470.084	0.000
380	12.0	1338.022	1509.816	0.000
390	12.0	1347.077	1549.548	0.000
400	12.0	1355.946	1589.280	0.000
410	12.0	1364.637	1629.012	0.000
420	12.0	1373.159	1668.744	0.000
430	11.0	1381.517	1708.476	0.000
440	11.0	1389.720	1748.208	0.000
450	11.0	1397.773	1787.940	0.000
460	11.0	1405.683	1827.672	0.000
470	11.0	1413.454	1867.404	0.000
480	10.0	1421.092	1907.136	0.000
490	10.0	1428.603	1946.868	0.000
500	10.0	1435.990	1986.600	0.000
510	10.0	1443.259	2026.332	0.000
520	10.0	1450.412	2066.064	0.000
530	10.0	1457.455	2105.796	0.000
540	10.0	1464.391	2145.528	0.000
550	9.0	1471.224	2185.260	0.000
560	9.0	1477.956	2224.992	0.000
570	9.0	1484.591	2264.724	0.000
580	9.0	1491.133	2304.456	0.000
590	9.0	1497.583	2344.188	0.000
600	9.0	1503.945	2383.920	0.000

Storage volume (m^3) = 540.8 m^3

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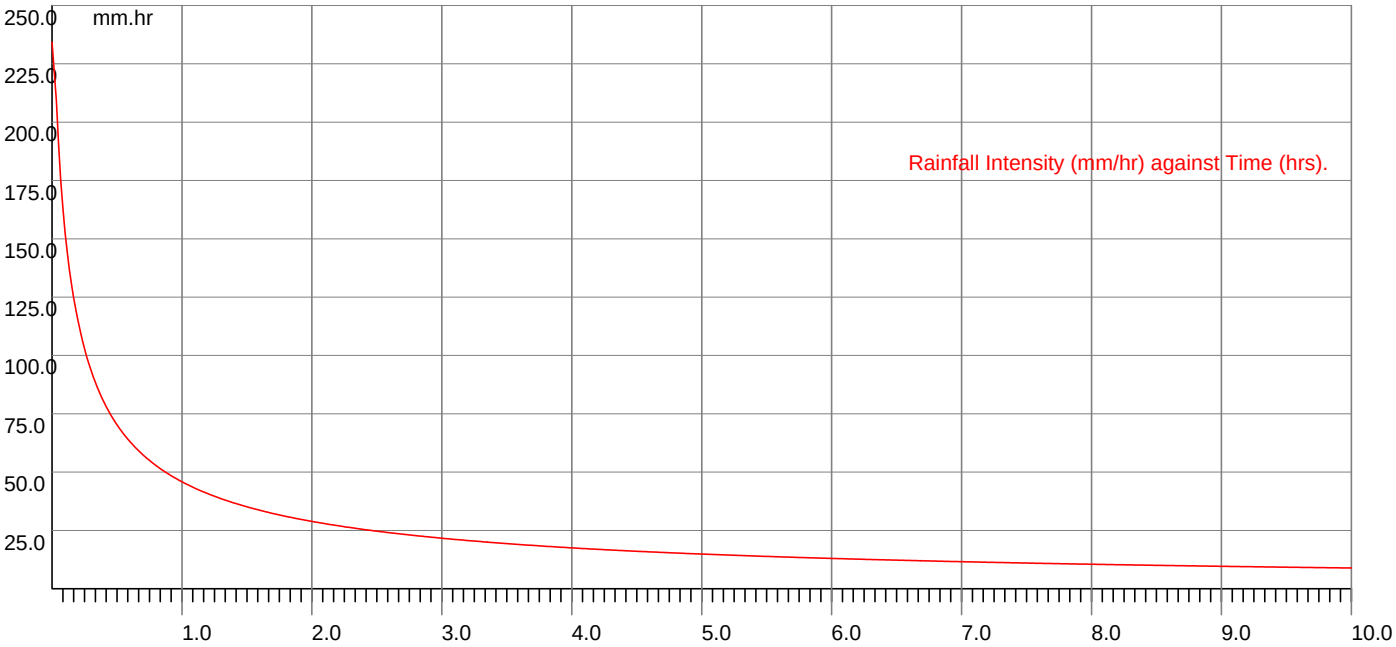
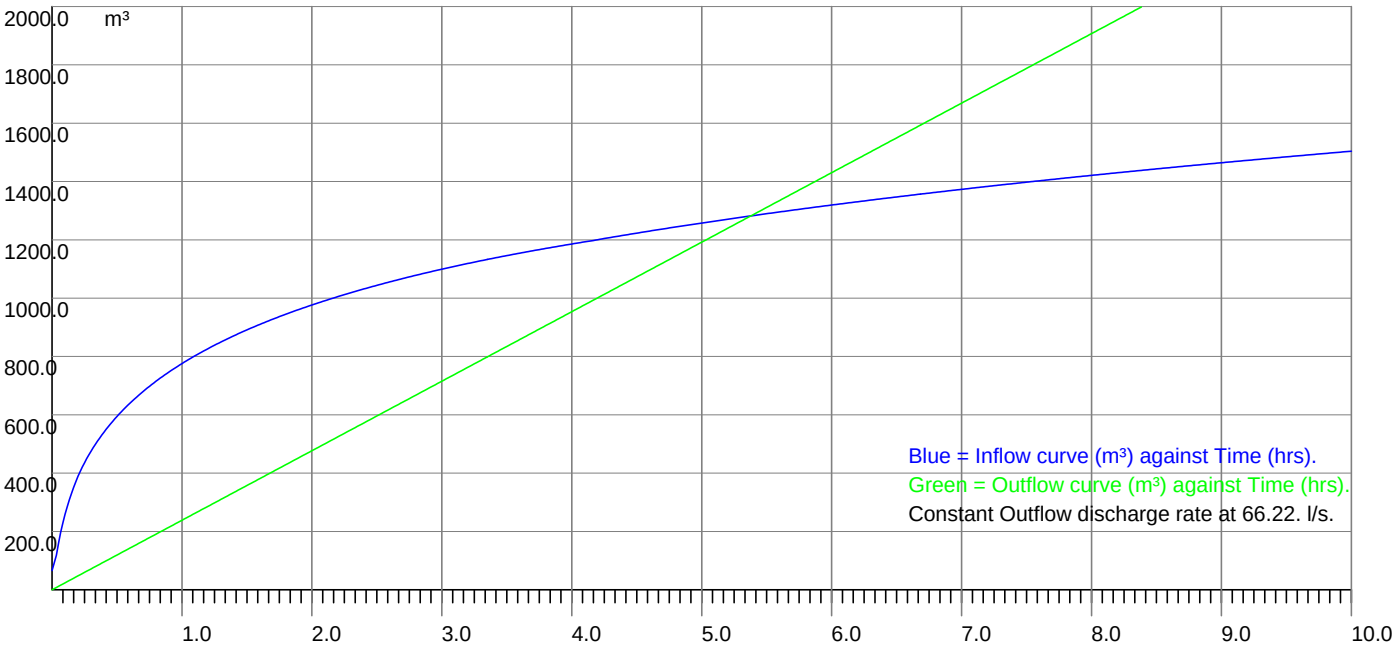
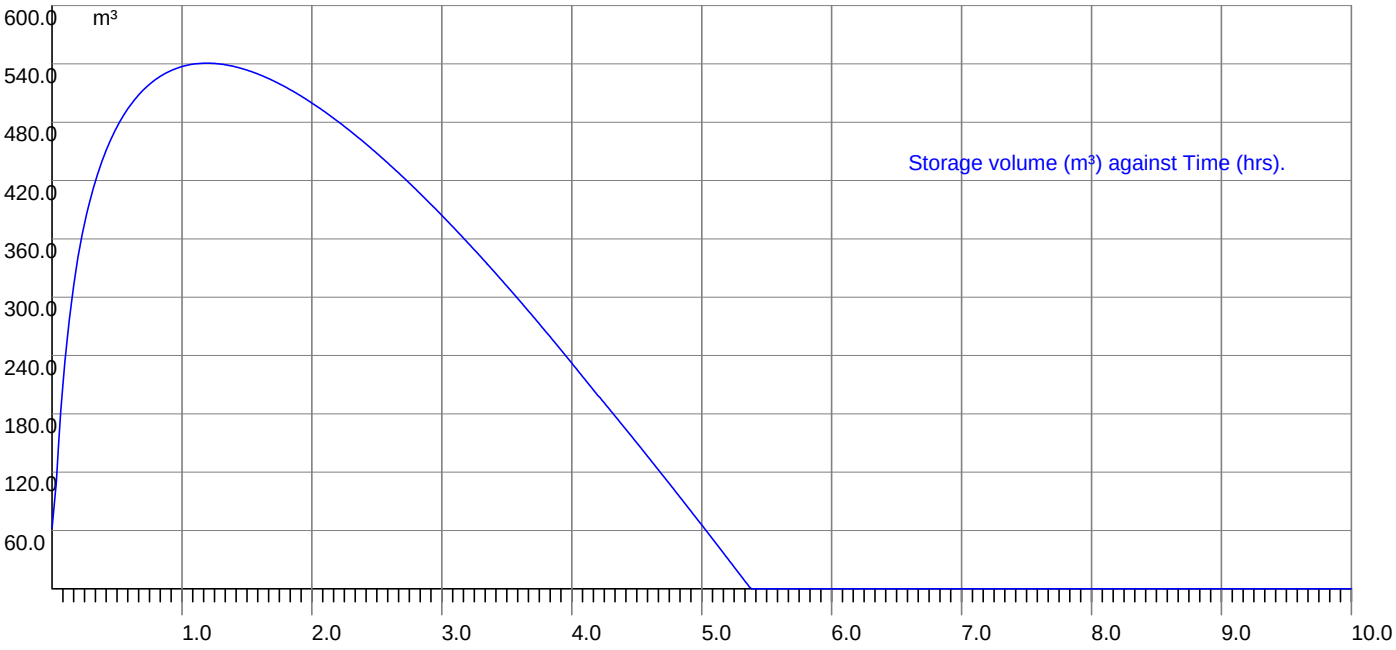
			Sheet no.	3	
			Date	01/08/18	
	Project: 100yr+20% Parcel E south		By	Checked	Reviewed
	Title: Peak flow storage calcs for Radcliffe				







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Job No.			
Sheet no.	1		
Date	01/08/18		
Project	100yr+40% Parcel E south	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil index	= 0.45	SAAR (mm/yr)	= 1100
Return period	= 100	WRAP	= 4
UCWI	= 113.8	Climate change	= 40

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 31.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 16100 m²	Pervious area	= 26200 m²
Total area (TA)	= 42300 m²	Equiv area	= 13113 m² (TA x RF).
Allowed discharge rate	= 66.220 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s	Climate change factor	= 40

Calculated data:-

Time to max	= 85.0 mins	Calculated storage volume	= 682.6 m³
Rainfall at max	= 42.57 mm/hr	Allowed discharge rate	= 66.220 l/s
Pipeline storage	= 0.0 m³	Available MH storage	= 0.0 m³
Offline storage	= 0.0 m³		

Fixed 6 hour data:-

Rainfall event	= 6 hours	Calculated storage volume	= 80.2 m³
Rainfall rate	= 15.00 mm/hr	Allowed discharge rate	= 66.220 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	86926.1	1125	686.8
150	38633.8	1200	603.7
225	17170.6	1275	534.7
300	9658.5	1350	477.0
375	6181.4	1425	428.1
450	4292.6	1500	386.3
525	3153.8	1575	350.4
600	2414.6	1650	319.3
675	1907.8	1725	292.1
750	1545.4	1800	268.3
825	1277.2	1875	247.3
900	1073.2	1950	228.6
975	914.4	2025	212.0
1050	788.4	2100	197.1

Ovoid	Len
400 x 600	3792.2
600 x 900	1651.2
800 x 1200	928.6

Box culvert	Len
500 x 500	2730.3
500 x 750	1820.2
500 x 1000	1365.2
750 x 1000	910.1
750 x 1200	758.4
750 x 1500	606.7
1000 x 1000	682.6
1000 x 1200	568.8
1000 x 1500	455.1
1000 x 1800	379.2
1000 x 2000	341.3
1500 x 1500	303.4
1500 x 1800	252.8
1500 x 2000	227.5

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Job No.	
Sheet no.	2
Date	01/08/18

MasterDrain SW

Project	100yr+40% Parcel E south	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	145.0	410.034	39.732	370.302
20	103.0	581.791	79.464	502.327
30	82.0	693.523	119.196	574.327
40	69.0	778.178	158.928	619.250
50	60.0	846.881	198.660	648.221
60	53.0	904.935	238.392	666.543
70	48.0	955.307	278.124	677.183
80	44.0	999.836	317.856	681.980
90	41.0	1039.749	357.588	682.161
100	38.0	1075.909	397.320	678.589
110	36.0	1108.946	437.052	671.894
120	34.0	1139.339	476.784	662.555
130	32.0	1167.458	516.516	650.942
140	30.0	1193.598	556.248	637.350
150	29.0	1217.998	595.980	622.018
160	28.0	1240.853	635.712	605.141
170	26.0	1262.327	675.444	586.883
180	25.0	1282.557	715.176	567.381
190	24.0	1301.661	754.908	546.753
200	23.0	1319.738	794.640	525.098
210	23.0	1336.877	834.372	502.505
220	22.0	1353.152	874.104	479.048
230	21.0	1368.632	913.836	454.796
240	20.0	1383.375	953.568	429.807
250	20.0	1397.434	993.300	404.134
260	19.0	1412.531	1033.032	379.499
270	19.0	1426.820	1072.764	354.056
280	18.0	1440.687	1112.496	328.191
290	18.0	1454.160	1152.228	301.932
300	17.0	1467.262	1191.960	275.302
310	17.0	1480.016	1231.692	248.324
320	17.0	1492.441	1271.424	221.017
330	16.0	1504.557	1311.156	193.401
340	16.0	1516.379	1350.888	165.491
350	15.0	1527.924	1390.620	137.304
360	15.0	1539.204	1430.352	108.852
370	15.0	1550.234	1470.084	80.150
380	15.0	1561.026	1509.816	51.209
390	14.0	1571.590	1549.548	22.042
400	14.0	1581.937	1589.280	0.000
410	14.0	1592.077	1629.012	0.000
420	14.0	1602.018	1668.744	0.000
430	13.0	1611.770	1708.476	0.000
440	13.0	1621.340	1748.208	0.000
450	13.0	1630.735	1787.940	0.000
460	13.0	1639.963	1827.672	0.000
470	12.0	1649.030	1867.404	0.000
480	12.0	1657.941	1907.136	0.000
490	12.0	1666.703	1946.868	0.000
500	12.0	1675.322	1986.600	0.000
510	12.0	1683.802	2026.332	0.000
520	12.0	1692.148	2066.064	0.000
530	11.0	1700.365	2105.796	0.000
540	11.0	1708.456	2145.528	0.000
550	11.0	1716.428	2185.260	0.000
560	11.0	1724.282	2224.992	0.000
570	11.0	1732.023	2264.724	0.000
580	11.0	1739.655	2304.456	0.000
590	11.0	1747.180	2344.188	0.000
600	10.0	1754.603	2383.920	0.000

Storage volume (m^3) = 682.6 m^3

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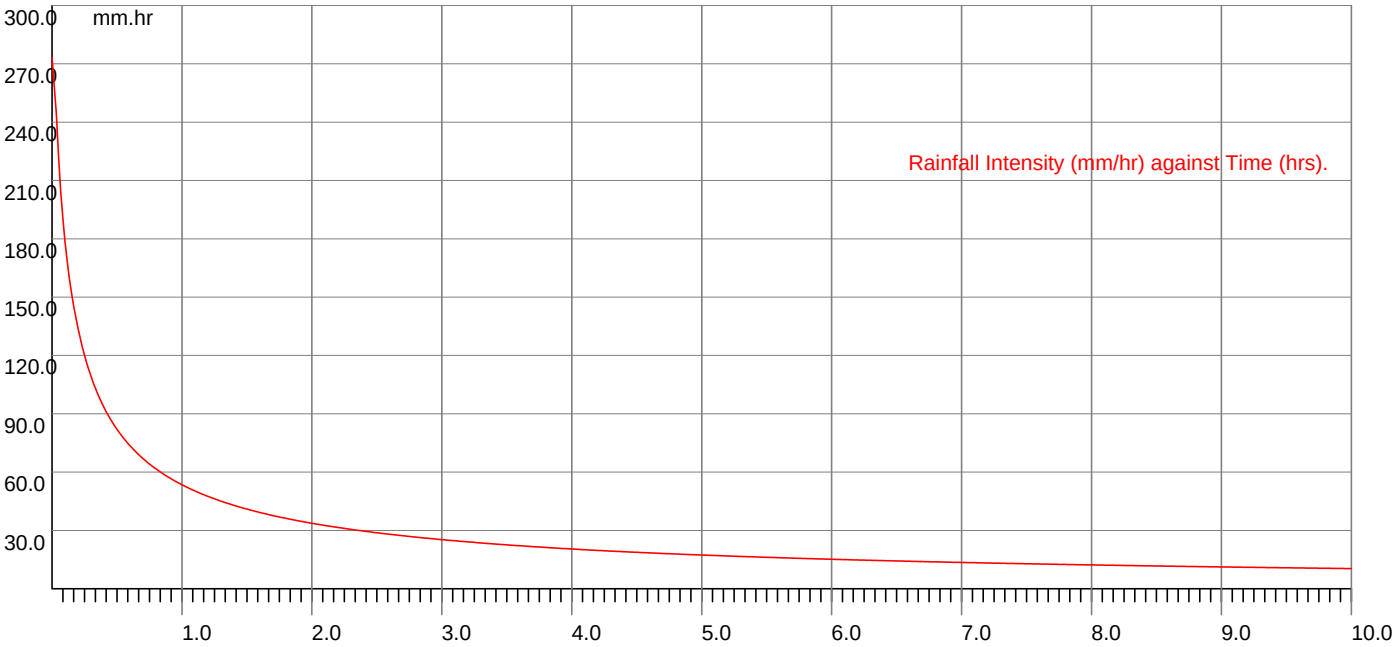
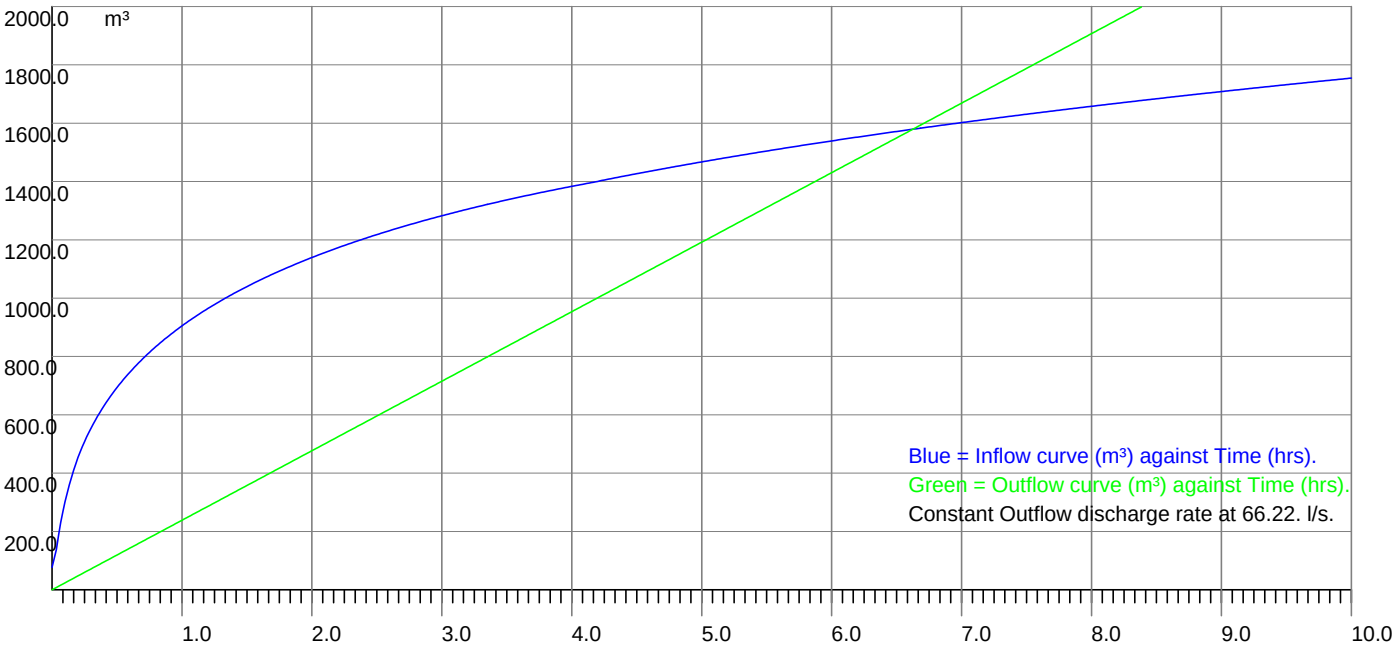
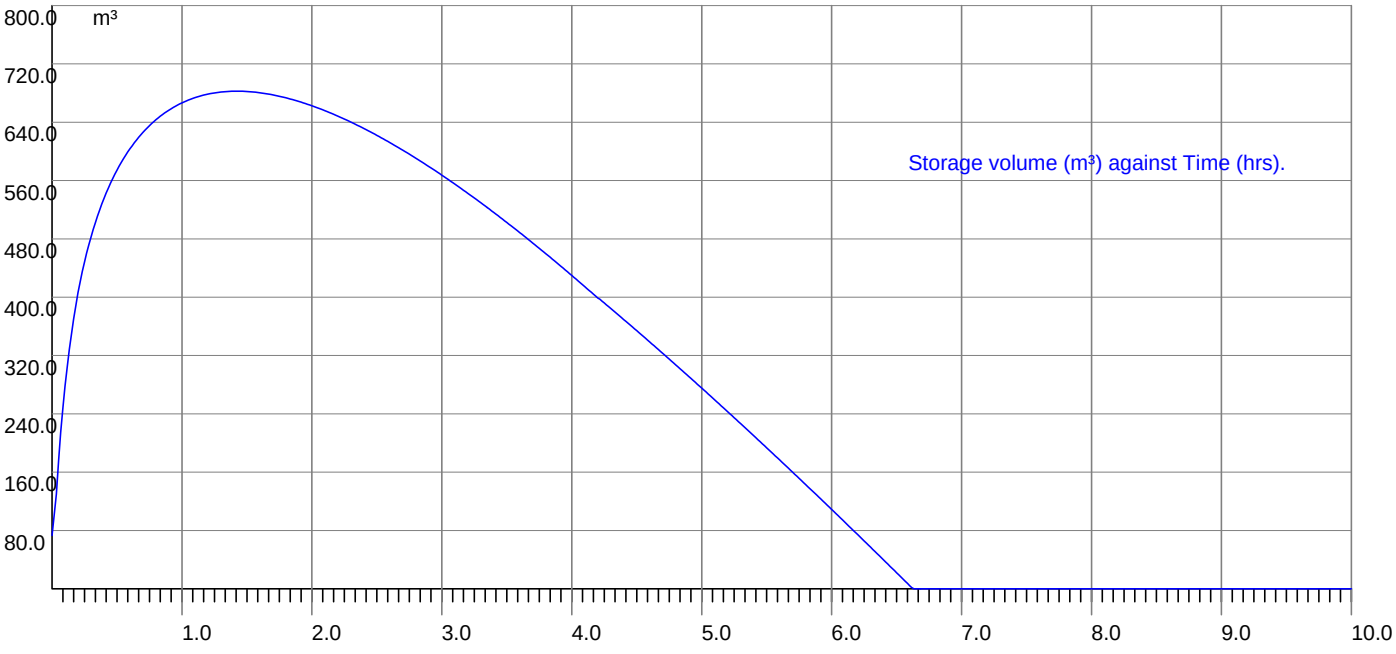
Project **100yr+40% Parcel E south**			By / Checked / Reviewed
Title **Peak flow storage calcs for Radcliffe**			







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Job No.			
Sheet no.	1		
Date	31/07/18		
Project	Parcel F west	By	Checked / Reviewed
Title	IoH 124 Runoff calcs for Radcliffe		

Hydrological Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil runoff	= 0.45	SAAR (mm/yr)	= 1100
WRAP	= 4	Area	= England & Wales
Hydrological area	= 10	Hydrological zone	= 7

Soil classification for WRAP type 4
Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Design data:-

Area = 0.0984 Km² - 9.84 Ha - 98400 m²

Calculation method:-

Runoff is calculated from:-

$$Q_{BAR(rural)} = 0.00108\ AREA^{0.89}\ .\ SAAR^{1.17}\ .\ SOIL^{2.17}$$

where

AREA = Site area in Km²
SAAR = Standard Average Annual Rainfall (mm/yr)
SOIL = Soil value derived from Winter Rainfall Acceptance Potential
$Q_{BAR(rural)}$ = Runoff (cumecs)

$Q_{BAR(rural)}$ is then multiplied by a growth factor - GC(T) - for different storm return periods derived from EA publication W5-074/A.

Calculated data:-

For areas less than 50Ha, a modified calculation which multiplies the 50Ha runoff value by the ratio of the site area to 50Ha is used
Reducing factor used for these calculations is 0.197

Mean Annual Peak Flow $Q_{BAR(rural)}$ = 73.36 l/s

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	By	Checked	Reviewed
Project: Parcel F west			
Title: IoH 124 Runoff calcs for Radcliffe			

Values for $Q_{BAR(rural)}$

Ret. per.	m³/hr	l/s	l/s/ha	Ret. per.	m³/hr	l/s	l/s/ha
1yr	224.468	62.352	6.337	100yr	554.567	154.047	15.655
2yr	245.594	68.221	6.933	100yr+20%	665.481	184.856	18.786
5yr	319.536	88.760	9.020	100yr+30%	720.938	200.260	20.352
10yr	364.430	101.231	10.288	200yr	633.791	176.053	17.892
30yr	443.654	123.237	12.524	200yr + 30%	823.929	228.869	23.259
50yr	488.548	135.708	13.791	500yr	720.938	200.260	20.352
				1000yr	802.802	223.001	22.663

Growth factors -

1yr	2yr	5yr	10yr	30yr	50yr	100yr	200yr	500yr	1000yr
0.85	0.93	1.21	1.38	1.68	1.85	2.10	2.40	2.73	3.04

The above is based on the Institute of Hydrology Report 124
to which you are referred for further details (see Sect 7).
Note that the 200 and above year growth curves were taken from W5-074.

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Job No.			
Sheet no.	1		
Date	01/08/18		
Project	30yr Parcel F west	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil index	= 0.45	SAAR (mm/yr)	= 1100
Return period	= 30	WRAP	= 4
UCWI	= 113.8	Climate change	= 0

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 21.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 25700 m²	Pervious area	= 72700 m²
Total area (TA)	= 98400 m²	Equiv area	= 20664 m² (TA x RF).
Allowed discharge rate	= 123.240 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s	Climate change factor	= 0

Calculated data:-

Time to max	= 53.0 mins	Calculated storage volume	= 703.4 m³
Rainfall at max	= 31.50 mm/hr	Allowed discharge rate	= 123.240 l/s
Pipeline storage	= 0.0 m³	Available MH storage	= 0.0 m³
Offline storage	= 0.0 m³		

Fixed 6 hour data:-

Rainfall event	= 6 hours	Calculated storage volume	= 0.0 m³
Rainfall rate	= 8.00 mm/hr	Allowed discharge rate	= 123.240 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	89572.9	1125	707.7
150	39810.2	1200	622.0
225	17693.4	1275	551.0
300	9952.5	1350	491.5
375	6369.6	1425	441.1
450	4423.4	1500	398.1
525	3249.8	1575	361.1
600	2488.1	1650	329.0
675	1965.9	1725	301.0
750	1592.4	1800	276.5
825	1316.0	1875	254.8
900	1105.8	1950	235.6
975	942.3	2025	218.4
1050	812.5	2100	203.1

Ovoid	Len
400 x 600	3907.6
600 x 900	1701.4
800 x 1200	956.9

Box culvert	Len
500 x 500	2813.5
500 x 750	1875.7
500 x 1000	1406.7
750 x 1000	937.8
750 x 1200	781.5
750 x 1500	625.2
1000 x 1000	703.4
1000 x 1200	586.1
1000 x 1500	468.9
1000 x 1800	390.8
1000 x 2000	351.7
1500 x 1500	312.6
1500 x 1800	260.5
1500 x 2000	234.5

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Job No.	
Sheet no.	2
Date	01/08/18

MasterDrain SW

Project	30yr Parcel F west	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	81.0	532.239	73.944	458.295
20	57.0	744.968	147.888	597.080
30	45.0	882.977	221.832	661.145
40	38.0	987.497	295.776	691.721
50	33.0	1072.500	369.720	702.780
60	29.0	1144.571	443.664	700.907
70	26.0	1207.370	517.608	689.762
80	24.0	1263.152	591.552	671.600
90	22.0	1313.410	665.496	647.914
100	21.0	1359.191	739.440	619.751
110	19.0	1401.259	813.384	587.875
120	18.0	1440.188	887.328	552.860
130	17.0	1476.425	961.272	515.153
140	16.0	1510.323	1035.216	475.108
150	16.0	1542.167	1109.160	433.006
160	15.0	1572.189	1183.104	389.085
170	14.0	1600.583	1257.048	343.535
180	14.0	1627.513	1330.992	296.521
190	13.0	1653.118	1404.936	248.182
200	13.0	1677.515	1478.880	198.635
210	12.0	1700.809	1552.824	147.985
220	12.0	1723.089	1626.768	96.321
230	12.0	1744.433	1700.712	43.721
240	11.0	1764.911	1774.656	0.000
250	11.0	1784.584	1848.600	0.000
260	11.0	1804.818	1922.544	0.000
270	10.0	1824.188	1996.488	0.000
280	10.0	1843.010	2070.432	0.000
290	10.0	1861.318	2144.376	0.000
300	10.0	1879.144	2218.320	0.000
310	9.0	1896.517	2292.264	0.000
320	9.0	1913.461	2366.208	0.000
330	9.0	1930.001	2440.152	0.000
340	9.0	1946.158	2514.096	0.000
350	9.0	1961.952	2588.040	0.000
360	8.0	1977.401	2661.984	0.000
370	8.0	1992.522	2735.928	0.000
380	8.0	2007.331	2809.872	0.000
390	8.0	2021.842	2883.816	0.000
400	8.0	2036.068	2957.760	0.000
410	8.0	2050.022	3031.704	0.000
420	7.0	2063.716	3105.648	0.000
430	7.0	2077.161	3179.592	0.000
440	7.0	2090.366	3253.536	0.000
450	7.0	2103.342	3327.480	0.000
460	7.0	2116.098	3401.424	0.000
470	7.0	2128.641	3475.368	0.000
480	7.0	2140.979	3549.312	0.000
490	7.0	2153.121	3623.256	0.000
500	7.0	2165.073	3697.200	0.000
510	7.0	2176.843	3771.144	0.000
520	6.0	2188.435	3845.088	0.000
530	6.0	2199.856	3919.032	0.000
540	6.0	2211.113	3992.976	0.000
550	6.0	2222.210	4066.920	0.000
560	6.0	2233.152	4140.864	0.000
570	6.0	2243.944	4214.808	0.000
580	6.0	2254.591	4288.752	0.000
590	6.0	2265.098	4362.696	0.000
600	6.0	2275.468	4436.640	0.000

Storage volume (m^3) = 703.4 m^3

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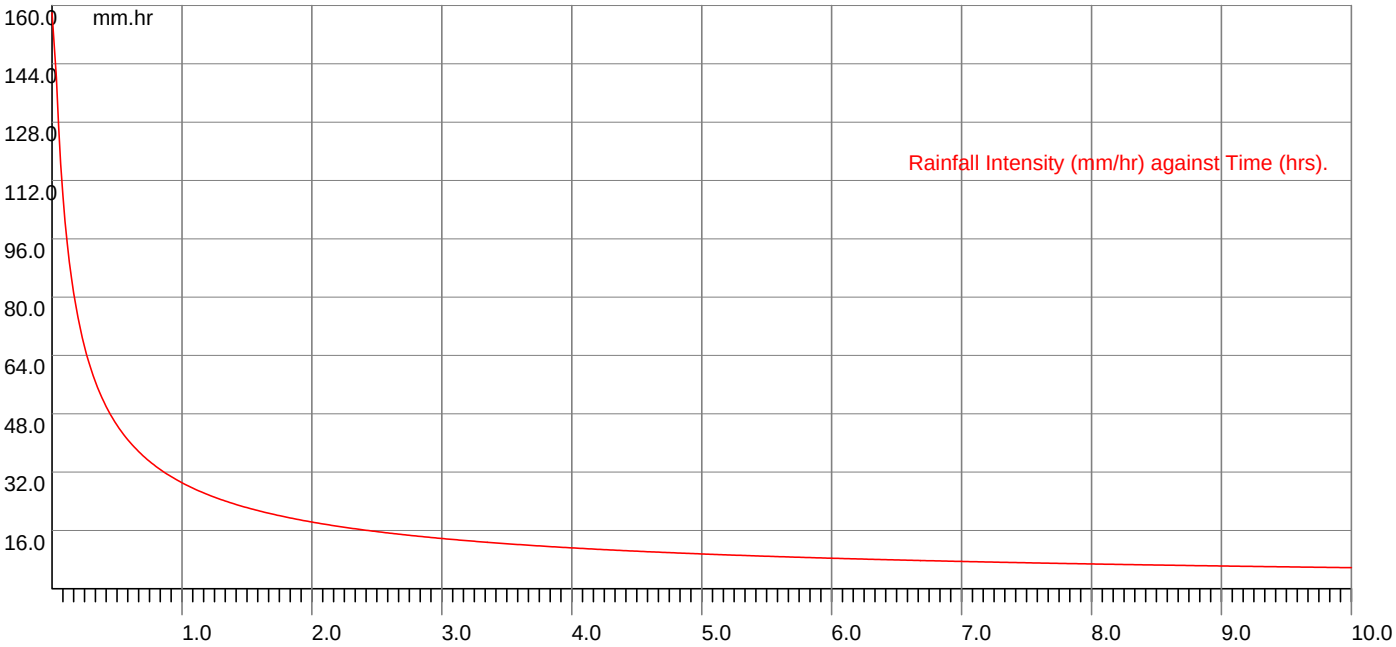
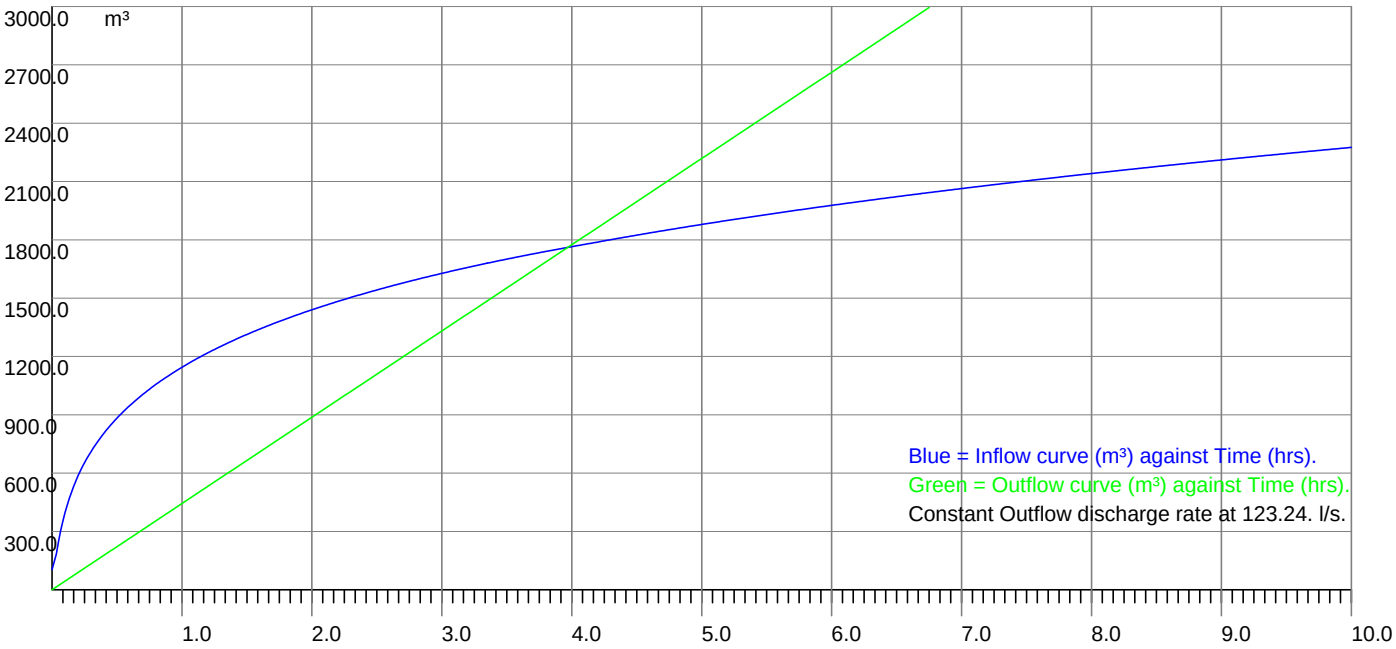
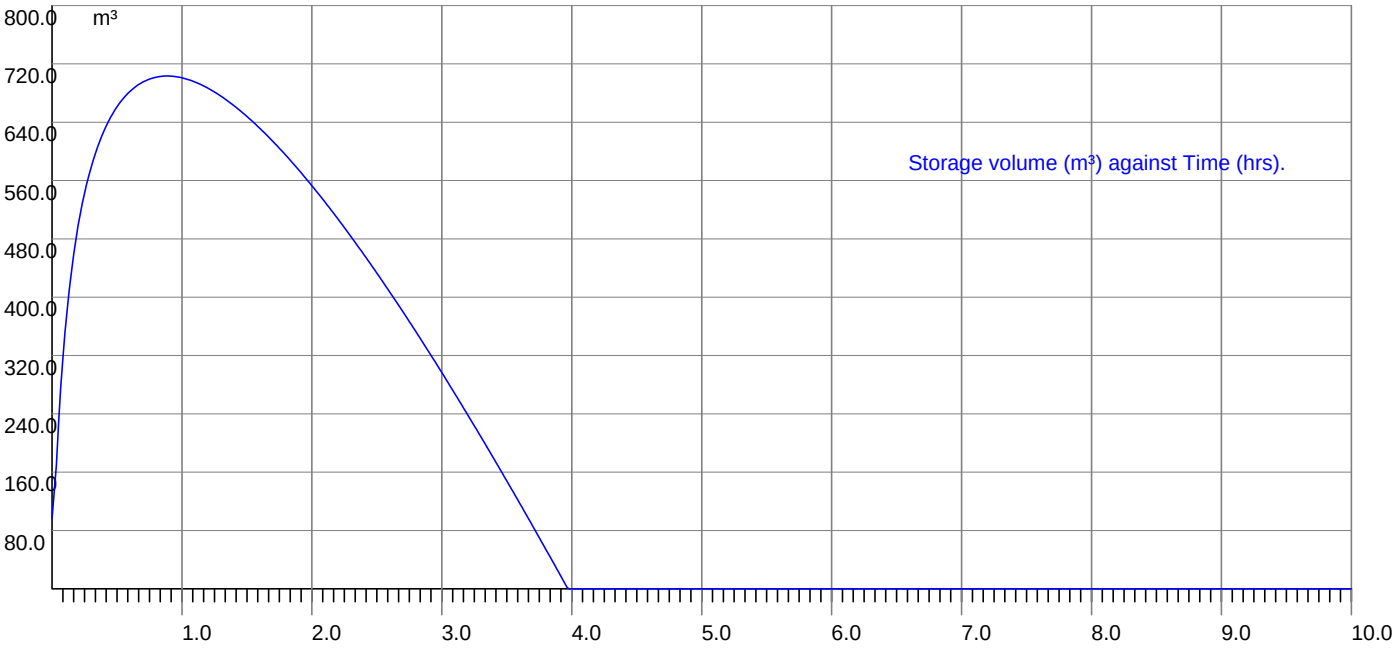
Job No.	
Sheet no.	3
Date	01/08/18

MasterDrain SW

Project	30yr Parcel F west	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		







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Job No.			
Sheet no.	1		
Date	01/08/18		
Project	100yr+20% Parcel F west	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil index	= 0.45	SAAR (mm/yr)	= 1100
Return period	= 100	WRAP	= 4
UCWI	= 113.8	Climate change	= 20

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 21.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 25700 m²	Pervious area	= 72700 m²
Total area (TA)	= 98400 m²	Equiv area	= 20664 m² (TA x RF).
Allowed discharge rate	= 154.050 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s	Climate change factor	= 20

Calculated data:-

Time to max	= 71.0 mins	Calculated storage volume	= 1257.9 m³
Rainfall at max	= 41.10 mm/hr	Allowed discharge rate	= 154.050 l/s
Pipeline storage	= 0.0 m³	Available MH storage	= 0.0 m³
Offline storage	= 0.0 m³		

Fixed 6 hour data:-

Rainfall event	= 6 hours	Calculated storage volume	= 0.0 m³
Rainfall rate	= 13.00 mm/hr	Allowed discharge rate	= 154.050 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	160192.1	1125	1265.7
150	71196.5	1200	1112.4
225	31642.9	1275	985.4
300	17799.1	1350	879.0
375	11391.4	1425	788.9
450	7910.7	1500	712.0
525	5812.0	1575	645.8
600	4449.8	1650	588.4
675	3515.9	1725	538.3
750	2847.9	1800	494.4
825	2353.6	1875	455.7
900	1977.7	1950	421.3
975	1685.1	2025	390.7
1050	1453.0	2100	363.2

Ovoid	Len
400 x 600	6988.4
600 x 900	3042.8
800 x 1200	1711.3

Box culvert	Len
500 x 500	5031.6
500 x 750	3354.4
500 x 1000	2515.8
750 x 1000	1677.2
750 x 1200	1397.7
750 x 1500	1118.1
1000 x 1000	1257.9
1000 x 1200	1048.3
1000 x 1500	838.6
1000 x 1800	698.8
1000 x 2000	629.0
1500 x 1500	559.1
1500 x 1800	465.9
1500 x 2000	419.3

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Job No.	
Sheet no.	2
Date	01/08/18

MasterDrain SW

Project	100yr+20% Parcel F west	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	125.0	817.575	92.430	725.145
20	88.0	1160.045	184.860	975.185
30	70.0	1382.830	277.290	1105.540
40	59.0	1551.626	369.720	1181.906
50	51.0	1688.615	462.150	1226.465
60	46.0	1804.369	554.580	1249.789
70	41.0	1904.806	647.010	1257.796
80	38.0	1993.594	739.440	1254.154
90	35.0	2073.178	831.870	1241.308
100	33.0	2145.277	924.300	1220.977
110	31.0	2211.151	1016.730	1194.421
120	29.0	2271.751	1109.160	1162.591
130	27.0	2327.818	1201.590	1126.228
140	26.0	2379.940	1294.020	1085.920
150	25.0	2428.591	1386.450	1042.141
160	24.0	2474.163	1478.880	995.283
170	23.0	2516.981	1571.310	945.671
180	22.0	2557.318	1663.740	893.578
190	21.0	2595.409	1756.170	839.239
200	20.0	2631.454	1848.600	782.854
210	19.0	2665.626	1941.030	724.596
220	19.0	2698.079	2033.460	664.619
230	18.0	2728.945	2125.890	603.054
240	18.0	2758.341	2218.320	540.021
250	17.0	2786.374	2310.750	475.624
260	17.0	2816.475	2403.180	413.295
270	16.0	2844.966	2495.610	349.356
280	16.0	2872.616	2588.040	284.576
290	15.0	2899.480	2680.470	219.010
300	15.0	2925.605	2772.900	152.705
310	15.0	2951.035	2865.330	85.705
320	14.0	2975.810	2957.760	18.050
330	14.0	2999.968	3050.190	0.000
340	14.0	3023.541	3142.620	0.000
350	13.0	3046.559	3235.050	0.000
360	13.0	3069.052	3327.480	0.000
370	13.0	3091.045	3419.910	0.000
380	12.0	3112.562	3512.340	0.000
390	12.0	3133.626	3604.770	0.000
400	12.0	3154.258	3697.200	0.000
410	12.0	3174.475	3789.630	0.000
420	12.0	3194.298	3882.060	0.000
430	11.0	3213.743	3974.490	0.000
440	11.0	3232.824	4066.920	0.000
450	11.0	3251.557	4159.350	0.000
460	11.0	3269.957	4251.780	0.000
470	11.0	3288.035	4344.210	0.000
480	10.0	3305.804	4436.640	0.000
490	10.0	3323.275	4529.070	0.000
500	10.0	3340.460	4621.500	0.000
510	10.0	3357.368	4713.930	0.000
520	10.0	3374.009	4806.360	0.000
530	10.0	3390.393	4898.790	0.000
540	10.0	3406.527	4991.220	0.000
550	9.0	3422.421	5083.650	0.000
560	9.0	3438.082	5176.080	0.000
570	9.0	3453.517	5268.510	0.000
580	9.0	3468.734	5360.940	0.000
590	9.0	3483.740	5453.370	0.000
600	9.0	3498.540	5545.800	0.000

Storage volume (m^3) = 1257.9 m^3

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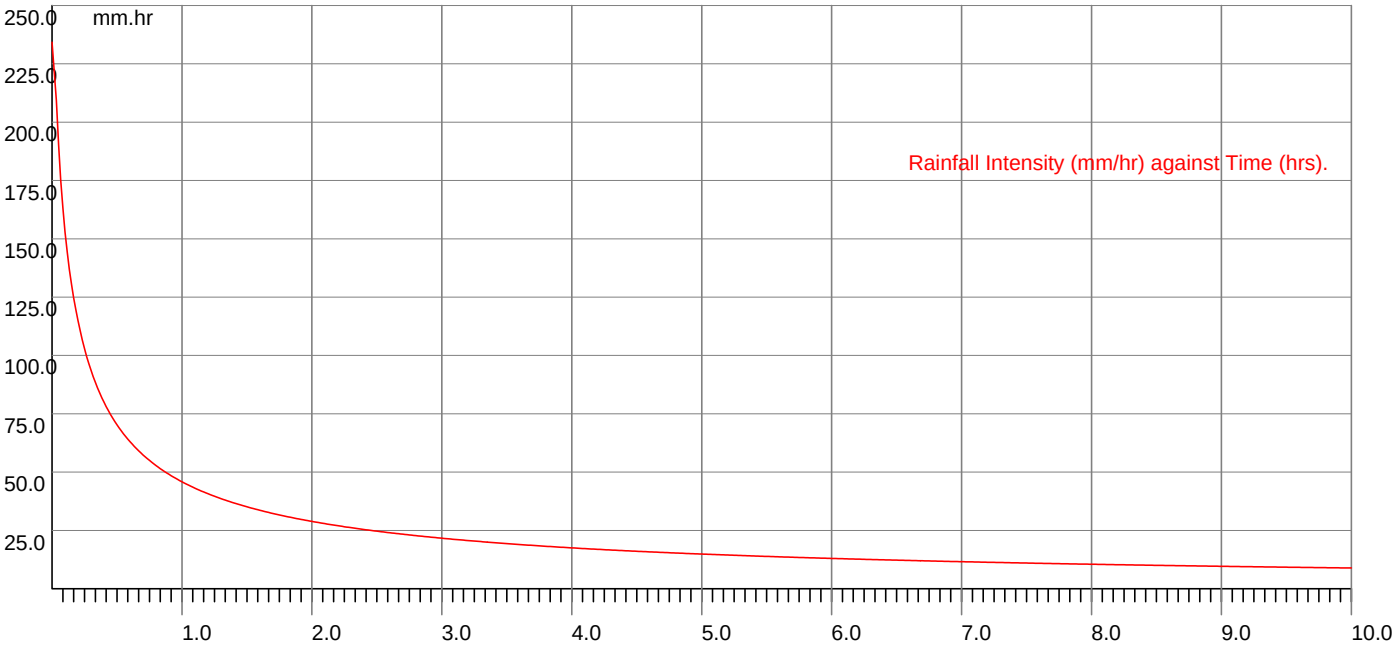
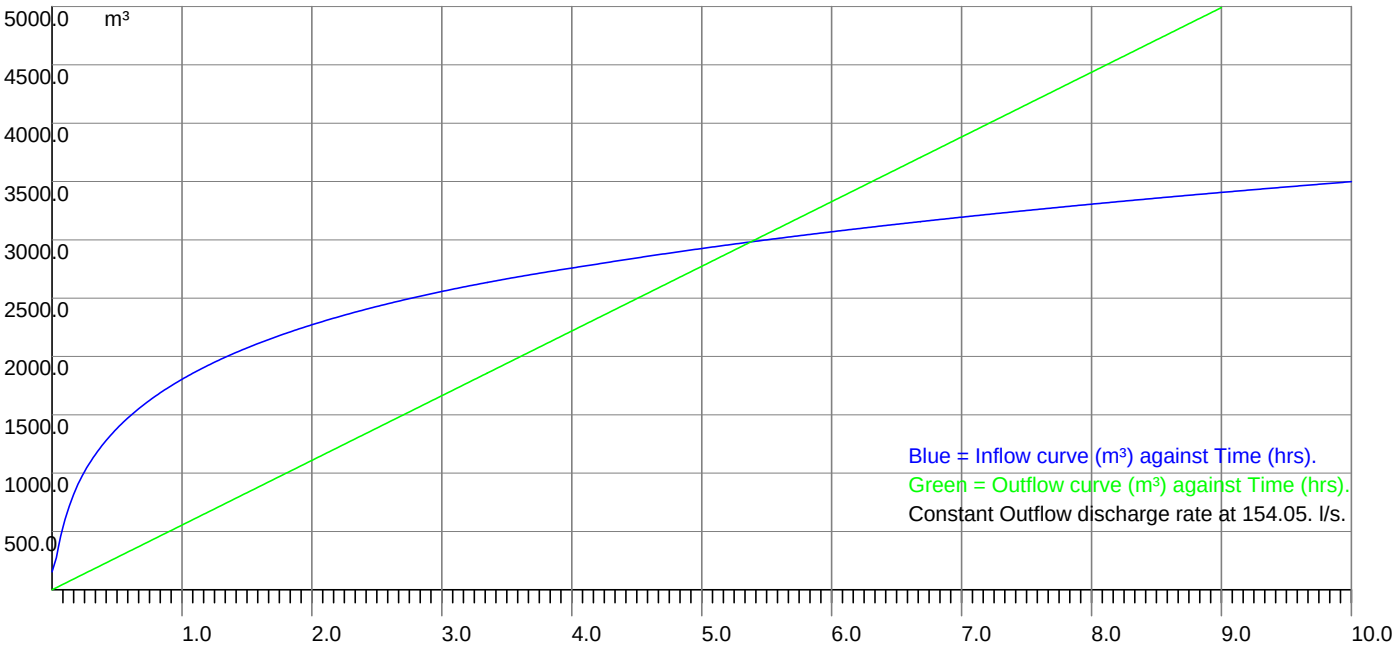
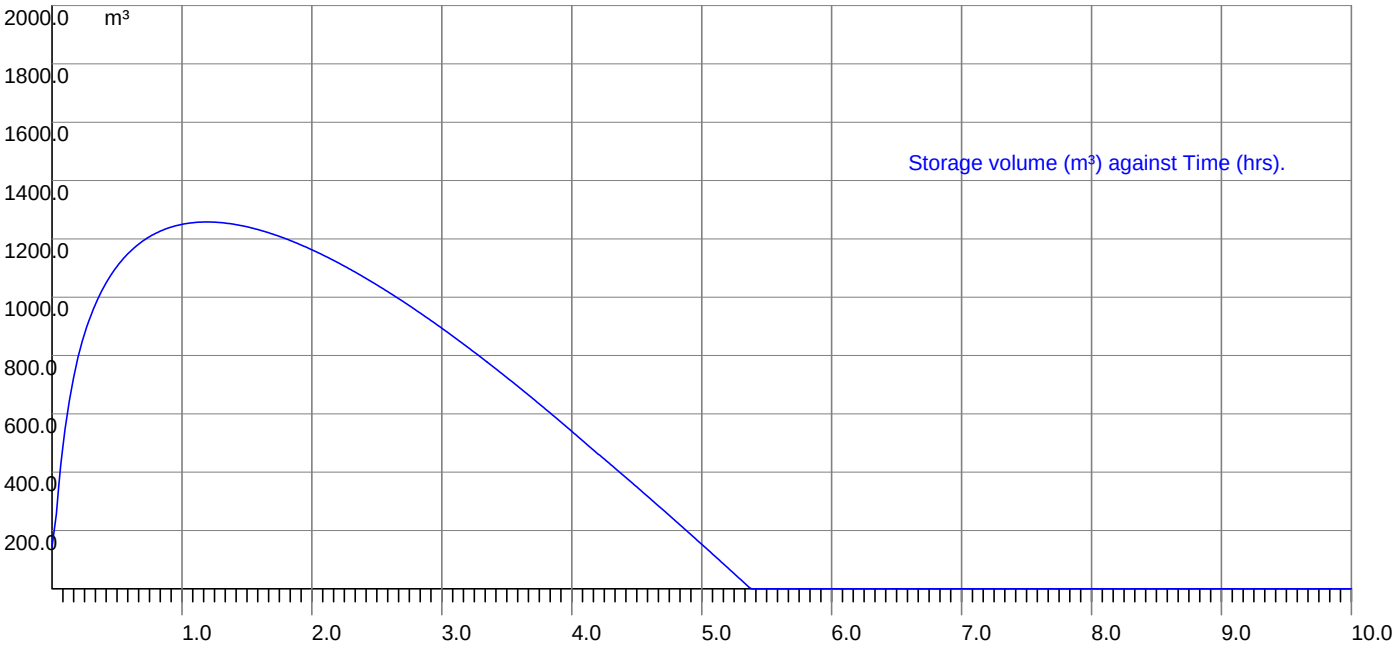
Job No.	
Sheet no.	3
Date	01/08/18

MasterDrain SW

Project	100yr+20% Parcel F west	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		







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Job No.			
Sheet no.	1		
Date	01/08/18		
Project	100yr+40% Parcel F west	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

FSR Hydrology:-

Location = Radcliffe
M5-60 (mm) = 18.9
Soil index = 0.45
Return period = 100
UCWI = 113.8

Grid reference = SD7808
r = 0.32
SAAR (mm/yr) = 1100
WRAP = 4
Climate change = 40

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 21.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area = 25700 m²
Total area (TA) = 98400 m²
Allowed discharge rate = 154.050 l/s
Additional flow = 0.00 l/s

Pervious area = 72700 m²
Equiv area = 20664 m² (TA x RF).
Areal reduction factor = 1.000
Climate change factor = 40

Calculated data:-

Time to max = 85.0 mins
Rainfall at max = 42.57 mm/hr
Pipeline storage = 0.0 m³
Offline storage = 0.0 m³

Calculated storage volume = 1587.8 m³
Allowed discharge rate = 154.050 l/s
Available MH storage = 0.0 m³

Fixed 6 hour data:-

Rainfall event = 6 hours
Rainfall rate = 15.00 mm/hr

Calculated storage volume = 186.3 m³
Allowed discharge rate = 154.050 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	202206.9	1125	1597.7
150	89869.7	1200	1404.2
225	39942.1	1275	1243.9
300	22467.4	1350	1109.5
375	14379.2	1425	995.8
450	9985.5	1500	898.7
525	7336.3	1575	815.1
600	5616.9	1650	742.7
675	4438.0	1725	679.5
750	3594.8	1800	624.1
825	2970.9	1875	575.2
900	2496.4	1950	531.8
975	2127.1	2025	493.1
1050	1834.1	2100	458.5

Ovoid	Len
400 x 600	8821.3
600 x 900	3840.9
800 x 1200	2160.2

Box culvert	Len
500 x 500	6351.3
500 x 750	4234.2
500 x 1000	3175.7
750 x 1000	2117.1
750 x 1200	1764.3
750 x 1500	1411.4
1000 x 1000	1587.8
1000 x 1200	1323.2
1000 x 1500	1058.6
1000 x 1800	882.1
1000 x 2000	793.9
1500 x 1500	705.7
1500 x 1800	588.1
1500 x 2000	529.3

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Sheet no.	2
Date	01/08/18
By	
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Reviewed	

MasterDrain SW

Project: 100yr+40% Parcel F west

Title: Peak flow storage calcs for Radcliffe

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	145.0	953.837	92.430	861.407
20	103.0	1353.385	184.860	1168.525
30	82.0	1613.302	277.290	1336.012
40	69.0	1810.231	369.720	1440.511
50	60.0	1970.050	462.150	1507.900
60	53.0	2105.097	554.580	1550.517
70	48.0	2222.273	647.010	1575.263
80	44.0	2325.860	739.440	1586.420
90	41.0	2418.708	831.870	1586.838
100	38.0	2502.823	924.300	1578.523
110	36.0	2579.676	1016.730	1562.946
120	34.0	2650.376	1109.160	1541.216
130	32.0	2715.788	1201.590	1514.198
140	30.0	2776.597	1294.020	1482.577
150	29.0	2833.356	1386.450	1446.906
160	28.0	2886.523	1478.880	1407.643
170	26.0	2936.477	1571.310	1365.167
180	25.0	2983.538	1663.740	1319.798
190	24.0	3027.977	1756.170	1271.807
200	23.0	3070.029	1848.600	1221.429
210	23.0	3109.897	1941.030	1168.867
220	22.0	3147.759	2033.460	1114.299
230	21.0	3183.769	2125.890	1057.878
240	20.0	3218.065	2218.320	999.745
250	20.0	3250.769	2310.750	940.019
260	19.0	3285.887	2403.180	882.707
270	19.0	3319.127	2495.610	823.517
280	18.0	3351.386	2588.040	763.346
290	18.0	3382.726	2680.470	702.256
300	17.0	3413.205	2772.900	640.305
310	17.0	3442.874	2865.330	577.544
320	17.0	3471.778	2957.760	514.018
330	16.0	3499.962	3050.190	449.772
340	16.0	3527.464	3142.620	384.844
350	15.0	3554.319	3235.050	319.269
360	15.0	3580.560	3327.480	253.080
370	15.0	3606.219	3419.910	186.309
380	15.0	3631.322	3512.340	118.982
390	14.0	3655.897	3604.770	51.127
400	14.0	3679.967	3697.200	0.000
410	14.0	3703.554	3789.630	0.000
420	14.0	3726.681	3882.060	0.000
430	13.0	3749.366	3974.490	0.000
440	13.0	3771.628	4066.920	0.000
450	13.0	3793.484	4159.350	0.000
460	13.0	3814.949	4251.780	0.000
470	12.0	3836.041	4344.210	0.000
480	12.0	3856.771	4436.640	0.000
490	12.0	3877.154	4529.070	0.000
500	12.0	3897.203	4621.500	0.000
510	12.0	3916.929	4713.930	0.000
520	12.0	3936.343	4806.360	0.000
530	11.0	3955.458	4898.790	0.000
540	11.0	3974.282	4991.220	0.000
550	11.0	3992.824	5083.650	0.000
560	11.0	4011.095	5176.080	0.000
570	11.0	4029.104	5268.510	0.000
580	11.0	4046.856	5360.940	0.000
590	11.0	4064.363	5453.370	0.000
600	10.0	4081.629	5545.800	0.000

Storage volume (m^3) = 1587.8 m^3

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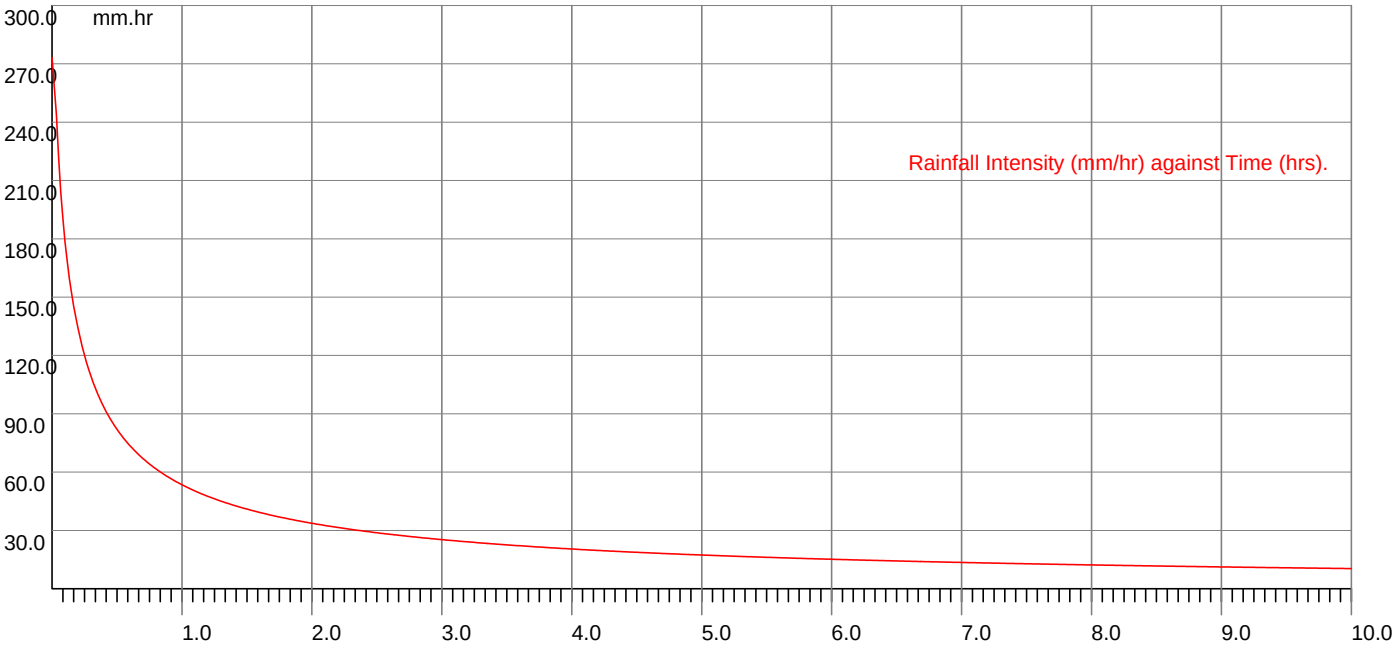
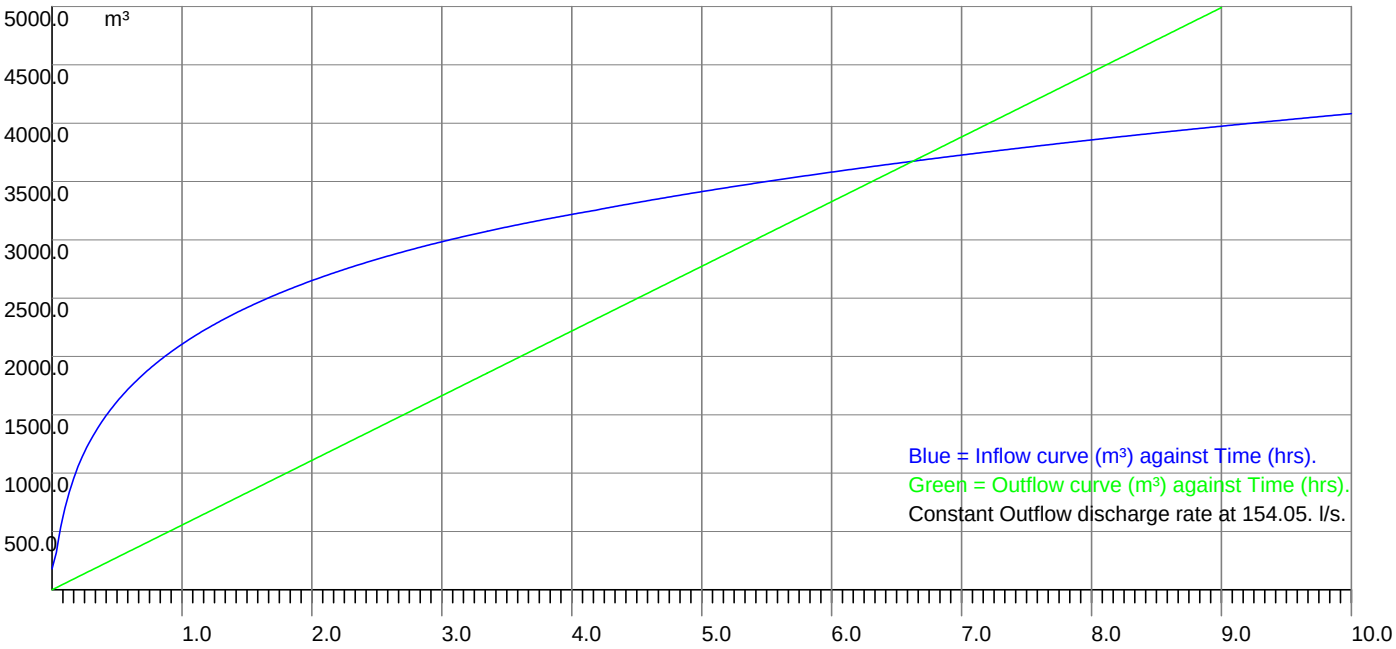
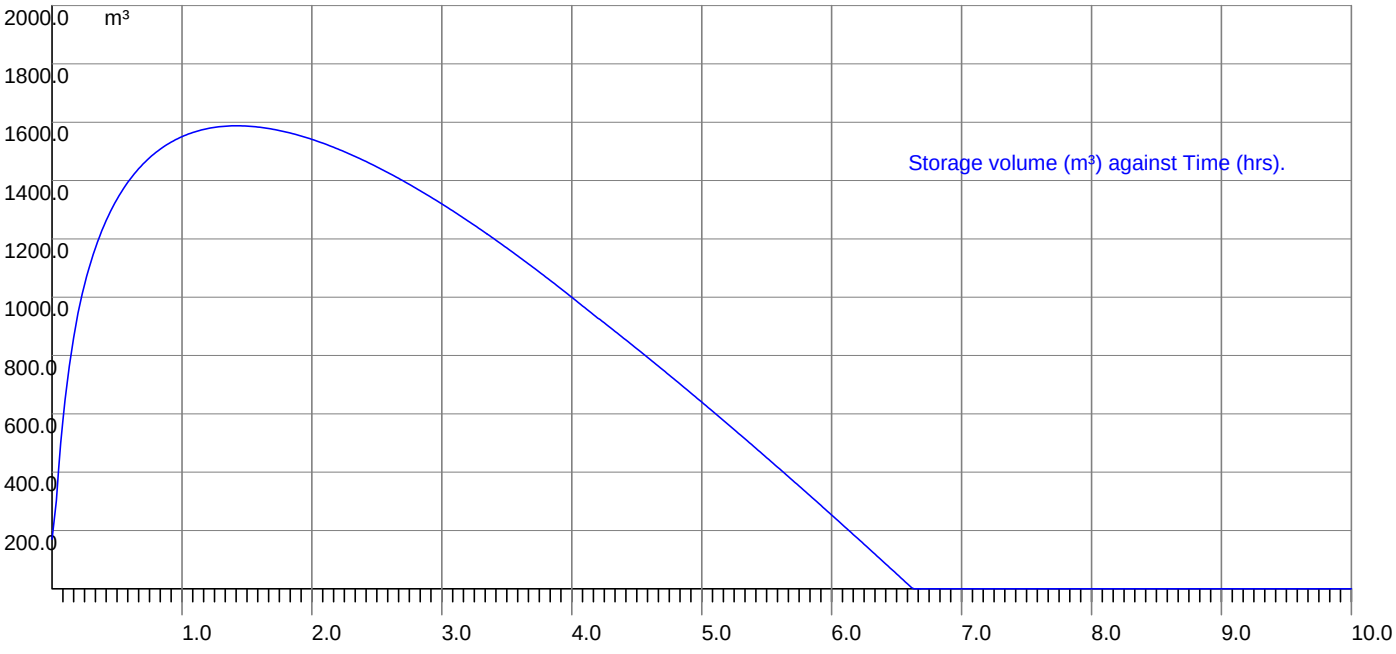
Job No.	
Sheet no.	3
Date	01/08/18

MasterDrain SW

Project	100yr+40% Parcel F west	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		







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www.thelkgroup.com		Sheet no.	1	
		Date	01/08/18	
Project 30yr Parcel F east		By	Checked	Reviewed
Title Peak flow storage calcs for Radcliffe				

Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil index	= 0.45	SAAR (mm/yr)	= 1100
Return period	= 30	WRAP	= 4
UCWI	= 113.8	Climate change	= 0

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 18.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 32100 m²	Pervious area	= 108500 m²
Total area (TA)	= 140600 m²	Equiv area	= 25308 m² (TA x RF).
Allowed discharge rate	= 176.090 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s	Climate change factor	= 0

Calculated data:-

Time to max	= 53.0 mins	Calculated storage volume	= 1005.0 m³
Rainfall at max	= 31.50 mm/hr	Allowed discharge rate	= 176.090 l/s
Pipeline storage	= 0.0 m³	Available MH storage	= 0.0 m³
Offline storage	= 0.0 m³		

Fixed 6 hour data:-

Rainfall event	= 6 hours	Calculated storage volume	= 0.0 m³
Rainfall rate	= 8.00 mm/hr	Allowed discharge rate	= 176.090 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	127988.5	1125	1011.3
150	56883.8	1200	888.8
225	25281.7	1275	787.3
300	14221.0	1350	702.3
375	9101.4	1425	630.3
450	6320.4	1500	568.8
525	4643.6	1575	516.0
600	3555.2	1650	470.1
675	2809.1	1725	430.1
750	2275.4	1800	395.0
825	1880.5	1875	364.1
900	1580.1	1950	336.6
975	1346.4	2025	312.1
1050	1160.9	2100	290.2

Ovoid	Len
400 x 600	5583.5
600 x 900	2431.1
800 x 1200	1367.3

Box culvert	Len
500 x 500	4020.1
500 x 750	2680.1
500 x 1000	2010.1
750 x 1000	1340.0
750 x 1200	1116.7
750 x 1500	893.4
1000 x 1000	1005.0
1000 x 1200	837.5
1000 x 1500	670.0
1000 x 1800	558.4
1000 x 2000	502.5
1500 x 1500	446.7
1500 x 1800	372.2
1500 x 2000	335.0

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Job No.
Sheet no. 2
Date 01/08/18

MasterDrain SW

Project 30yr Parcel F east

Title Peak flow storage calcs for Radcliffe

By | Checked | Reviewed

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	81.0	760.496	105.654	654.842
20	57.0	1064.457	211.308	853.149
30	45.0	1261.652	316.962	944.690
40	38.0	1410.997	422.616	988.381
50	33.0	1532.453	528.270	1004.183
60	29.0	1635.434	633.924	1001.510
70	26.0	1725.165	739.578	985.587
80	24.0	1804.869	845.232	959.637
90	22.0	1876.681	950.886	925.795
100	21.0	1942.096	1056.540	885.556
110	19.0	2002.205	1162.194	840.011
120	18.0	2057.830	1267.848	789.982
130	17.0	2109.608	1373.502	736.106
140	16.0	2158.043	1479.156	678.887
150	16.0	2203.543	1584.810	618.733
160	15.0	2246.440	1690.464	555.976
170	14.0	2287.012	1796.118	490.894
180	14.0	2325.491	1901.772	423.719
190	13.0	2362.076	2007.426	354.651
200	13.0	2396.938	2113.080	283.857
210	12.0	2430.221	2218.734	211.487
220	12.0	2462.056	2324.388	137.668
230	12.0	2492.553	2430.042	62.511
240	11.0	2521.813	2535.696	0.000
250	11.0	2549.924	2641.350	0.000
260	11.0	2578.835	2747.004	0.000
270	10.0	2606.512	2852.658	0.000
280	10.0	2633.406	2958.312	0.000
290	10.0	2659.566	3063.966	0.000
300	10.0	2685.037	3169.620	0.000
310	9.0	2709.860	3275.274	0.000
320	9.0	2734.071	3380.928	0.000
330	9.0	2757.705	3486.582	0.000
340	9.0	2780.791	3592.236	0.000
350	9.0	2803.358	3697.890	0.000
360	8.0	2825.433	3803.544	0.000
370	8.0	2847.039	3909.198	0.000
380	8.0	2868.198	4014.852	0.000
390	8.0	2888.932	4120.506	0.000
400	8.0	2909.260	4226.160	0.000
410	8.0	2929.198	4331.814	0.000
420	7.0	2948.765	4437.468	0.000
430	7.0	2967.976	4543.122	0.000
440	7.0	2986.845	4648.776	0.000
450	7.0	3005.385	4754.430	0.000
460	7.0	3023.611	4860.084	0.000
470	7.0	3041.533	4965.738	0.000
480	7.0	3059.163	5071.392	0.000
490	7.0	3076.512	5177.046	0.000
500	7.0	3093.591	5282.700	0.000
510	7.0	3110.407	5388.354	0.000
520	6.0	3126.971	5494.008	0.000
530	6.0	3143.291	5599.662	0.000
540	6.0	3159.375	5705.316	0.000
550	6.0	3175.230	5810.970	0.000
560	6.0	3190.865	5916.624	0.000
570	6.0	3206.286	6022.278	0.000
580	6.0	3221.500	6127.932	0.000
590	6.0	3236.512	6233.586	0.000
600	6.0	3251.329	6339.240	0.000

Storage volume (m³) = 1005.0 m³

MasterDrain SW

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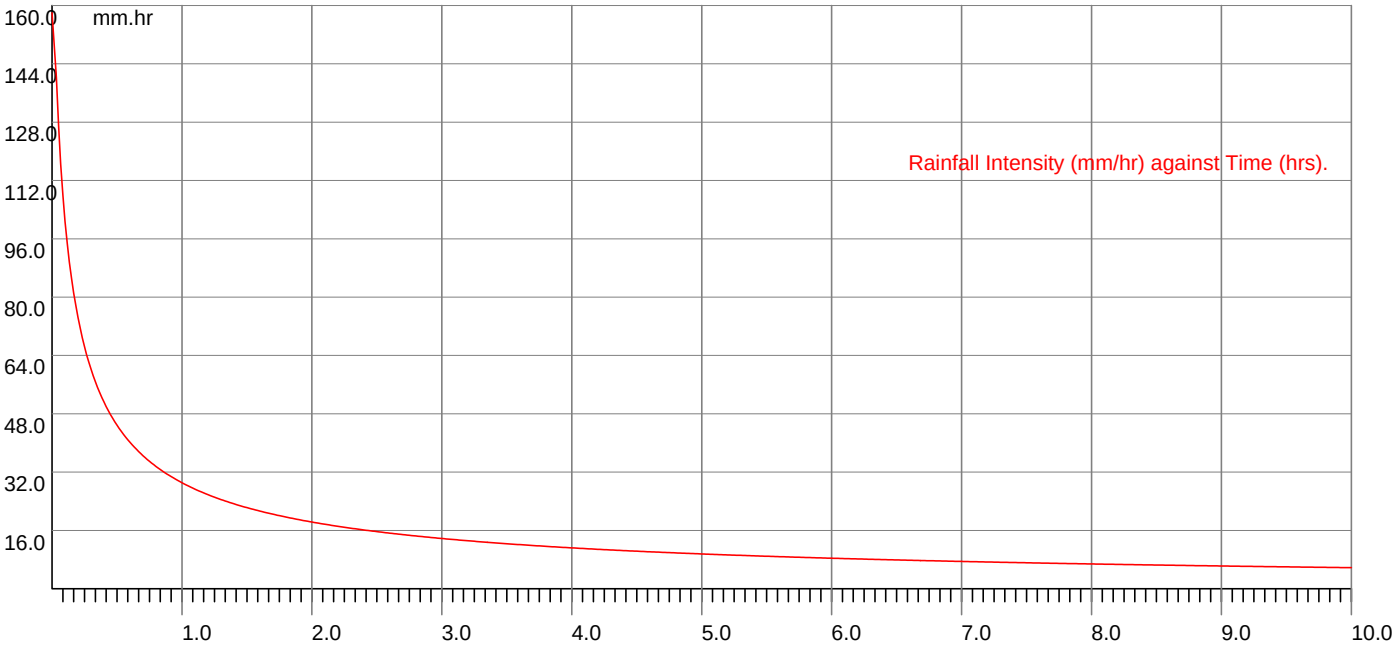
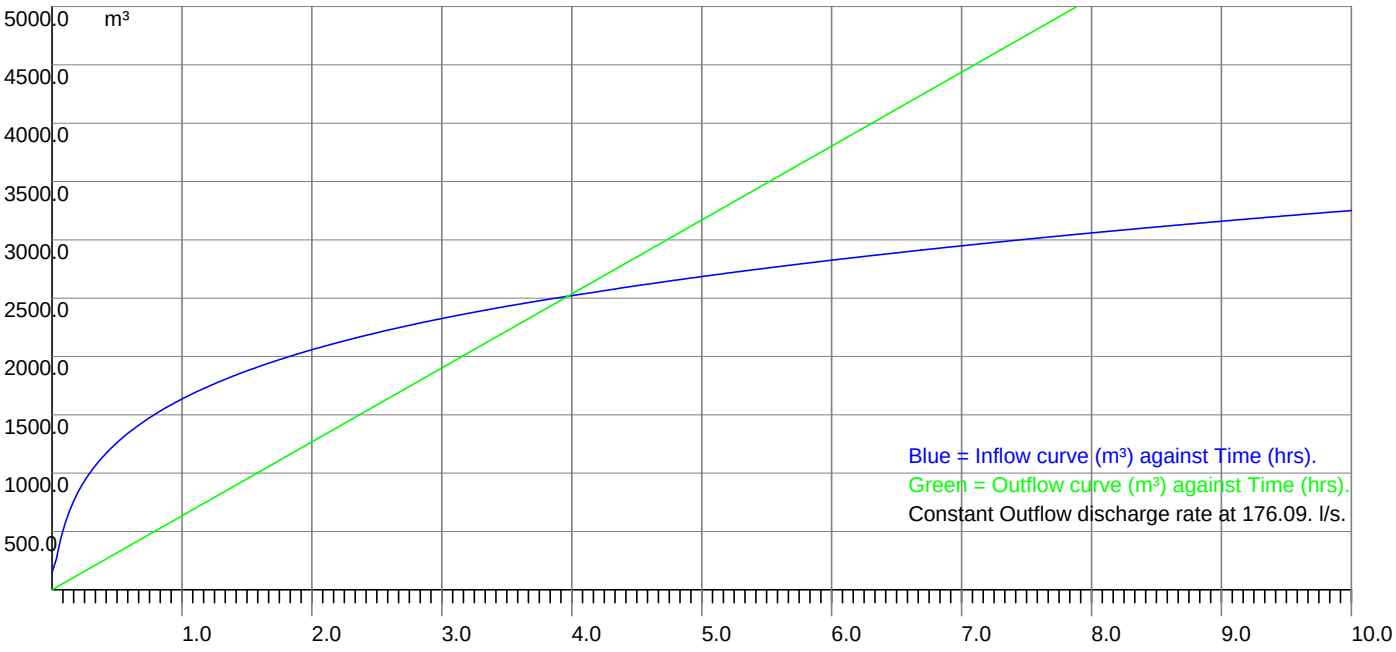
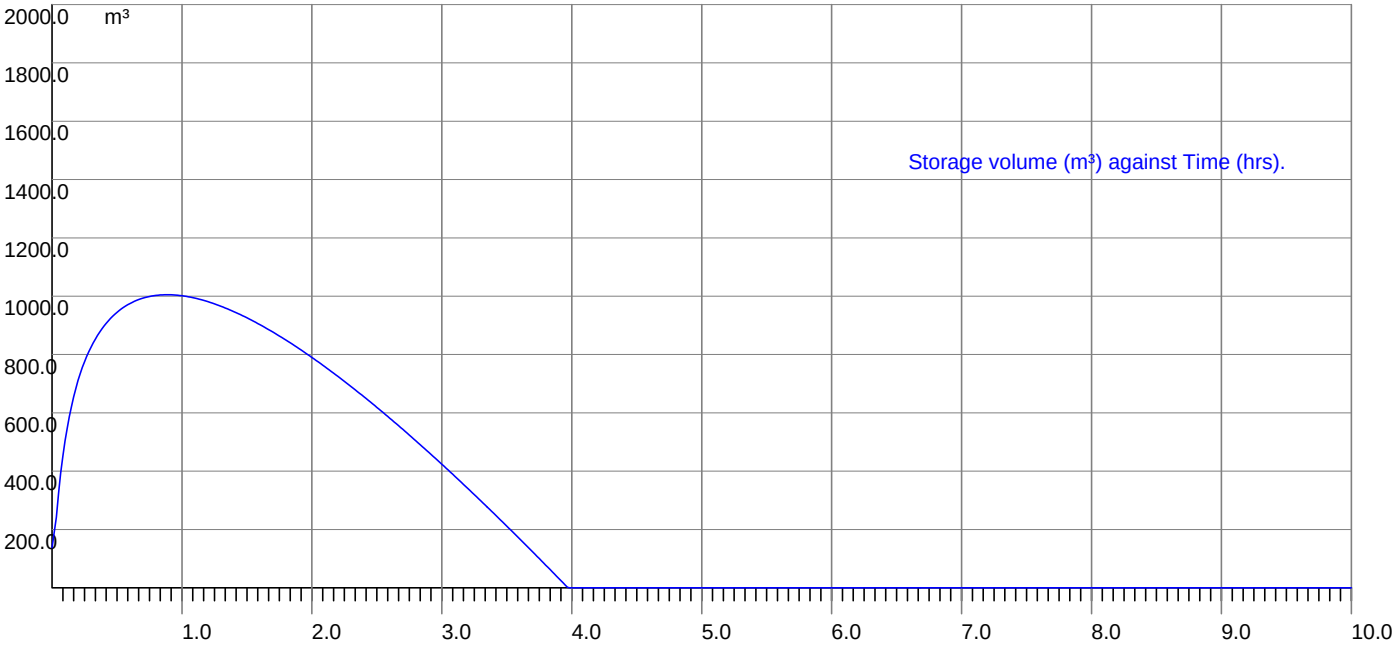
Job No.			
Sheet no.	3		
Date	01/08/18		
By		Checked	Reviewed

Project 30yr Parcel F east

Title Peak flow storage calcs for Radcliffe







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Job No.			
Sheet no.	1		
Date	01/08/18		
Project	100yr +20% Parcel F east	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil index	= 0.45	SAAR (mm/yr)	= 1100
Return period	= 100	WRAP	= 4
UCWI	= 113.8	Climate change	= 20

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 18.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 32100 m²	Pervious area	= 108500 m²
Total area (TA)	= 140600 m²	Equiv area	= 25308 m² (TA x RF).
Allowed discharge rate	= 220.110 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s	Climate change factor	= 20

Calculated data:-

Time to max	= 71.0 mins	Calculated storage volume	= 1797.4 m³
Rainfall at max	= 41.10 mm/hr	Allowed discharge rate	= 220.110 l/s
Pipeline storage	= 0.0 m³	Available MH storage	= 0.0 m³
Offline storage	= 0.0 m³		

Fixed 6 hour data:-

Rainfall event	= 6 hours	Calculated storage volume	= 0.0 m³
Rainfall rate	= 13.00 mm/hr	Allowed discharge rate	= 220.110 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	228895.7	1125	1808.6
150	101731.4	1200	1589.6
225	45214.0	1275	1408.0
300	25432.9	1350	1255.9
375	16277.0	1425	1127.2
450	11303.5	1500	1017.3
525	8304.6	1575	922.7
600	6358.2	1650	840.8
675	5023.8	1725	769.2
750	4069.3	1800	706.5
825	3363.0	1875	651.1
900	2825.9	1950	602.0
975	2407.8	2025	558.2
1050	2076.2	2100	519.0

Ovoid	Len
400 x 600	9985.6
600 x 900	4347.9
800 x 1200	2445.3

Box culvert	Len
500 x 500	7189.6
500 x 750	4793.1
500 x 1000	3594.8
750 x 1000	2396.5
750 x 1200	1997.1
750 x 1500	1597.7
1000 x 1000	1797.4
1000 x 1200	1497.8
1000 x 1500	1198.3
1000 x 1800	998.6
1000 x 2000	898.7
1500 x 1500	798.8
1500 x 1800	665.7
1500 x 2000	599.1

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Job No.	
Sheet no.	2
Date	01/08/18

MasterDrain SW

Project	100yr +20% Parcel F east	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	125.0	1168.201	132.066	1036.135
20	88.0	1657.543	264.132	1393.411
30	70.0	1975.873	396.198	1579.675
40	59.0	2217.060	528.264	1688.796
50	51.0	2412.797	660.330	1752.467
60	46.0	2578.194	792.396	1785.798
70	41.0	2721.704	924.462	1797.242
80	38.0	2848.570	1056.528	1792.042
90	35.0	2962.285	1188.594	1773.691
100	33.0	3065.305	1320.660	1744.645
110	31.0	3159.429	1452.726	1706.703
120	29.0	3246.019	1584.792	1661.227
130	27.0	3326.130	1716.858	1609.272
140	26.0	3400.605	1848.924	1551.682
150	25.0	3470.121	1980.990	1489.131
160	24.0	3535.237	2113.056	1422.181
170	23.0	3596.417	2245.122	1351.295
180	22.0	3654.054	2377.188	1276.866
190	21.0	3708.481	2509.254	1199.227
200	20.0	3759.984	2641.320	1118.664
210	19.0	3808.812	2773.386	1035.426
220	19.0	3855.182	2905.452	949.730
230	18.0	3899.285	3037.518	861.767
240	18.0	3941.289	3169.584	771.705
250	17.0	3981.343	3301.650	679.693
260	17.0	4024.354	3433.716	590.637
270	16.0	4065.063	3565.782	499.281
280	16.0	4104.572	3697.848	406.724
290	15.0	4142.956	3829.914	313.042
300	15.0	4180.285	3961.980	218.305
310	15.0	4216.621	4094.046	122.575
320	14.0	4252.021	4226.112	25.910
330	14.0	4286.540	4358.178	0.000
340	14.0	4320.222	4490.244	0.000
350	13.0	4353.112	4622.310	0.000
360	13.0	4385.250	4754.376	0.000
370	13.0	4416.676	4886.442	0.000
380	12.0	4447.420	5018.508	0.000
390	12.0	4477.519	5150.574	0.000
400	12.0	4506.998	5282.640	0.000
410	12.0	4535.886	5414.706	0.000
420	12.0	4564.211	5546.772	0.000
430	11.0	4591.994	5678.838	0.000
440	11.0	4619.259	5810.904	0.000
450	11.0	4646.026	5942.970	0.000
460	11.0	4672.316	6075.036	0.000
470	11.0	4698.148	6207.102	0.000
480	10.0	4723.537	6339.168	0.000
490	10.0	4748.500	6471.234	0.000
500	10.0	4773.056	6603.300	0.000
510	10.0	4797.215	6735.366	0.000
520	10.0	4820.992	6867.432	0.000
530	10.0	4844.402	6999.498	0.000
540	10.0	4867.457	7131.564	0.000
550	9.0	4890.167	7263.630	0.000
560	9.0	4912.544	7395.696	0.000
570	9.0	4934.599	7527.762	0.000
580	9.0	4956.341	7659.828	0.000
590	9.0	4977.783	7791.894	0.000
600	9.0	4998.930	7923.960	0.000

Storage volume (m^3) = 1797.4 m^3

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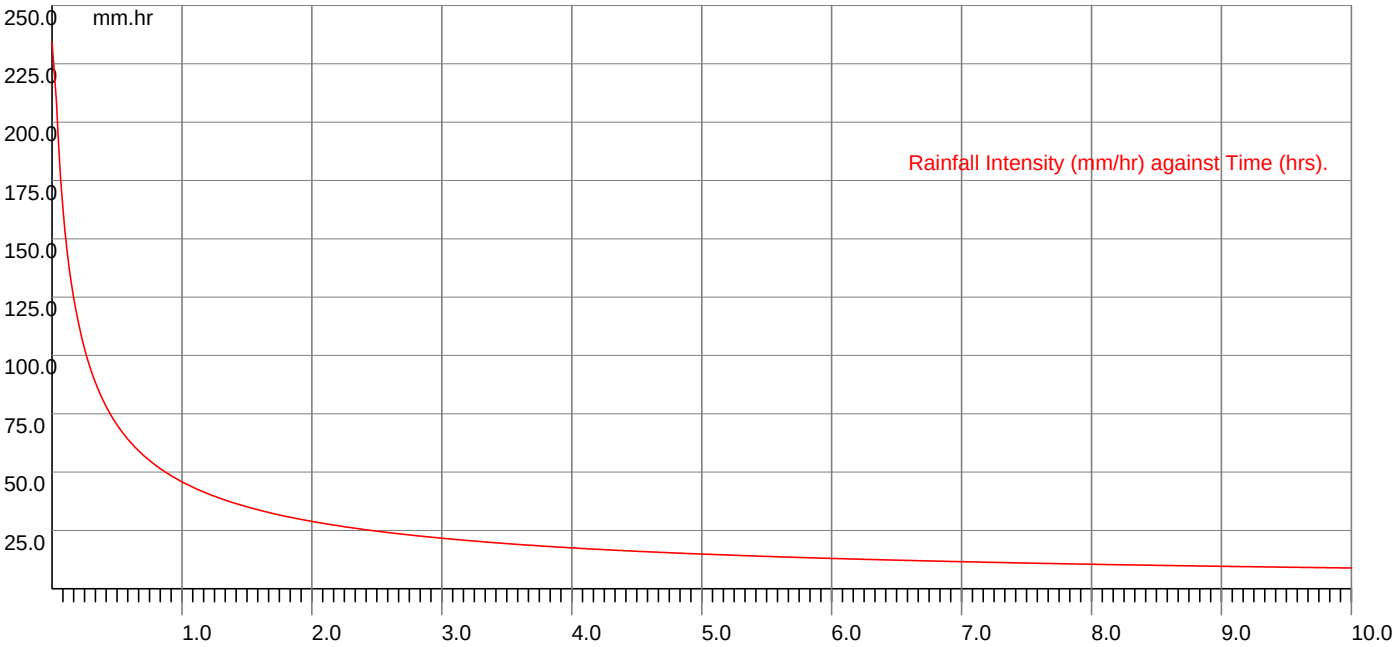
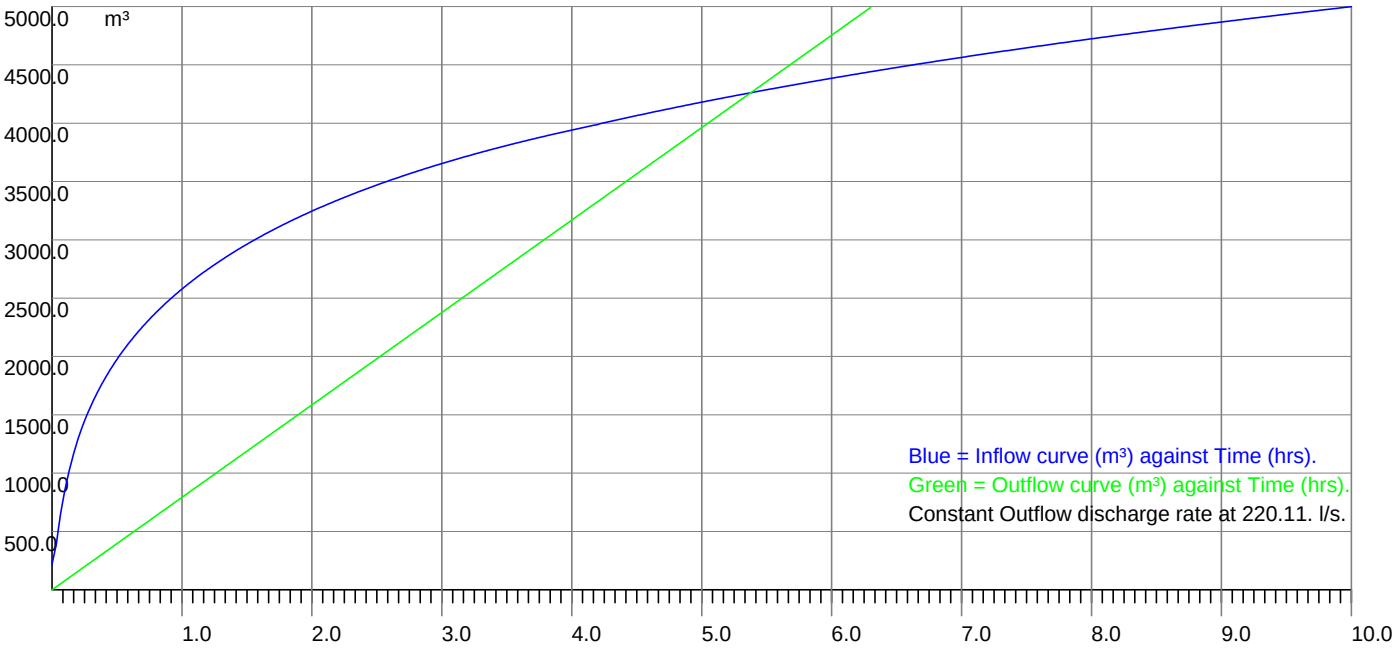
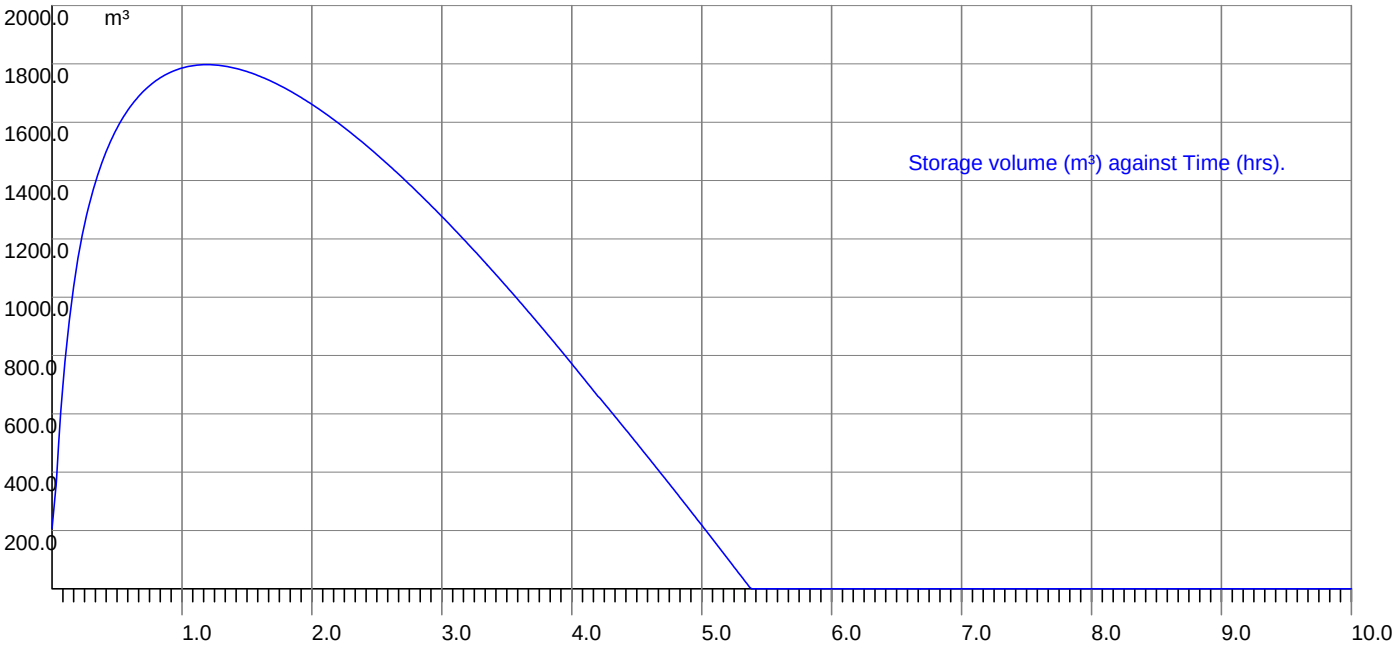
Job No.	
Sheet no.	3
Date	01/08/18

MasterDrain SW

Project	100yr +20% Parcel F east	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		







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Job No.	
Sheet no.	1
Date	01/08/18

MasterDrain SW

Project	100yr +40% Parcel F east	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil index	= 0.45	SAAR (mm/yr)	= 1100
Return period	= 100	WRAP	= 4
UCWI	= 113.8	Climate change	= 40

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 18.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 32100 m²	Pervious area	= 108500 m²
Total area (TA)	= 140600 m²	Equiv area	= 25308 m² (TA x RF).
Allowed discharge rate	= 220.110 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s	Climate change factor	= 40

Calculated data:-

Time to max	= 85.0 mins	Calculated storage volume	= 2268.8 m³
Rainfall at max	= 42.57 mm/hr	Allowed discharge rate	= 220.110 l/s
Pipeline storage	= 0.0 m³	Available MH storage	= 0.0 m³
Offline storage	= 0.0 m³		

Fixed 6 hour data:-

Rainfall event	= 6 hours	Calculated storage volume	= 266.3 m³
Rainfall rate	= 15.00 mm/hr	Allowed discharge rate	= 220.110 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	288929.7	1125	2282.9
150	128413.2	1200	2006.5
225	57072.5	1275	1777.3
300	32103.3	1350	1585.3
375	20546.1	1425	1422.9
450	14268.1	1500	1284.1
525	10482.7	1575	1164.7
600	8025.8	1650	1061.3
675	6341.4	1725	971.0
750	5136.5	1800	891.8
825	4245.1	1875	821.8
900	3567.0	1950	759.8
975	3039.4	2025	704.6
1050	2620.7	2100	655.2

Ovoid	Len
400 x 600	12604.6
600 x 900	5488.2
800 x 1200	3086.7

Box culvert	Len
500 x 500	9075.3
500 x 750	6050.2
500 x 1000	4537.6
750 x 1000	3025.1
750 x 1200	2520.9
750 x 1500	2016.7
1000 x 1000	2268.8
1000 x 1200	1890.7
1000 x 1500	1512.5
1000 x 1800	1260.5
1000 x 2000	1134.4
1500 x 1500	1008.4
1500 x 1800	840.3
1500 x 2000	756.3

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Job No.	
Sheet no.	2
Date	01/08/18

MasterDrain SW

Project	100yr +40% Parcel F east	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	145.0	1362.901	132.066	1230.835
20	103.0	1933.800	264.132	1669.668
30	82.0	2305.185	396.198	1908.987
40	69.0	2586.569	528.264	2058.305
50	60.0	2814.930	660.330	2154.600
60	53.0	3007.893	792.396	2215.497
70	48.0	3175.322	924.462	2250.860
80	44.0	3323.332	1056.528	2266.804
90	41.0	3455.999	1188.594	2267.405
100	38.0	3576.188	1320.660	2255.528
110	36.0	3686.001	1452.726	2233.275
120	34.0	3787.022	1584.792	2202.230
130	32.0	3880.485	1716.858	2163.627
140	30.0	3967.373	1848.924	2118.449
150	29.0	4048.474	1980.990	2067.484
160	28.0	4124.443	2113.056	2011.387
170	26.0	4195.820	2245.122	1950.698
180	25.0	4263.063	2377.188	1885.875
190	24.0	4326.561	2509.254	1817.307
200	23.0	4386.647	2641.320	1745.327
210	23.0	4443.614	2773.386	1670.228
220	22.0	4497.712	2905.452	1592.260
230	21.0	4549.166	3037.518	1511.647
240	20.0	4598.169	3169.584	1428.585
250	20.0	4644.900	3301.650	1343.250
260	19.0	4695.079	3433.716	1261.363
270	19.0	4742.573	3565.782	1176.791
280	18.0	4788.667	3697.848	1090.819
290	18.0	4833.448	3829.914	1003.534
300	17.0	4876.999	3961.980	915.019
310	17.0	4919.391	4094.046	825.345
320	17.0	4960.691	4226.112	734.580
330	16.0	5000.962	4358.178	642.784
340	16.0	5040.258	4490.244	550.014
350	15.0	5078.630	4622.310	456.320
360	15.0	5116.125	4754.376	361.750
370	15.0	5152.788	4886.442	266.346
380	15.0	5188.657	5018.508	170.149
390	14.0	5223.771	5150.574	73.197
400	14.0	5258.164	5282.640	0.000
410	14.0	5291.867	5414.706	0.000
420	14.0	5324.912	5546.772	0.000
430	13.0	5357.326	5678.838	0.000
440	13.0	5389.135	5810.904	0.000
450	13.0	5420.364	5942.970	0.000
460	13.0	5451.036	6075.036	0.000
470	12.0	5481.172	6207.102	0.000
480	12.0	5510.792	6339.168	0.000
490	12.0	5539.917	6471.234	0.000
500	12.0	5568.564	6603.300	0.000
510	12.0	5596.750	6735.366	0.000
520	12.0	5624.490	6867.432	0.000
530	11.0	5651.803	6999.498	0.000
540	11.0	5678.699	7131.564	0.000
550	11.0	5705.194	7263.630	0.000
560	11.0	5731.301	7395.696	0.000
570	11.0	5757.032	7527.762	0.000
580	11.0	5782.398	7659.828	0.000
590	11.0	5807.413	7791.894	0.000
600	10.0	5832.084	7923.960	0.000

Storage volume (m^3) = 2268.8 m^3

MasterDrain SW

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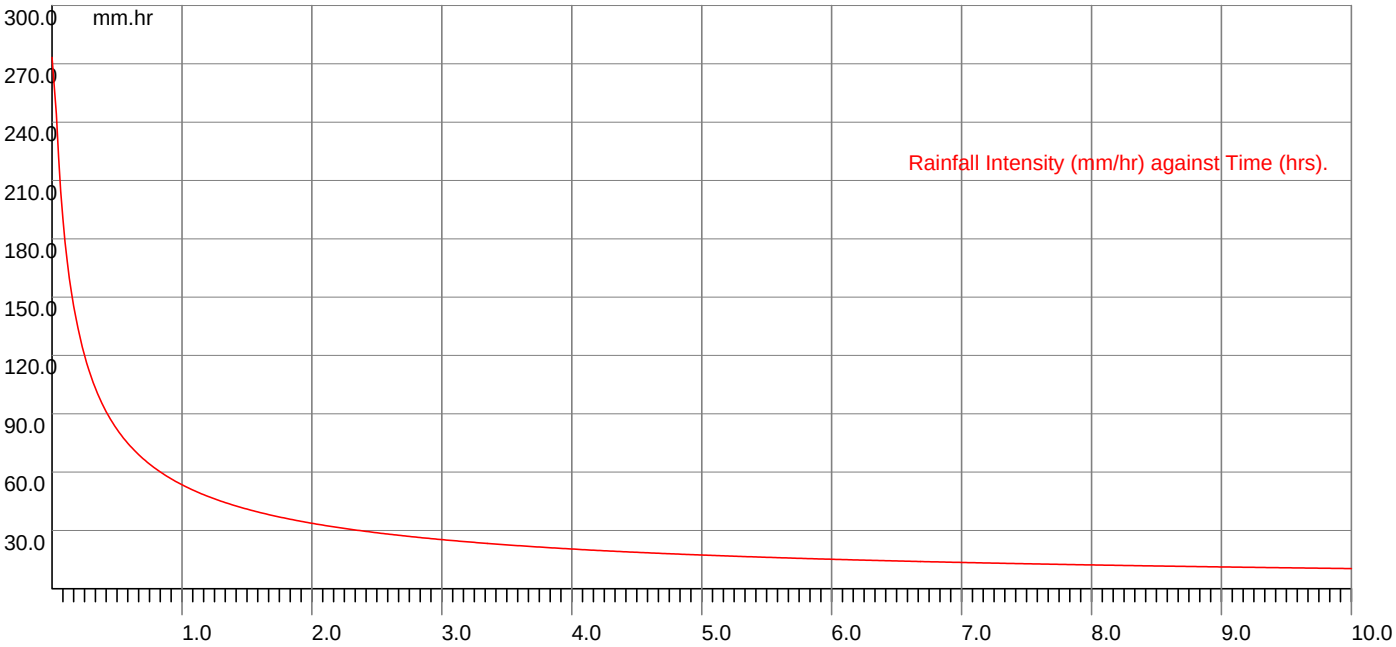
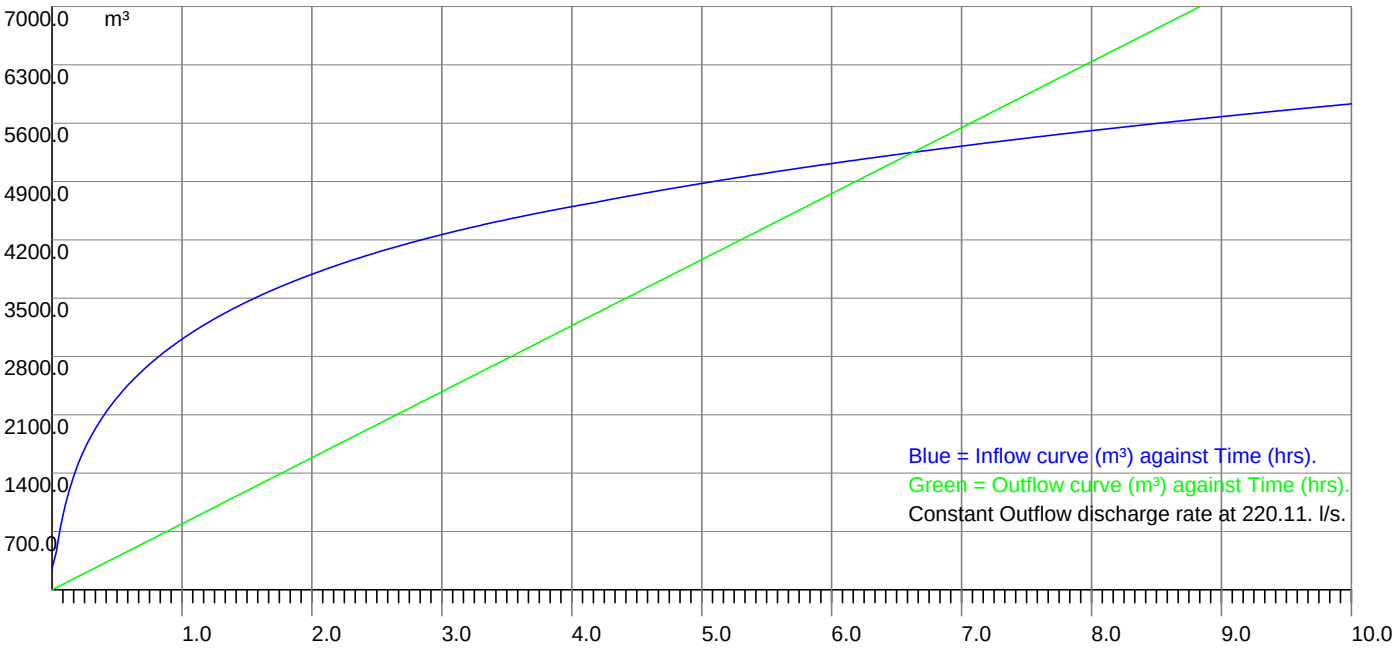
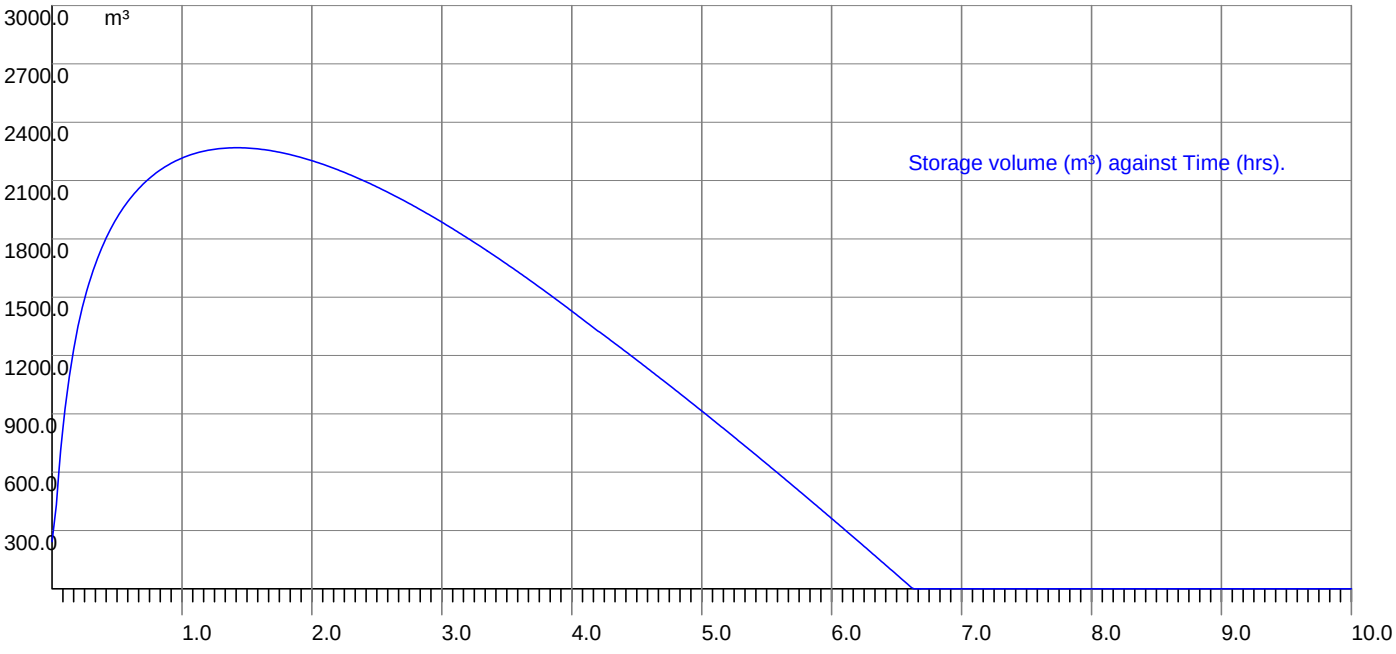
		Sheet no.	3
		Date	01/08/18
Project: **100yr +40% Parcel F east**		By	Checked / Reviewed
Title: **Peak flow storage calcs for Radcliffe**			







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Job No.			
Sheet no.	1		
Date	31/07/18		
Project	Parcel G	By	Checked / Reviewed
Title	IoH 124 Runoff calcs for Radcliffe		

Hydrological Data:-

FSR Hydrology:-

Location = Radcliffe — Grid reference = SD7808
M5-60 (mm) = 18.9 — r = 0.32
Soil runoff = 0.45 — SAAR (mm/yr) = 1100
WRAP = 4 — Area = England & Wales
Hydrological area = 10 — Hydrological zone = 7

Soil classification for WRAP type 4
Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Design data:-

Area = 0.087 Km² - 8.7 Ha - 87000 m²

Calculation method:-

Runoff is calculated from:-

$$Q_{BAR(rural)} = 0.00108\ AREA^{0.89}\ .\ SAAR^{1.17}\ .\ SOIL^{2.17}$$

where

AREA = Site area in Km²
SAAR = Standard Average Annual Rainfall (mm/yr)
SOIL = Soil value derived from Winter Rainfall Acceptance Potential
$Q_{BAR(rural)}$ = Runoff (cumecs)

$Q_{BAR(rural)}$ is then multiplied by a growth factor - GC(T) - for different storm return periods derived from EA publication W5-074/A.

Calculated data:-

For areas less than 50Ha, a modified calculation which multiplies the 50Ha runoff value by the ratio of the site area to 50Ha is used
Reducing factor used for these calculations is 0.174

Mean Annual Peak Flow $Q_{BAR(rural)}$ = 64.86 l/s

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By	Checked	Reviewed

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HY 9.36

Project: **Parcel G**

Title: **IoH 124 Runoff calcs for Radcliffe**

Values for $Q_{BAR(rural)}$

Ret. per.	m³/hr	l/s	l/s/ha	Ret. per.	m³/hr	l/s	l/s/ha
1yr	198.462	55.128	6.337	100yr	490.319	136.200	15.655
2yr	217.141	60.317	6.933	100yr+20%	588.382	163.440	18.786
5yr	282.517	78.477	9.020	100yr+30%	637.414	177.060	20.352
10yr	322.209	89.503	10.288	200yr	560.364	155.657	17.892
30yr	392.255	108.960	12.524	200yr + 30%	728.474	202.354	23.259
50yr	431.947	119.985	13.791	500yr	637.414	177.060	20.352
				1000yr	709.795	197.165	22.663

Growth factors -

1yr	2yr	5yr	10yr	30yr	50yr	100yr	200yr	500yr	1000yr
0.85	0.93	1.21	1.38	1.68	1.85	2.10	2.40	2.73	3.04

The above is based on the Institute of Hydrology Report 124
to which you are referred for further details (see Sect 7).
Note that the 200 and above year growth curves were taken from W5-074.

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Job No.			
Sheet no.	1		
Date	01/08/18		
Project	30yr Parcel G	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil index	= 0.45	SAAR (mm/yr)	= 1100
Return period	= 30	WRAP	= 4
UCWI	= 113.8	Climate change	= 0

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 45.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 47900 m²	Pervious area	= 39100 m²
Total area (TA)	= 87000 m²	Equiv area	= 39150 m² (TA x RF).
Allowed discharge rate	= 108.960 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s	Climate change factor	= 0

Calculated data:-

Time to max	= 61.0 mins	Calculated storage volume	= 746.3 m³
Rainfall at max	= 28.77 mm/hr	Allowed discharge rate	= 108.960 l/s
Pipeline storage	= 0.0 m³	Available MH storage	= 0.0 m³
Offline storage	= 0.0 m³		

Fixed 6 hour data:-

Rainfall event	= 6 hours	Calculated storage volume	= 0.0 m³
Rainfall rate	= 8.00 mm/hr	Allowed discharge rate	= 108.960 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	95038.1	1125	750.9
150	42239.2	1200	660.0
225	18773.0	1275	584.6
300	10559.8	1350	521.5
375	6758.3	1425	468.0
450	4693.2	1500	422.4
525	3448.1	1575	383.1
600	2639.9	1650	349.1
675	2085.9	1725	319.4
750	1689.6	1800	293.3
825	1396.3	1875	270.3
900	1173.3	1950	249.9
975	999.7	2025	231.8
1050	862.0	2100	215.5

Ovoid	Len
400 x 600	4146.0
600 x 900	1805.2
800 x 1200	1015.3

Box culvert	Len
500 x 500	2985.1
500 x 750	1990.1
500 x 1000	1492.6
750 x 1000	995.0
750 x 1200	829.2
750 x 1500	663.4
1000 x 1000	746.3
1000 x 1200	621.9
1000 x 1500	497.5
1000 x 1800	414.6
1000 x 2000	373.1
1500 x 1500	331.7
1500 x 1800	276.4
1500 x 2000	248.8

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Sheet no.	2
Date	01/08/18

MasterDrain SW

Project	30yr Parcel G	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	81.0	529.399	65.376	464.023
20	57.0	740.994	130.752	610.242
30	45.0	878.266	196.128	682.138
40	38.0	982.229	261.504	720.725
50	33.0	1066.777	326.880	739.897
60	29.0	1138.464	392.256	746.208
70	26.0	1200.928	457.632	743.297
80	24.0	1256.412	523.008	733.404
90	22.0	1306.402	588.384	718.018
100	21.0	1351.939	653.760	698.179
110	19.0	1393.782	719.136	674.646
120	18.0	1432.505	784.512	647.993
130	17.0	1468.548	849.888	618.660
140	16.0	1502.265	915.264	587.001
150	16.0	1533.938	980.640	553.298
160	15.0	1563.800	1046.016	517.784
170	14.0	1592.043	1111.392	480.651
180	14.0	1618.830	1176.768	442.062
190	13.0	1644.297	1242.144	402.153
200	13.0	1668.565	1307.520	361.045
210	12.0	1691.735	1372.896	318.839
220	12.0	1713.895	1438.272	275.623
230	12.0	1735.125	1503.648	231.478
240	11.0	1755.494	1569.024	186.470
250	11.0	1775.062	1634.400	140.662
260	11.0	1795.188	1699.776	95.412
270	10.0	1814.455	1765.152	49.303
280	10.0	1833.177	1830.528	2.649
290	10.0	1851.387	1895.904	0.000
300	10.0	1869.118	1961.280	0.000
310	9.0	1886.398	2026.656	0.000
320	9.0	1903.252	2092.032	0.000
330	9.0	1919.704	2157.408	0.000
340	9.0	1935.775	2222.784	0.000
350	9.0	1951.484	2288.160	0.000
360	8.0	1966.851	2353.536	0.000
370	8.0	1981.891	2418.912	0.000
380	8.0	1996.621	2484.288	0.000
390	8.0	2011.054	2549.664	0.000
400	8.0	2025.205	2615.040	0.000
410	8.0	2039.085	2680.416	0.000
420	7.0	2052.706	2745.792	0.000
430	7.0	2066.079	2811.168	0.000
440	7.0	2079.214	2876.544	0.000
450	7.0	2092.120	2941.920	0.000
460	7.0	2104.808	3007.296	0.000
470	7.0	2117.283	3072.672	0.000
480	7.0	2129.556	3138.048	0.000
490	7.0	2141.633	3203.424	0.000
500	7.0	2153.522	3268.800	0.000
510	7.0	2165.228	3334.176	0.000
520	6.0	2176.759	3399.552	0.000
530	6.0	2188.119	3464.928	0.000
540	6.0	2199.316	3530.304	0.000
550	6.0	2210.353	3595.680	0.000
560	6.0	2221.237	3661.056	0.000
570	6.0	2231.972	3726.432	0.000
580	6.0	2242.562	3791.808	0.000
590	6.0	2253.013	3857.184	0.000
600	6.0	2263.327	3922.560	0.000

Storage volume (m^3) = 746.3 m^3

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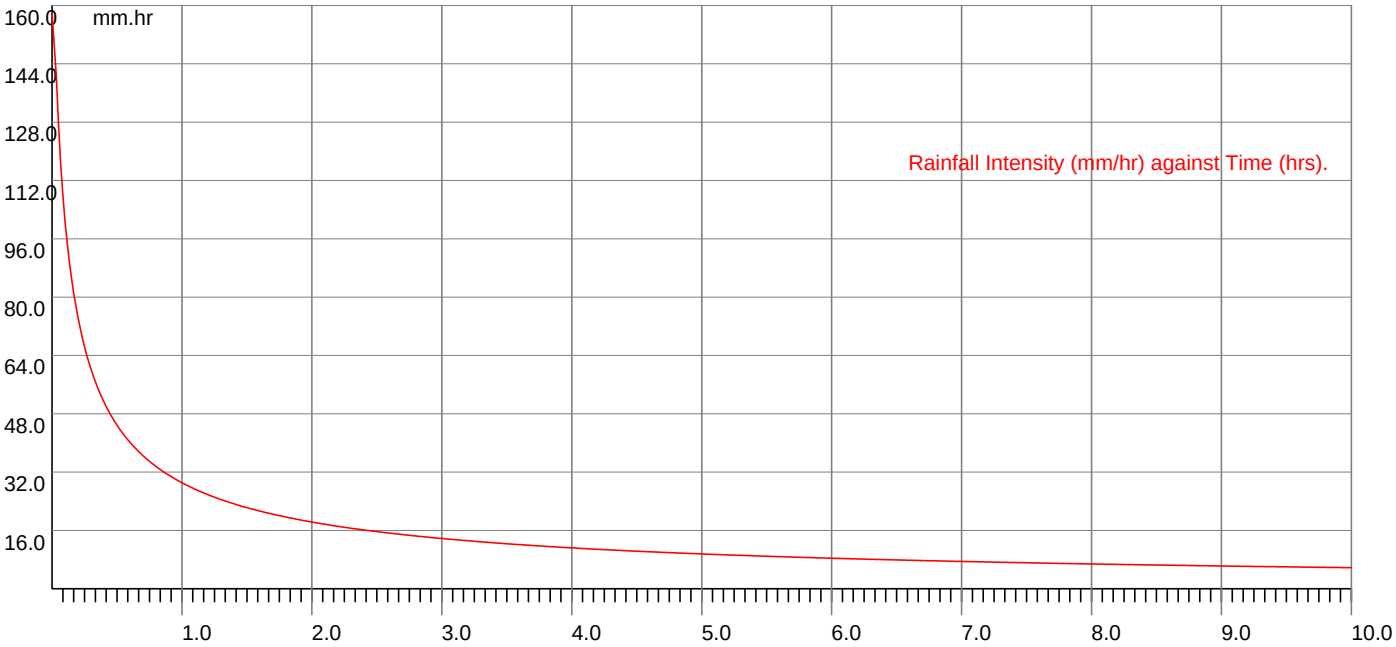
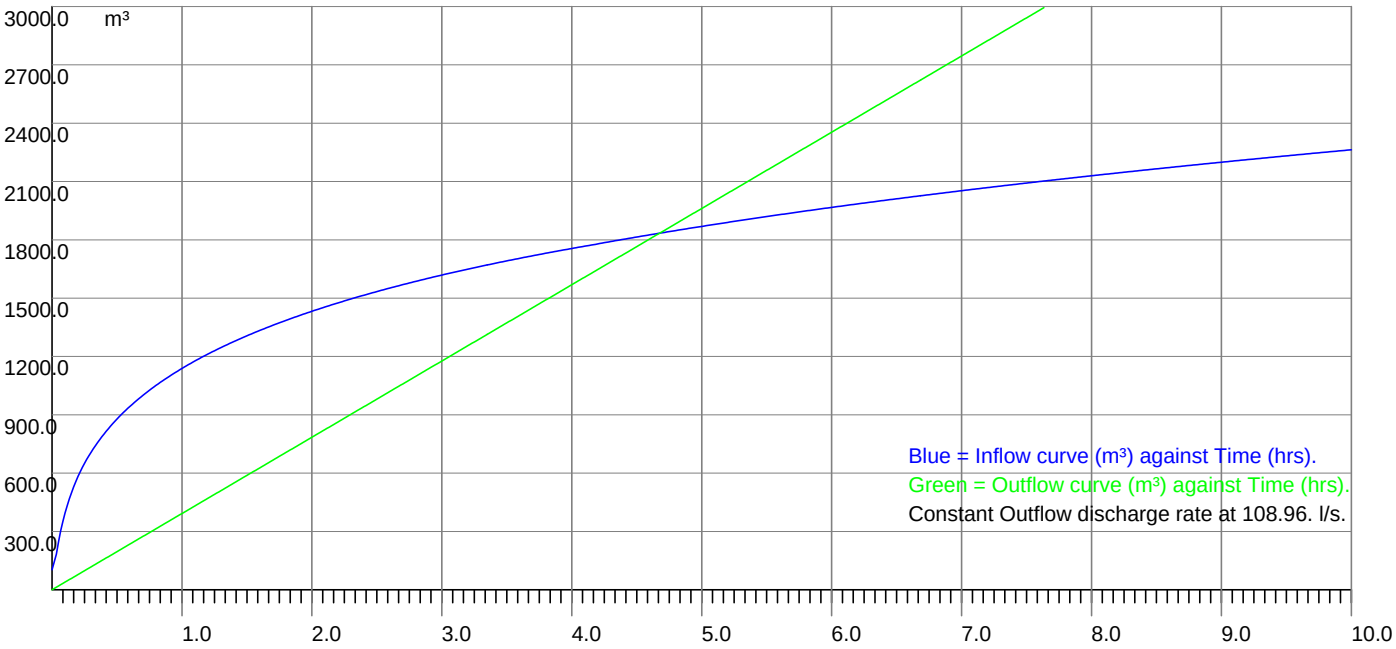
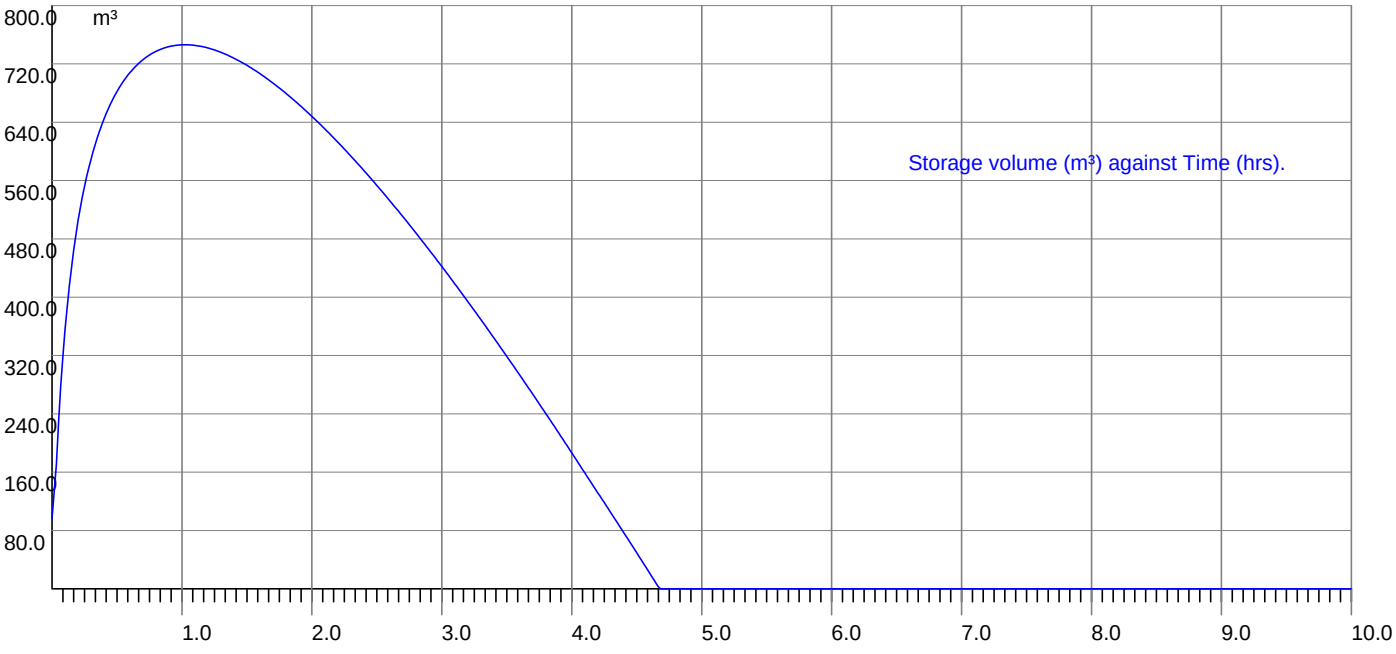
Project	30yr Parcel G	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		







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Job No.			
Sheet no.	1		
Date	01/08/18		
Project	100yr+20% Parcel G	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil index	= 0.45	SAAR (mm/yr)	= 1100
Return period	= 100	WRAP	= 4
UCWI	= 113.8	Climate change	= 20

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 45.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 47900 m²	Pervious area	= 39100 m²
Total area (TA)	= 87000 m²	Equiv area	= 39150 m² (TA x RF).
Allowed discharge rate	= 136.200 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s	Climate change factor	= 20

Calculated data:-

Time to max	= 82.0 mins	Calculated storage volume	= 1329.4 m³
Rainfall at max	= 37.37 mm/hr	Allowed discharge rate	= 136.200 l/s
Pipeline storage	= 0.0 m³	Available MH storage	= 0.0 m³
Offline storage	= 0.0 m³		

Fixed 6 hour data:-

Rainfall event	= 6 hours	Calculated storage volume	= 50.9 m³
Rainfall rate	= 13.00 mm/hr	Allowed discharge rate	= 136.200 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	169290.6	1125	1337.6
150	75240.3	1200	1175.6
225	33440.1	1275	1041.4
300	18810.1	1350	928.9
375	12038.4	1425	833.7
450	8360.0	1500	752.4
525	6142.1	1575	682.5
600	4702.5	1650	621.8
675	3715.6	1725	568.9
750	3009.6	1800	522.5
825	2487.3	1875	481.5
900	2090.0	1950	445.2
975	1780.8	2025	412.8
1050	1535.5	2100	383.9

Ovoid	Len
400 x 600	7385.3
600 x 900	3215.7
800 x 1200	1808.5

Box culvert	Len
500 x 500	5317.4
500 x 750	3544.9
500 x 1000	2658.7
750 x 1000	1772.5
750 x 1200	1477.1
750 x 1500	1181.6
1000 x 1000	1329.4
1000 x 1200	1107.8
1000 x 1500	886.2
1000 x 1800	738.5
1000 x 2000	664.7
1500 x 1500	590.8
1500 x 1800	492.4
1500 x 2000	443.1

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Sheet no.	2
Date	01/08/18

MasterDrain SW

Project	100yr+20% Parcel G	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	125.0	813.212	81.720	731.492
20	88.0	1153.855	163.440	990.415
30	70.0	1375.452	245.160	1130.292
40	59.0	1543.348	326.880	1216.468
50	51.0	1679.605	408.600	1271.005
60	46.0	1794.742	490.320	1304.422
70	41.0	1894.643	572.040	1322.603
80	38.0	1982.957	653.760	1329.197
90	35.0	2062.117	735.480	1326.637
100	33.0	2133.831	817.200	1316.631
110	31.0	2199.354	898.920	1300.434
120	29.0	2259.631	980.640	1278.991
130	27.0	2315.398	1062.360	1253.038
140	26.0	2367.242	1144.080	1223.162
150	25.0	2415.634	1225.800	1189.834
160	24.0	2460.962	1307.520	1153.442
170	23.0	2503.552	1389.240	1114.312
180	22.0	2543.674	1470.960	1072.714
190	21.0	2581.562	1552.680	1028.882
200	20.0	2617.414	1634.400	983.014
210	19.0	2651.404	1716.120	935.284
220	19.0	2683.684	1797.840	885.844
230	18.0	2714.385	1879.560	834.825
240	18.0	2743.625	1961.280	782.345
250	17.0	2771.507	2043.000	728.507
260	17.0	2801.448	2124.720	676.728
270	16.0	2829.787	2206.440	623.347
280	16.0	2857.290	2288.160	569.130
290	15.0	2884.010	2369.880	514.130
300	15.0	2909.996	2451.600	458.396
310	15.0	2935.290	2533.320	401.970
320	14.0	2959.933	2615.040	344.893
330	14.0	2983.962	2696.760	287.202
340	14.0	3007.409	2778.480	228.929
350	13.0	3030.305	2860.200	170.105
360	13.0	3052.677	2941.920	110.757
370	13.0	3074.553	3023.640	50.913
380	12.0	3095.955	3105.360	0.000
390	12.0	3116.907	3187.080	0.000
400	12.0	3137.428	3268.800	0.000
410	12.0	3157.538	3350.520	0.000
420	12.0	3177.256	3432.240	0.000
430	11.0	3196.596	3513.960	0.000
440	11.0	3215.576	3595.680	0.000
450	11.0	3234.209	3677.400	0.000
460	11.0	3252.510	3759.120	0.000
470	11.0	3270.492	3840.840	0.000
480	10.0	3288.166	3922.560	0.000
490	10.0	3305.544	4004.280	0.000
500	10.0	3322.637	4086.000	0.000
510	10.0	3339.455	4167.720	0.000
520	10.0	3356.007	4249.440	0.000
530	10.0	3372.304	4331.160	0.000
540	10.0	3388.352	4412.880	0.000
550	9.0	3404.161	4494.600	0.000
560	9.0	3419.739	4576.320	0.000
570	9.0	3435.092	4658.040	0.000
580	9.0	3450.227	4739.760	0.000
590	9.0	3465.153	4821.480	0.000
600	9.0	3479.874	4903.200	0.000

Storage volume (m^3) = 1329.4 m^3

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Date	01/08/18

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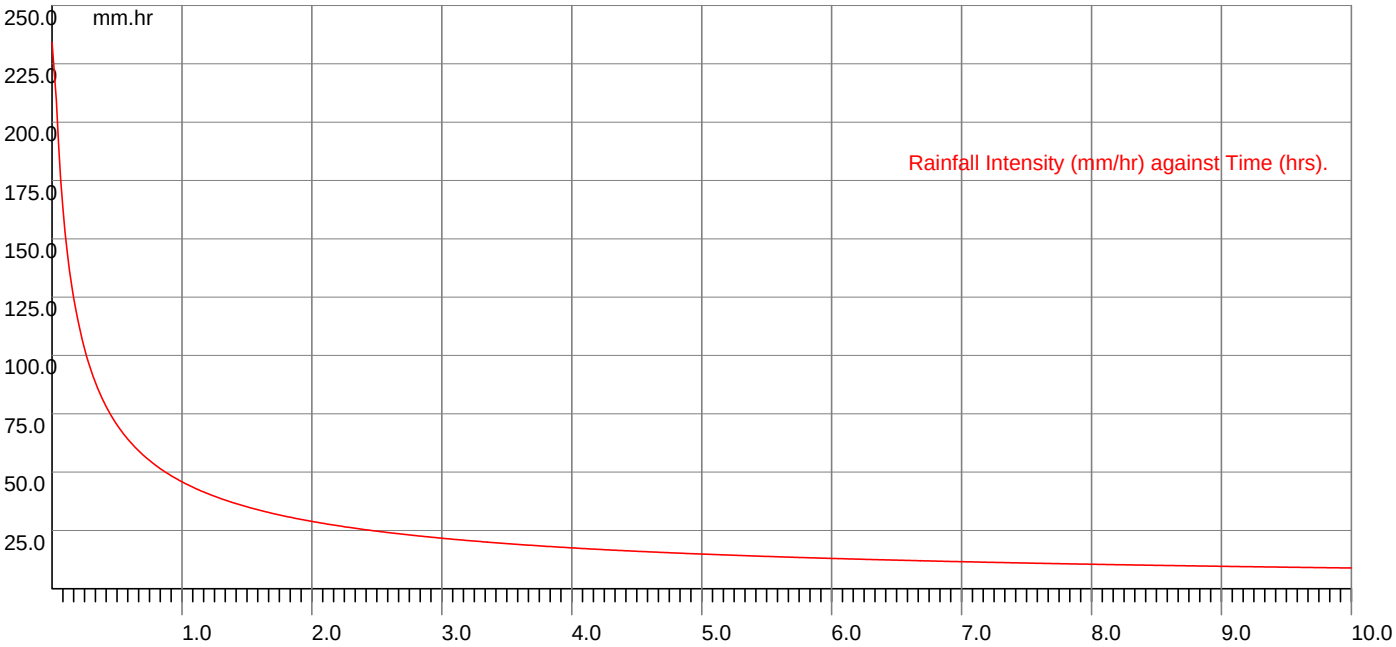
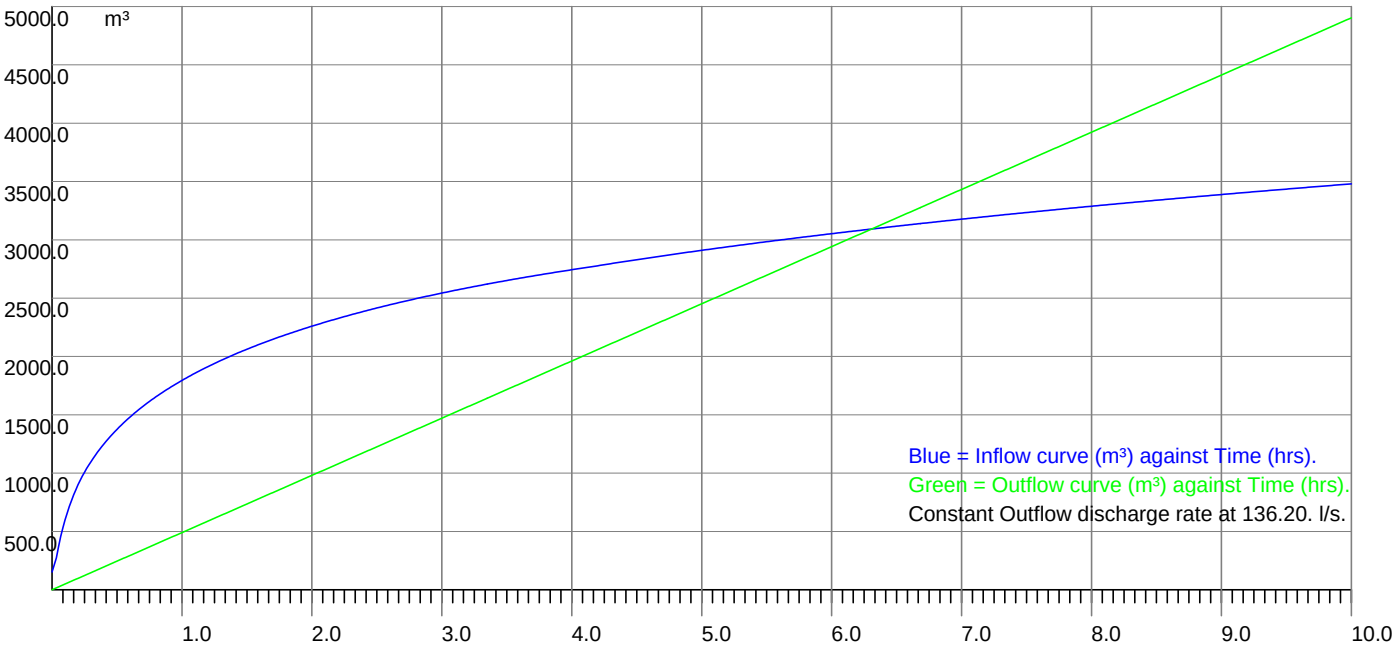
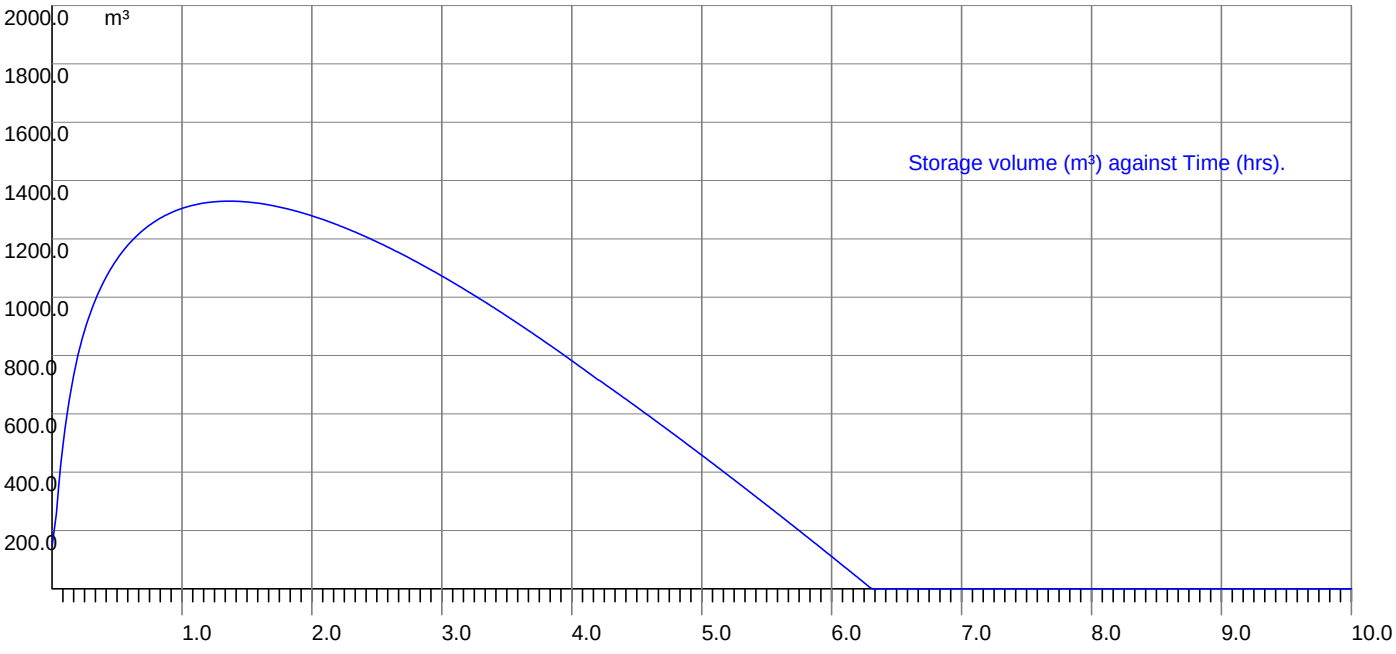
	By	Checked	Reviewed
Project: 100yr+20% Parcel G			
Title: Peak flow storage calcs for Radcliffe			







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www.thelkgroup.com		Sheet no.	1	
		Date	01/08/18	
Project 100yr+40% Parcel G		By	Checked	Reviewed
Title Peak flow storage calcs for Radcliffe				

Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil index	= 0.45	SAAR (mm/yr)	= 1100
Return period	= 100	WRAP	= 4
UCWI	= 113.8	Climate change	= 40

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 45.0, calculated from:-

Runoff factor = (0.829*PIMP)+(25*SOIL)+(0.078*UCWI)-20.7
where
PIMP = Impervious Area*100/(Impervious Area+Pervious Area)
UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 47900 m²	Pervious area	= 39100 m²
Total area (TA)	= 87000 m²	Equiv area	= 39150 m² (TA x RF).
Allowed discharge rate	= 136.200 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s	Climate change factor	= 40

Calculated data:-

Time to max	= 97.0 mins	Calculated storage volume	= 1672.5 m³
Rainfall at max	= 38.95 mm/hr	Allowed discharge rate	= 136.200 l/s
Pipeline storage	= 0.0 m³	Available MH storage	= 0.0 m³
Offline storage	= 0.0 m³		

Fixed 6 hour data:-

Rainfall event	= 6 hours	Calculated storage volume	= 563.3 m³
Rainfall rate	= 15.00 mm/hr	Allowed discharge rate	= 136.200 l/s

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len
100	212989.9	1125	1682.9
150	94662.2	1200	1479.1
225	42072.1	1275	1310.2
300	23665.5	1350	1168.7
375	15145.9	1425	1048.9
450	10518.0	1500	946.6
525	7727.5	1575	858.6
600	5916.4	1650	782.3
675	4674.7	1725	715.8
750	3786.5	1800	657.4
825	3129.3	1875	605.8
900	2629.5	1950	560.1
975	2240.5	2025	519.4
1050	1931.9	2100	483.0

Ovoid	Len
400 x 600	9291.7
600 x 900	4045.7
800 x 1200	2275.4

Box culvert	Len
500 x 500	6690.0
500 x 750	4460.0
500 x 1000	3345.0
750 x 1000	2230.0
750 x 1200	1858.3
750 x 1500	1486.7
1000 x 1000	1672.5
1000 x 1200	1393.8
1000 x 1500	1115.0
1000 x 1800	929.2
1000 x 2000	836.3
1500 x 1500	743.3
1500 x 1800	619.4
1500 x 2000	557.5

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Project	100yr+40% Parcel G	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	145.0	948.748	81.720	867.028
20	103.0	1346.164	163.440	1182.724
30	82.0	1604.694	245.160	1359.534
40	69.0	1800.572	326.880	1473.692
50	60.0	1959.539	408.600	1550.939
60	53.0	2093.866	490.320	1603.546
70	48.0	2210.417	572.040	1638.377
80	44.0	2313.450	653.760	1659.690
90	41.0	2405.803	735.480	1670.323
100	38.0	2489.470	817.200	1672.270
110	36.0	2565.913	898.920	1666.993
120	34.0	2636.236	980.640	1655.596
130	32.0	2701.298	1062.360	1638.938
140	30.0	2761.782	1144.080	1617.703
150	29.0	2818.239	1225.800	1592.439
160	28.0	2871.123	1307.520	1563.603
170	26.0	2920.810	1389.240	1531.570
180	25.0	2967.619	1470.960	1496.659
190	24.0	3011.822	1552.680	1459.142
200	23.0	3053.650	1634.400	1419.250
210	23.0	3093.305	1716.120	1377.185
220	22.0	3130.964	1797.840	1333.124
230	21.0	3166.782	1879.560	1287.222
240	20.0	3200.895	1961.280	1239.615
250	20.0	3233.425	2043.000	1190.425
260	19.0	3268.356	2124.720	1143.636
270	19.0	3301.418	2206.440	1094.978
280	18.0	3333.505	2288.160	1045.345
290	18.0	3364.678	2369.880	994.798
300	17.0	3394.995	2451.600	943.395
310	17.0	3424.505	2533.320	891.185
320	17.0	3453.255	2615.040	838.215
330	16.0	3481.289	2696.760	784.529
340	16.0	3508.644	2778.480	730.164
350	15.0	3535.355	2860.200	675.155
360	15.0	3561.457	2941.920	619.537
370	15.0	3586.978	3023.640	563.338
380	15.0	3611.947	3105.360	506.587
390	14.0	3636.391	3187.080	449.311
400	14.0	3660.333	3268.800	391.533
410	14.0	3683.795	3350.520	333.275
420	14.0	3706.798	3432.240	274.558
430	13.0	3729.362	3513.960	215.402
440	13.0	3751.505	3595.680	155.825
450	13.0	3773.244	3677.400	95.844
460	13.0	3794.595	3759.120	35.476
470	12.0	3815.574	3840.840	0.000
480	12.0	3836.193	3922.560	0.000
490	12.0	3856.468	4004.280	0.000
500	12.0	3876.410	4086.000	0.000
510	12.0	3896.031	4167.720	0.000
520	12.0	3915.341	4249.440	0.000
530	11.0	3934.354	4331.160	0.000
540	11.0	3953.077	4412.880	0.000
550	11.0	3971.521	4494.600	0.000
560	11.0	3989.695	4576.320	0.000
570	11.0	4007.607	4658.040	0.000
580	11.0	4025.265	4739.760	0.000
590	11.0	4042.678	4821.480	0.000
600	10.0	4059.852	4903.200	0.000

Storage volume (m^3) = 1672.5 m^3

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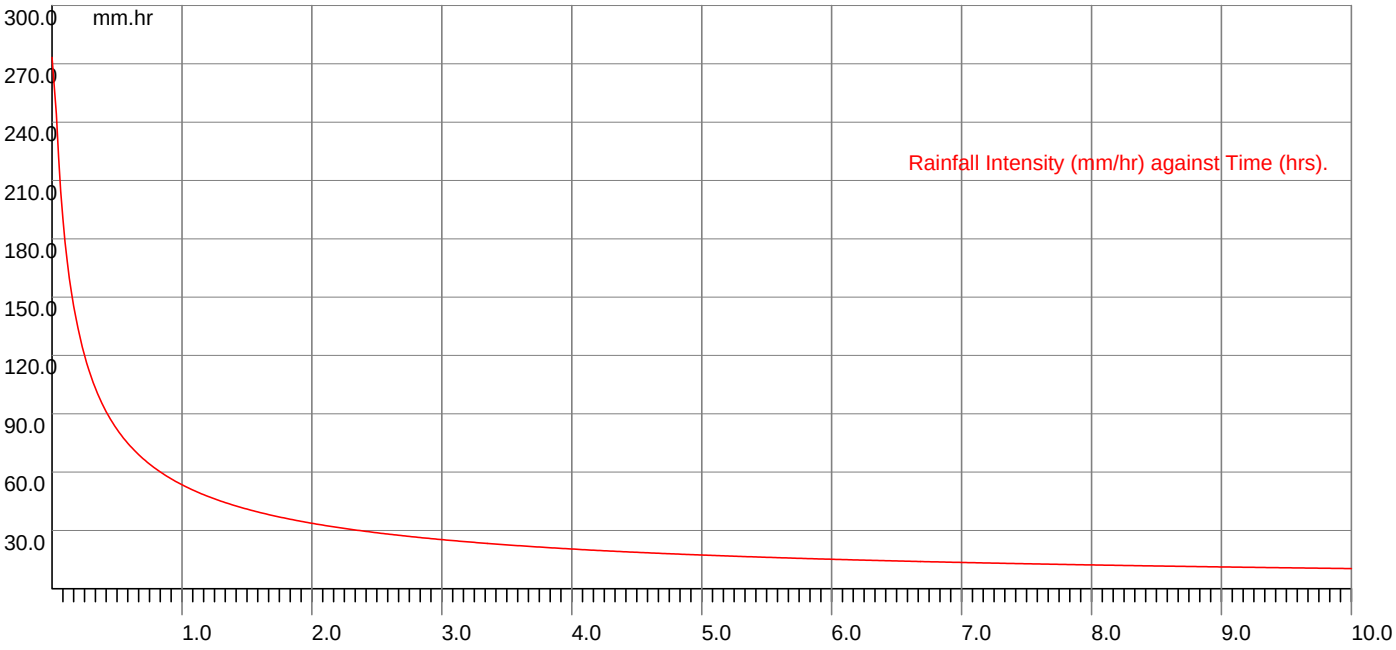
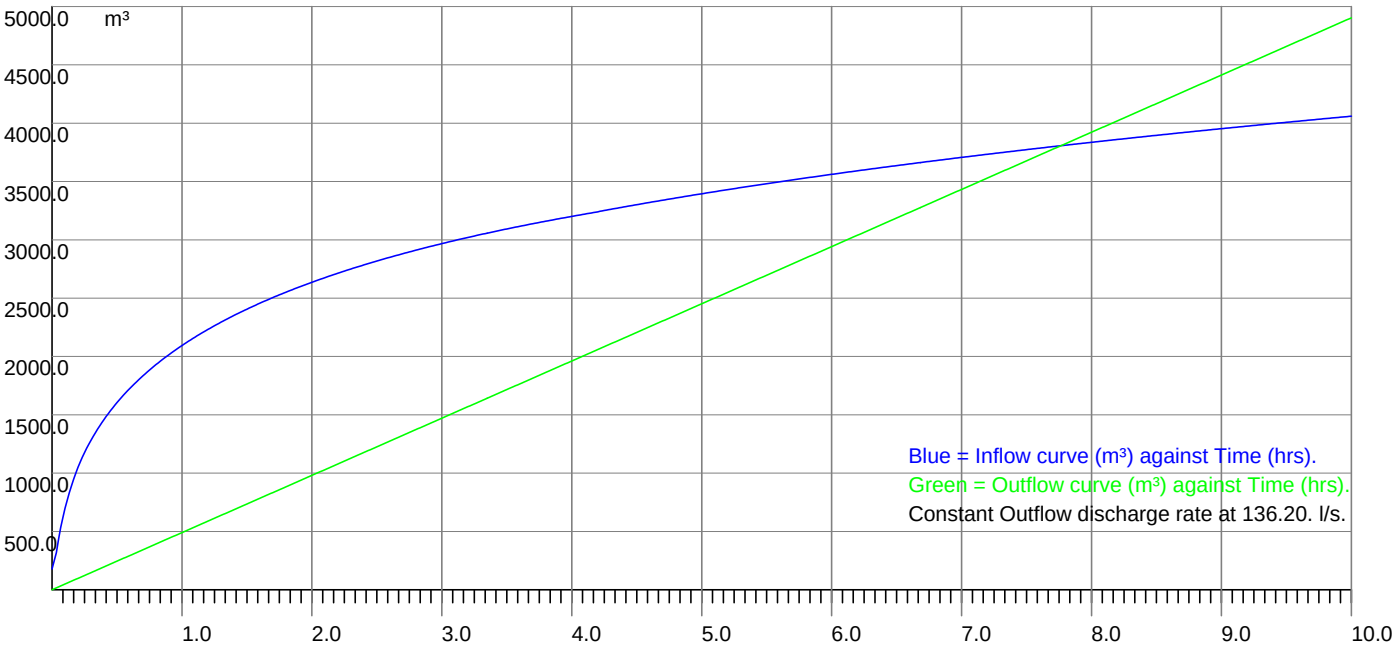
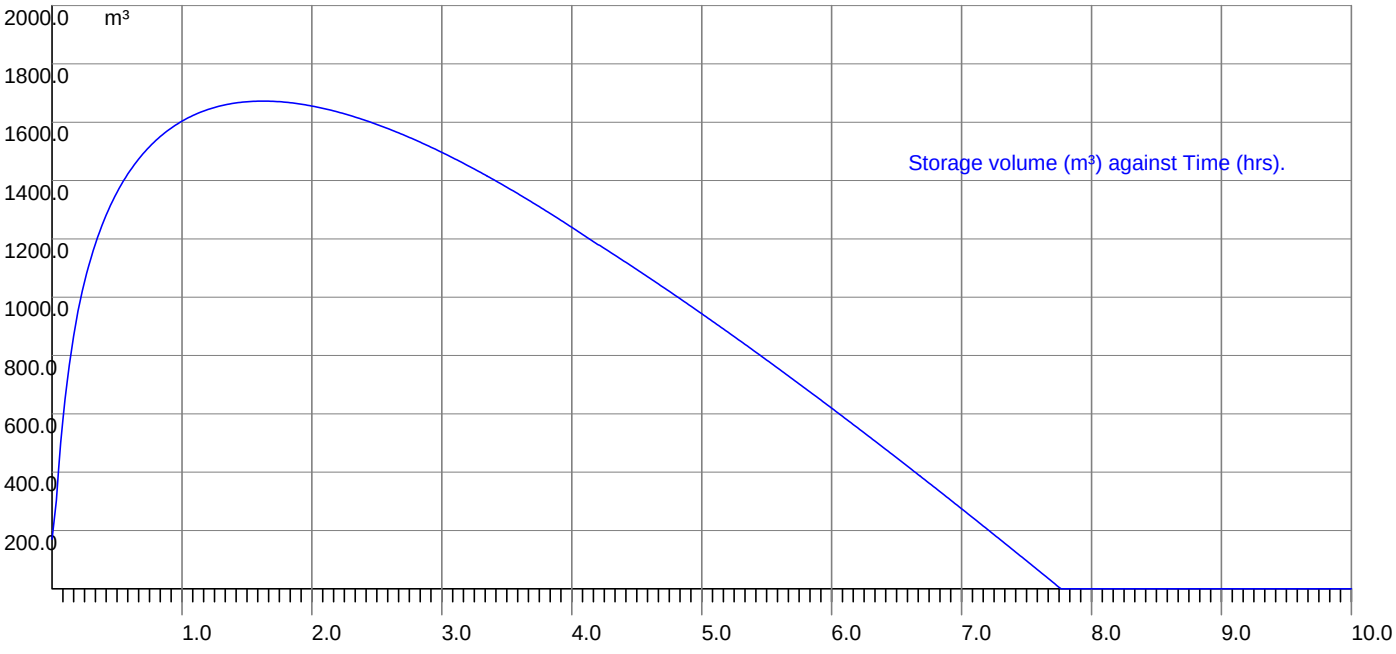
Job No.	
Sheet no.	3
Date	01/08/18

MasterDrain SW

Project	100yr+40% Parcel G	By	Checked / Reviewed
Title	Peak flow storage calcs for Radcliffe		







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MasterDrain
HY 11.0

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Job No.			
Sheet no.	1		
Date	24/03/20		
Project	Elton C & C1 Catchment	By	Checked / Reviewed
Title	IoH 124 Runoff calcs for Radcliffe		

Hydrological Data:-

FSR Hydrology:-

Location	= Radcliffe	Grid reference	= SD7808
M5-60 (mm)	= 18.9	r	= 0.32
Soil runoff	= 0.45	SAAR (mm/yr)	= 1100
WRAP	= 4	Area = England & Wales	
Hydrological area = 10		Hydrological zone = 7	

Soil classification for WRAP type 4
Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Design data:-

Area = 0.2325 Km^2 - 23.25 Ha - 232500 m^2

Calculation method:-

Runoff is calculated from:-

$$Q_{BAR(rural)} = 0.00108\ AREA^{0.89} \cdot SAAR^{1.17} \cdot SOIL^{2.17}$$

where

AREA = Site area in Km^2
SAAR = Standard Average Annual Rainfall (mm/yr)
SOIL = Soil value derived from Winter Rainfall Acceptance Potential
$Q_{BAR(rural)}$ = Runoff (cumecs)

$Q_{BAR(rural)}$ is then multiplied by a growth factor - GC(T) - for different storm return periods derived from EA publication W5-074/A.

Calculated data:-

For areas less than 50Ha, a modified calculation which multiplies the 50Ha runoff value by the ratio of the site area to 50Ha is used
Reducing factor used for these calculations is 0.465

Mean Annual Peak Flow $Q_{BAR(rural)}$ = 173.32 l/s

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Job No.	
Sheet no.	2
Date	24/03/20

By	Checked	Reviewed

MasterDrain
HY 11.0

Project: **Elton C & C1 Catchment**

Title: **IoH 124 Runoff calcs for Radcliffe**

Values for $Q_{BAR(rural)}$

Ret. per.	m³/hr	l/s	l/s/ha	Ret. per.	m³/hr	l/s	l/s/ha
1yr	530.374	147.326	6.337	100yr+20%	1572.402	436.778	18.786
2yr	580.291	161.192	6.933	100yr+30%	1703.435	473.176	20.352
5yr	755.002	209.723	9.020	100yr+40%	1834.468	509.575	21.917
10yr	861.077	239.188	10.288	200yr	1497.525	415.979	17.892
30yr	1048.268	291.185	12.524	200yr + 30%	1946.783	540.773	23.259
50yr	1154.342	320.651	13.791	500yr	1703.435	473.176	20.352
100yr	1310.335	363.982	15.655	1000yr	1896.865	526.907	22.663

Growth factors -

1yr	2yr	5yr	10yr	30yr	50yr	100yr	200yr	500yr	1000yr
0.85	0.93	1.21	1.38	1.68	1.85	2.10	2.40	2.73	3.04

The above is based on the Institute of Hydrology Report 124
to which you are referred for further details (see Sect 7).
Note that the 200 and above year growth curves were taken from W5-074.

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Job No.			
Sheet no.	1		
Date	21/07/20		
Project	crow trees catchment greenfield	By	Checked / Reviewed
Title	IoH 124 Runoff calcs for Radcliffe		

Hydrological Data:-

FSR Hydrology:-

Location = Radcliffe
Grid reference = SD7808
M5-60 (mm) = 18.9
r = 0.32
Soil runoff = 0.45
SAAR (mm/yr) = 1100
WRAP = 4
Area = England & Wales
Hydrological area = 10
Hydrological zone = 7

Soil classification for WRAP type 4
Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Design data:-

Area = 0.6924 Km^2 - 69.24 Ha - 692400 m^2

Calculation method:-

Runoff is calculated from:-

$$Q_{BAR(rural)} = 0.00108\ AREA^{0.89}\ .\ SAAR^{1.17}\ .\ SOIL^{2.17}$$

where

AREA = Site area in Km^2
SAAR = Standard Average Annual Rainfall (mm/yr)
SOIL = Soil value derived from Winter Rainfall Acceptance Potential
$Q_{BAR(rural)}$ = Runoff (cumecs)

$Q_{BAR(rural)}$ is then multiplied by a growth factor - GC(T) - for different storm return periods derived from EA publication W5-074/A.

Calculated data:-

Mean Annual Peak Flow $Q_{BAR(rural)}$ = 498.01 l/s

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Job No.	
Sheet no.	2
Date	21/07/20
Project	crow trees catchment greenfield
Title	IoH 124 Runoff calcs for Radcliffe

By	Checked	Reviewed

Values for $Q_{BAR(rural)}$

Ret. per.	m³/hr	l/s	l/s/ha	Ret. per.	m³/hr	l/s	l/s/ha
1yr	1523.924	423.312	6.114	100yr+20%	4517.987	1254.996	18.125
2yr	1667.352	463.153	6.689	100yr+30%	4894.485	1359.579	19.636
5yr	2169.351	602.597	8.703	100yr+40%	5270.984	1464.162	21.146
10yr	2474.136	687.260	9.926	200yr	4302.845	1195.235	17.262
30yr	3011.991	836.664	12.084	200yr + 30%	5593.698	1553.805	22.441
50yr	3316.776	921.327	13.306	500yr	4894.486	1359.579	19.636
100yr	3764.989	1045.830	15.104	1000yr	5450.270	1513.964	21.865

Growth factors -

1yr	2yr	5yr	10yr	30yr	50yr	100yr	200yr	500yr	1000yr
0.85	0.93	1.21	1.38	1.68	1.85	2.10	2.40	2.73	3.04

The above is based on the Institute of Hydrology Report 124
to which you are referred for further details (see Sect 7).
Note that the 200 and above year growth curves were taken from W5-074.

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APPENDIX F

DRAINAGE STRATEGY PLANS

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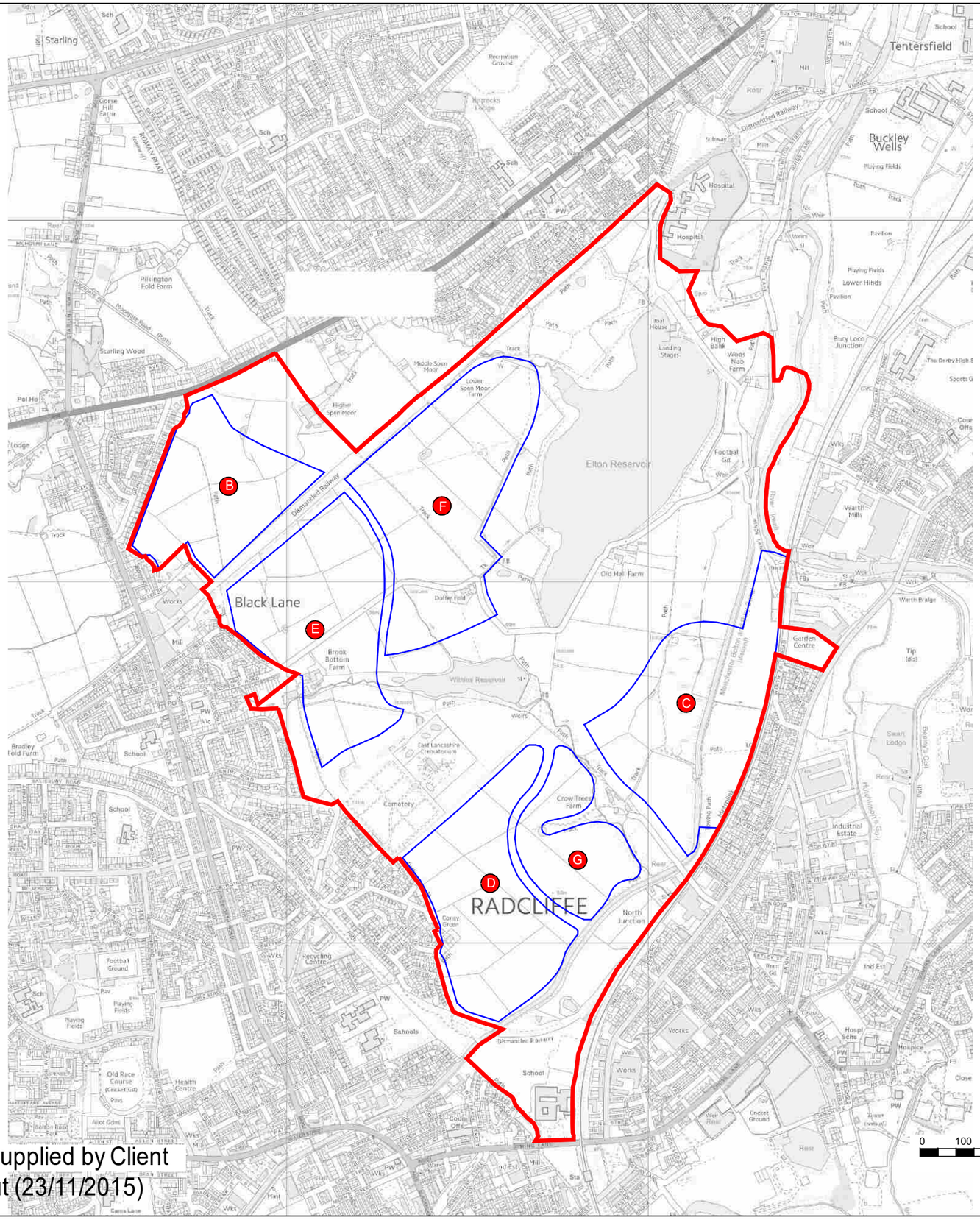


Extract from: Mapping Supplied by Client
Drawing Ref: Site Layout (23/11/2015)

KEY

Site Boundary

Parcel Boundary

G — Parcel Identification Letter (B to G)

NOTE:

Approximate Area's of Parcels

Parcel B = 13.4ha
Parcel C = 21.8ha
Parcel D = 17.6ha
Parcel E = 19.7ha
Parcel F = 23.9ha
Parcel G = 8.7ha

LK CONSULT LIMITED

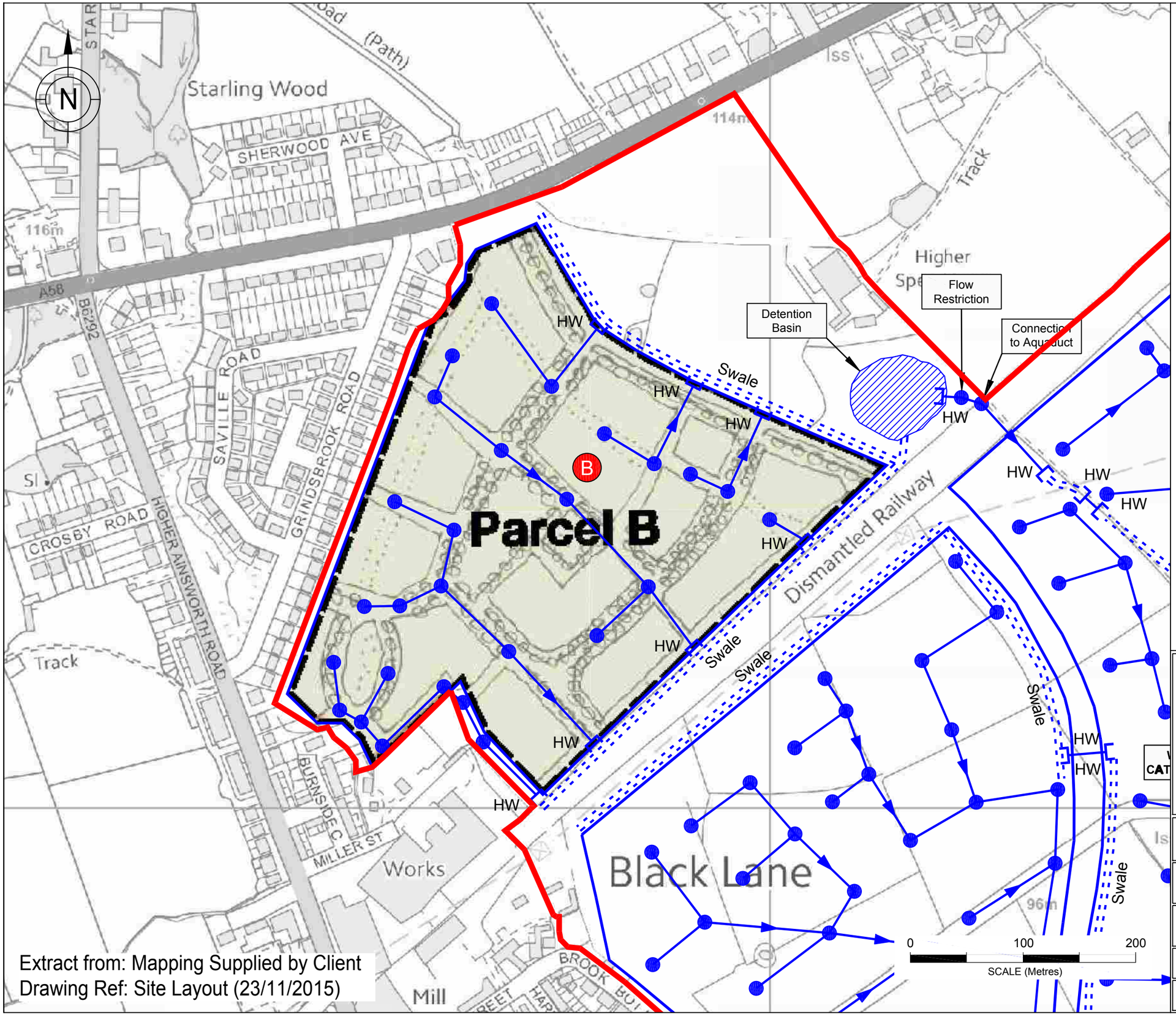
Client: Peel Holdings (Land & Property) Ltd

Site: Elton Parkland Site

Title: Development Parcel Plan (Index)

Job No.:	Scale (See Scale Bar)	Figure:	Revision
FRA 18 1024	1:12500 @ A3	3	C

Drawn By:	Checked By:	Drawn:
AC	MJ	July 2020



Extract from: Mapping Supplied by Client
Drawing Ref: Site Layout (23/11/2015)

KEY

- Site Boundary
- Parcel Boundary
- Chamber
- Pipework & Direction of Flow
- Headwall (HW)
- Swale
- Existing Watercourse
- Existing Sewer
- Detention Basin

Event Storage: **1149.5 m³**
(1 in 30 year event)
Event Retention on site volume: **2047.5 m³**
(1 in 100 year event + 20% Climate Change)
Event Retention on site volume: **2576.0 m³**
(1 in 100 year event + 40% Climate Change)

LK CONSULT LIMITED

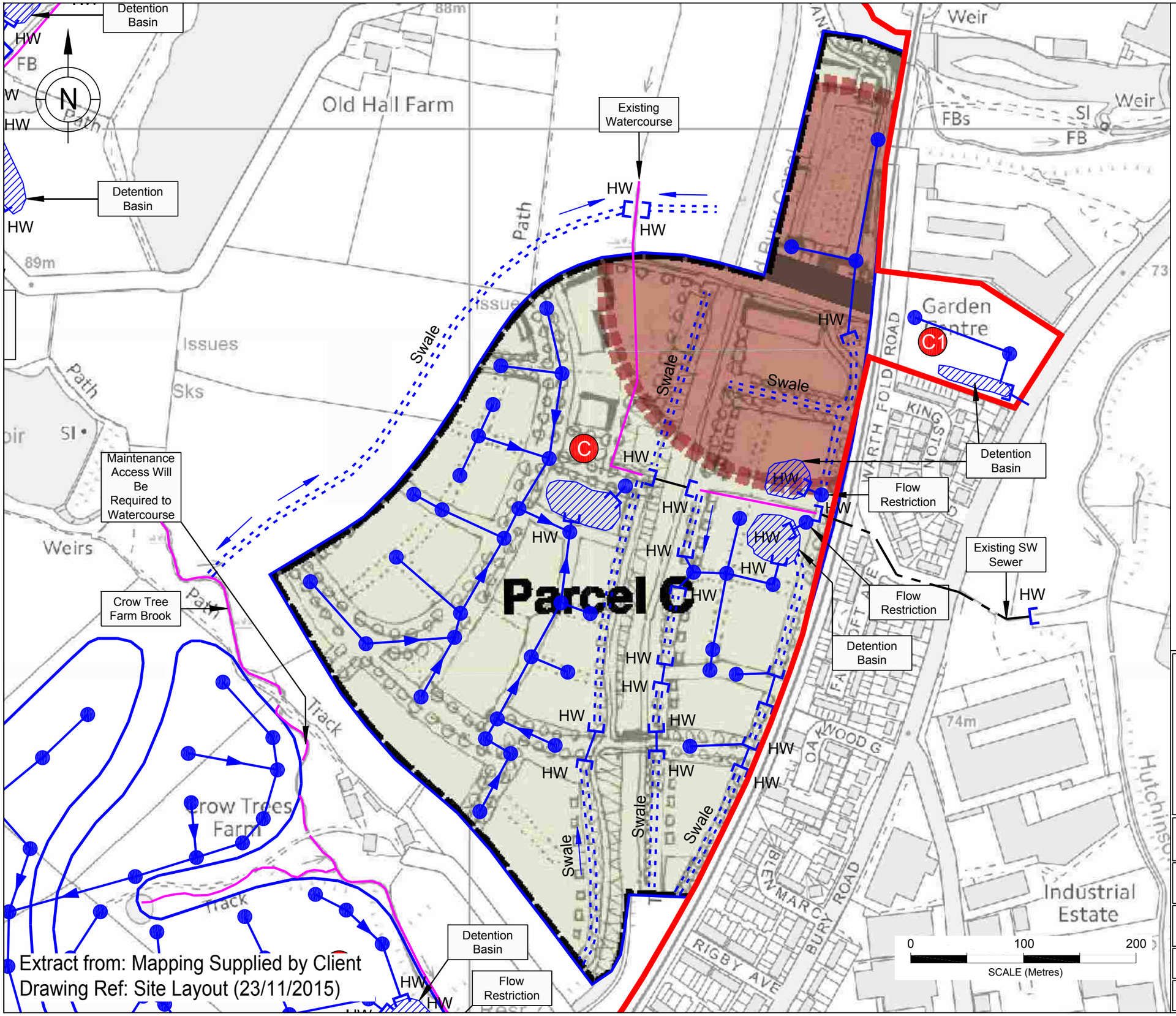
Client: Peel Investments (North) Ltd

Site: Elton Parkland Site

Title: Drainage Strategy: Development Parcel (B)

Job No.:	Scale (See Scale Bar):	Figure:	Revision:
FRA 18 1024	See Scale Bar	3b	

Drawn By:	Checked By:	Drawn:
AC	MJ	Aug 2018



KEY

- Site Boundary
- Parcel Boundary
- Chamber
- Pipework & Direction of Flow
- Headwall (HW)
- Swale
- Existing Watercourse
- Existing Sewer
- Detention Basin

Event Storage: **1557.2 m³**
(1 in 30 year event)
Event Retention on site volume: **2784.9 m³**
(1 in 100 year event + 20% Climate Change)
Event Retention on site volume: **3515.4 m³**
(1 in 100 year event + 40% Climate Change)

Do not scale from this drawing and work from marked dimensions only. All dimensions and features should be confirmed on site by the Contractor. Where this drawing includes information provided to LK Consult Ltd by others, LK Consult Ltd gives no warranty, representation or assurance as to the accuracy of such information.

LK CONSULT LIMITED

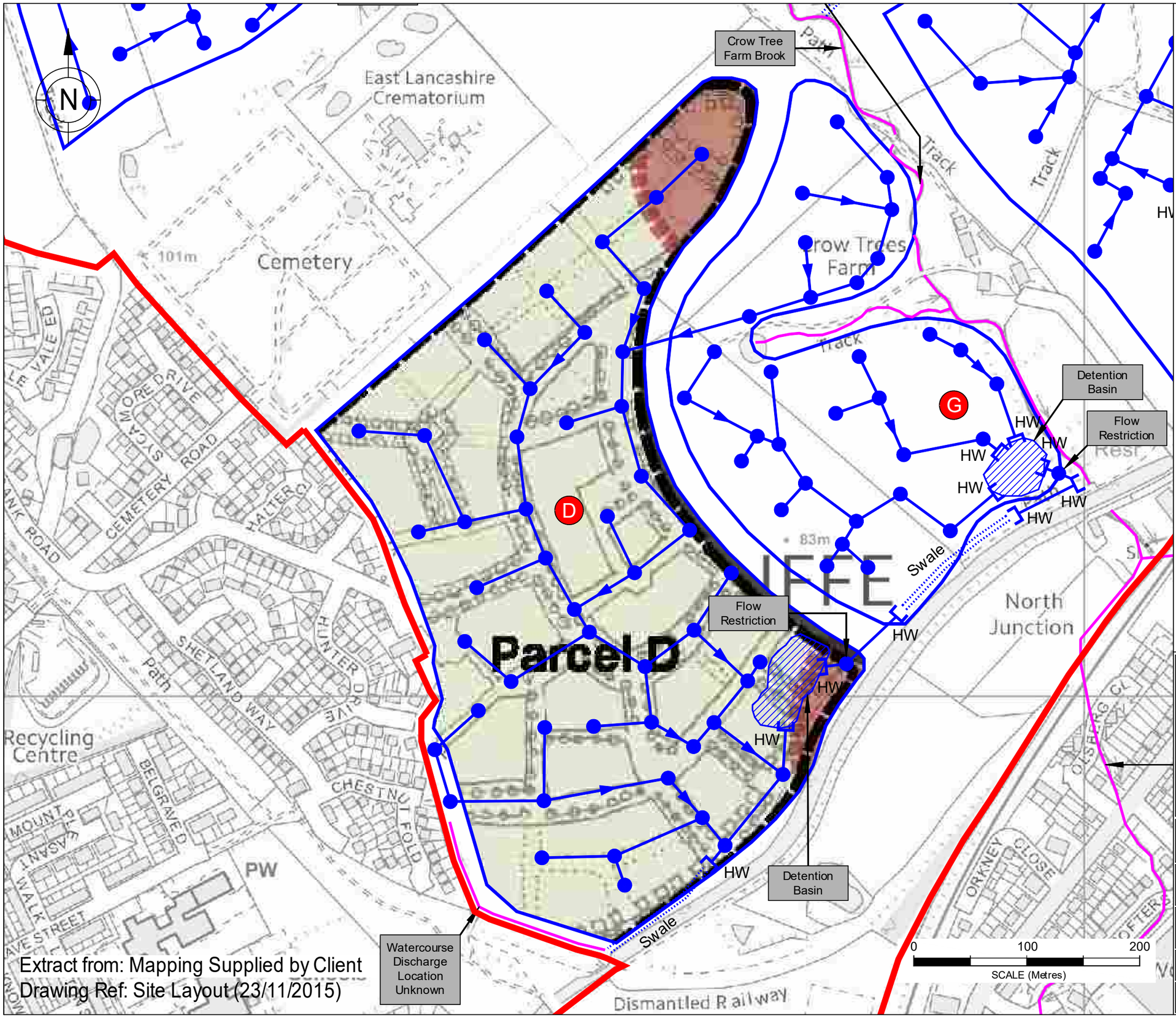
Client: Peel Investments (North) Ltd

Site: Elton Parkland Site

Title: Drainage Strategy: Development Parcel (C)

Job No.:	Scale (See Scale Bar):	Figure:	Revision:
FRA 18 1024	See Scale Bar	3c	

Drawn By:	Checked By:	Drawn:
AC	MJ	Aug 2018



Extract from: Mapping Supplied by Client
Drawing Ref: Site Layout (23/11/2015)

KEY

- Site Boundary
- Parcel Boundary
- Chamber
- Pipework & Direction of Flow
- Headwall (HW)
- Swale
- Existing Watercourse
- Existing Sewer
- Detention Basin

Event Storage: **1458.4 m³**
(1 in 30 year event)
Event Retention on site volume **2689.4 m³**
(1 in 100 year event + 20% Climate Change)
Event Retention on site volume **3379.4 m³**
(1 in 100 year event + 40% Climate Change)

LK CONSULT LIMITED

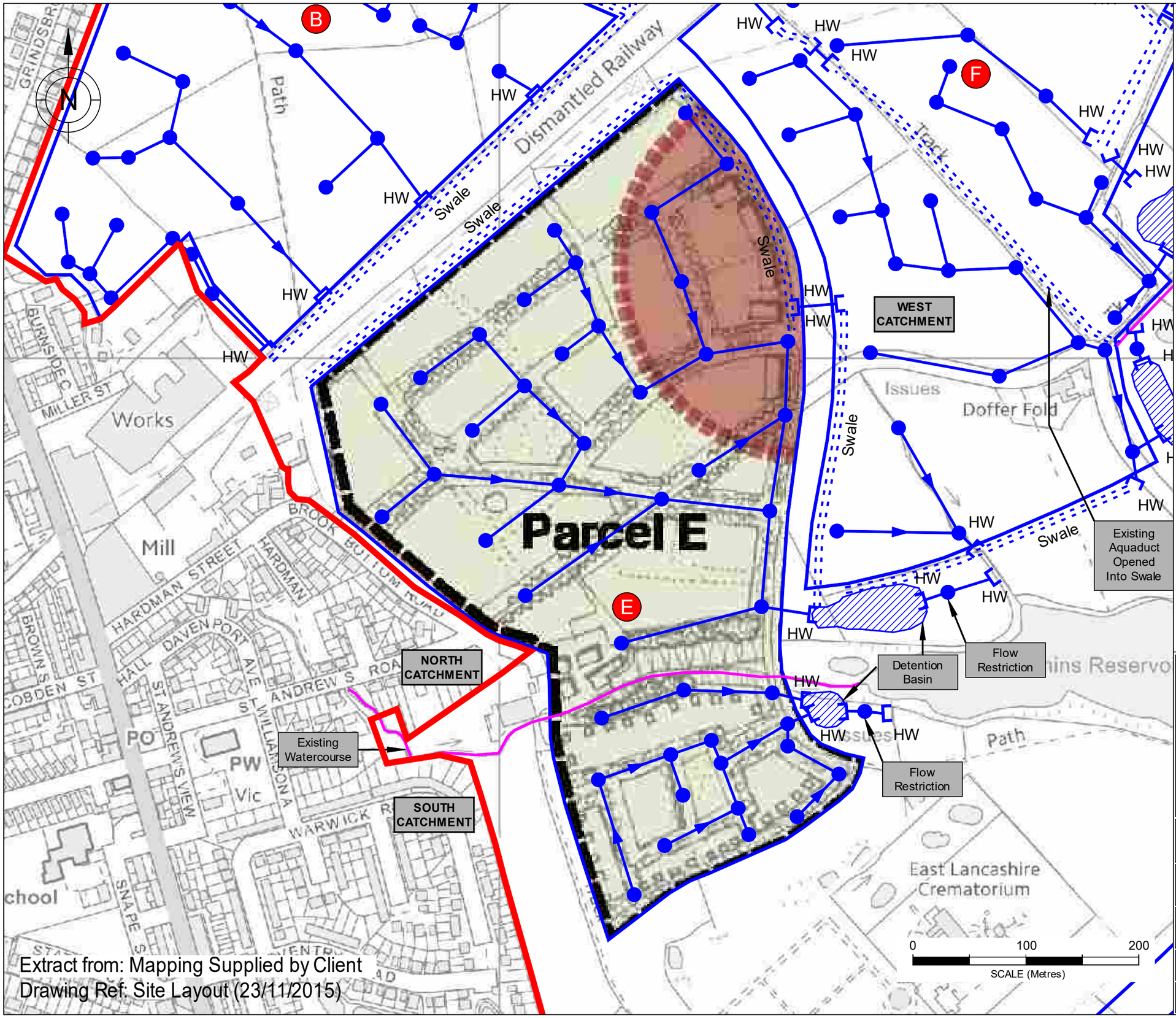
Client: Peel Investments (North) Ltd

Site: Elton Parkland Site

Title: Drainage Strategy: Development Parcel (D)

Job No.:	Scale (See Scale Bar)	Figure:	Revision
FRA 18 1024	See Scale Bar	3d	

Drawn By:	Checked By:	Drawn:
AC	MJ	Aug 2018



Extract from: Mapping Supplied by Client
Drawing Ref: Site Layout (23/11/2015)

KEY

- Site Boundary
- Parcel Boundary
- Chamber
- Pipework & Direction of Flow
- Headwall (HW)
- Swale
- Existing Watercourse
- Existing Sewer
- Detention Basin

North Catchment
Event Storage: **955.7 m³**
(1 in 30 year event)
Event Retention on site volume **≈1709.2 m³**
(1 in 100 year event + 20% Climate Change)
Event Retention on site volume **≈2157.5 m³**
(1 in 100 year event + 40% Climate Change)

South Catchment
Event Storage: **302.4 m³**
(1 in 30 year event)
Event Retention on site volume **≈540.8 m³**
(1 in 100 year event + 20% Climate Change)
Event Retention on site volume **≈682.8 m³**
(1 in 100 year event + 40% Climate Change)

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LK CONSULT LIMITED

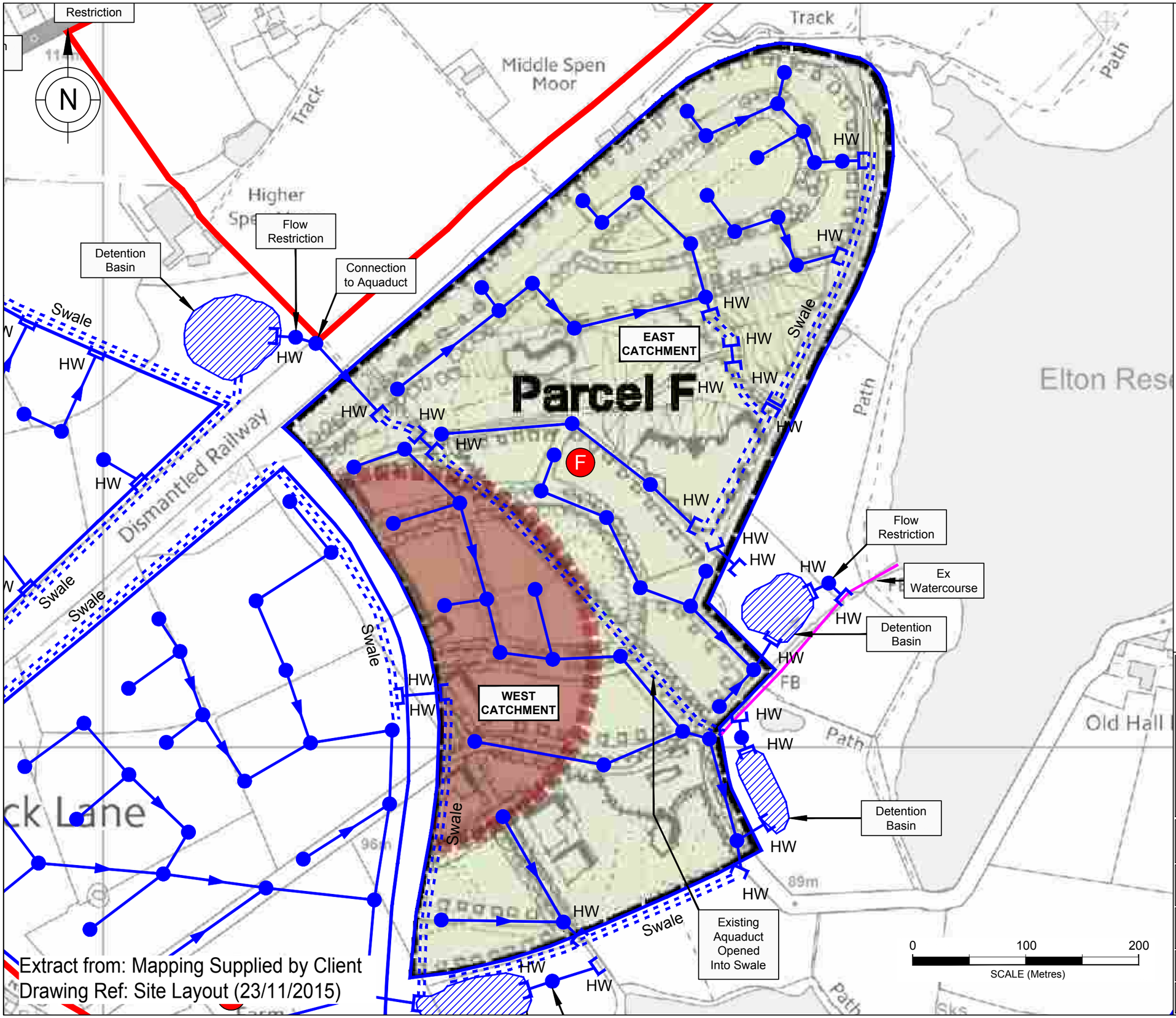
Client: Peel Investments (North) Ltd

Site: Elton Parkland Site

Title: Drainage Strategy: Development Parcel (E)

Job No.:	Scale (See Scale Bar)	Figure:	Revision
FRA 18 1024	See Scale Bar	3e	

Drawn By:	Checked By:	Drawn:
AC	MJ	Aug 2018



KEY

- Site Boundary
- Parcel Boundary
- Chamber
- Pipework & Direction of Flow
- Headwall (HW)
- Swale
- Existing Watercourse
- Existing Sewer
- Detention Basin

West Catchment
Event Storage: **703.4 m³**
(1 in 30 year event)
Event Retention on site volume: **1257.9 m³**
(1 in 100 year event + 20% Climate Change)
Event Retention on site volume: **1587.8 m³**
(1 in 100 year event + 40% Climate Change)

East Catchment
Event Storage: **1005.0 m³**
(1 in 30 year event)
Event Retention on site volume: **1797.4 m³**
(1 in 100 year event + 20% Climate Change)
Event Retention on site volume: **2288.8 m³**
(1 in 100 year event + 40% Climate Change)

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Client: Peel Investments (North) Ltd

Site: Elton Parkland Site

Title: Drainage Strategy: Development Parcel (F)

Job No.:	Scale (See Scale Bar):	Figure:	Revision:
FRA 18 1024	See Scale Bar	3f	

Drawn By:	Checked By:	Drawn:
AC	MJ	Aug 2018

Detention Basin

Flow Restriction

Flow Restriction

Maintenance Access Will Be Required to Watercourse

Crow Tree Farm Brook

Parcel G

Detention Basin

Flow Restriction

Flow Restriction

Swale

Swale

Swale

Limited Flows Possibly Isolated

Existing Watercourse 1.0m Diameter

0 100 200

SCALE (Metres)

Extract from: Mapping Supplied by Client
Drawing Ref: Site Layout (23/11/2015)

KEY

- Site Boundary
- Parcel Boundary
- Chamber
- Pipework & Direction of Flow
- Headwall (HW)
- Swale
- Existing Watercourse
- Existing Sewer
- Detention Basin

Event Storage: **764.3 m³**
(1 in 30 year event)
Event Retention on site volume **1329.4 m³**
(1 in 100 year event + 20% Climate Change)
Event Retention on site volume **1672.5 m³**
(1 in 100 year event + 40% Climate Change)

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Client: Peel Investments (North) Ltd

Site: Elton Parkland Site

Title: Drainage Strategy: Development Parcel (G)

Job No.:	Scale (See Scale Bar):	Figure:	Revision:
FRA 18 1024	See Scale Bar	3g	

Drawn By:	Checked By:	Drawn:
AC	MJ	Aug 2018

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- Land Drilling