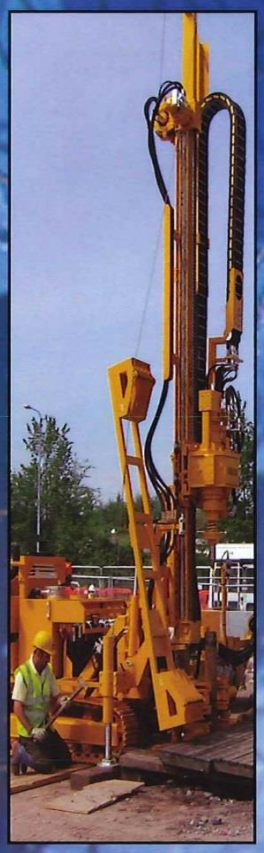

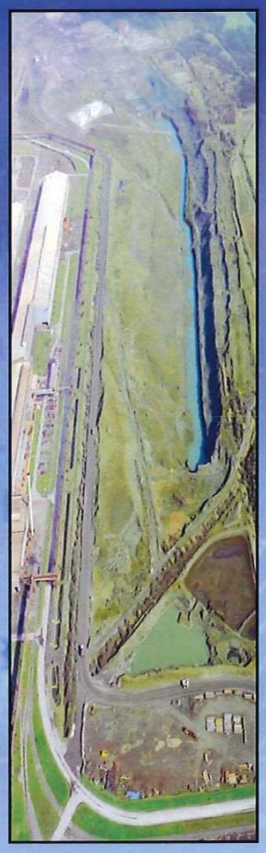

TerraConsult

April 2021

TOW-TCL-HDG-XX-RP-D-0500

The Oaks, Wrexham

Flood Consequence Assessment and Drainage Strategy

Prepared for:

Cefn Park Developments Ltd.

TerraConsult

The Oaks, Wrexham

Flood Consequence Assessment and Drainage Strategy

April 2021

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4	**Development plans reduced and drainage updated to suit**	**30/04/21**	**Prepared By:**	*M Wilson B Hall*	

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bsi. ISO 9001 Quality Management FS573193

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CONTENTS

1.0 INTRODUCTION 1
1.1 Context 1
1.2 Existing Site 1
1.3 Proposed Development 2
2.0 POLICY DOCUMENTS AND PLANNING 4
2.1 Planning Policy Wales and Technical Advice Note 15 (TAN15) 4
2.2 Preliminary Flood Risk Assessment 4
2.3 Wrexham County Borough Council (WCBC) Flood Risk Management Plan 2016-2021 4
2.4 Factoring In Climate Change 5
3.0 FLOOD CONSEQUENCE ASSESSMENT 6
3.1 Development Advice Maps and TAN15 6
3.2 Rivers and Sea (Fluvial) 6
3.3 Rainfall (Pluvial) 8
3.4 Groundwater 8
3.5 Artificial (Canals and Reservoirs) 9
3.6 Sewers 9
3.7 Wider Catchment/Downstream Flood Risk 9
4.0 FLOOD MITIGATION 10
4.1 Proposed Pluvial Mitigation 10
4.2 Proposed Fluvial Mitigation 10
4.3 Further Mitigation 10
5.0 DRAINAGE STRATEGY 11
5.1 Existing Site Run Off 11
5.2 Drainage Hierarchy 11
5.3 Proposed Run-off Rates 12
5.4 Climate Change 13
5.5 Attenuation Requirements 13
5.6 Pollution Prevention 14
5.7 Sustainable Drainage Systems 15
5.8 Residual Risk and Designing for Exceedance 16
5.9 Maintenance 16
6.0 MANAGEMENT AND MAINTENANCE PLAN 17
7.0 FOUL WATER STRATEGY 18
7.1 Existing Site Drainage and Pre-Planning Discussion 18
7.2 Proposed Foul Drainage 19
8.0 Summary 20
8.1 Flood Consequence 20

8.2 Flood Risk Mitigation 20
8.3 Surface Water 21
8.4 Foul Water 22

APPENDICES

Appendix 1 Site Layout
Appendix 2 DCWW Correspondence
Appendix 3 NRW Correspondence
Appendix 4 Greenfield Run Off
Appendix 5 Infiltration Tests
Appendix 6 Surface Water Drainage Layout
Appendix 7 Surface Water Calculations
Appendix 8 Pollution Hazard Plan

FIGURES

Figure 1 – Site Location Plan 1
Figure 2 – Levels and Gradients Sketch 2
Figure 3 – Redwither Brook - Heavily Modified Channel and Culvert 7
Figure 4 – River Clywedog – Predominantly Natural Channel 7
Figure 5 – DCWW Sewer Map 18

TABLES

Table 1 – Existing Site Details 3
Table 2 – Existing Run-off Rates 11
Table 3 – Proposed Run off Rates 13
Table 4 – Calculated Attenuation Volumes 13
Table 5 – Pollution Hazard Table 14
Table 6 – Pollution Mitigation Index and Treatment Train 15

1.0 INTRODUCTION

1.1 Context

1.1.1 The Oaks is a proposed industrial development on the fringe of Wrexham Industrial Estate.

1.1.2 This Flood Consequence Assessment and Drainage Strategy has been produced by TerraConsult on behalf of Cefn Park Developments Ltd. In respect of an Outline Planning Application to construct 11no. Industrial Units and Associated Infrastructure as part of an extension to Wrexham Industrial Estate. The site location is included in Figure 1 below.

1.1.3 This Flood Consequence Assessment will look at the consequences of flooding from all sources in line with TAN15 and will propose an option for draining the site in accordance with the Welsh Government Statutory Standards, CIRIA 753 and Schedule 3 of the Flood and water Management Act 2010.

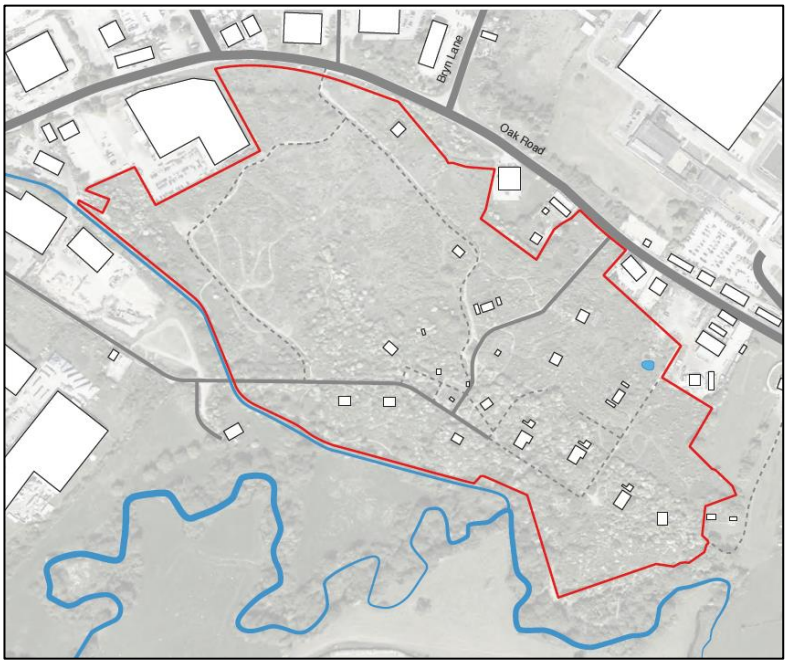


Figure 1 – Site Location Plan

1.2 Existing Site

1.2.1 The site is located along Oak Road Wrexham, with a nearby postcode of LL13 9RG. The site is at approximate co-ordinates 338745, 349271 (SJ387492). The total site area covers 22.20 ha, whilst the site development area (red line) covers 5.48 ha.

1.2.2 The site was formerly part of the Royal Ordinance Factory that previously occupied Wrexham Industrial Estate.

1.2.3 The site is bounded to the north by Oak Road, east by agricultural fields, west by industrial units and to the south by Redwither Brook and the River Clywedog.

1.2.4 The site level slope generally in a southerly direction. With slopes of approximately 1:60 in the west and 1:25 in the eastern areas of the site. There is a distinct steepening of gradient to the south of the site towards Redwither Brook. The top of this steeper embankment follows a former Royal Ordinance Road. A sketch has been included in **Figure 2**.

1.2.5 The levels along Oak Road are approximately 31.4m AOD. Falling to between 25 and 26m AOD at the former Royal Ordinance Road, before falling to approximately 23m AOD adjacent to Redwither Brook.

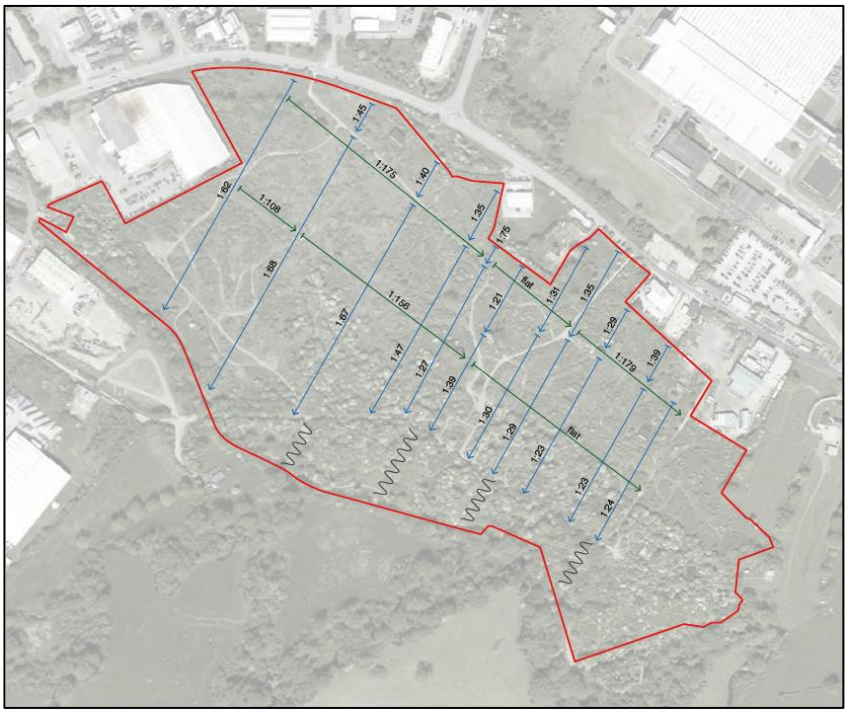


Figure 2 – Levels and Gradients Sketch

1.2.6 The site currently comprises of various woodland, scrub, and grassland habitats. The north/west half of the site have undergone scrub clearance in 1970 and 2000. These areas have been relatively undisturbed and left to naturally regenerate. The site now largely comprises of dense, continuous hawthorn scrub.

1.2.7 Within the wider area of scrub are some small glades of flower-rich, short sward grassland along with ribbons of further flower-rich grassland. Interspersed amongst these areas are patches of bramble under scrub and taller swards of coarser grasses.

1.2.8 The southern half of the site comprises various types of broadleaved woodland habitat.

1.2.9 The site is crossed by a variety of public utilities, including 132kV, 33kV and 11kV power lines, Dee Valley Water mains, 2no. Dwr Cymru Welsh Water combined sewers.

1.3 Proposed Development

1.3.1 The Outline Planning Application at The Oaks Wrexham proposes 8No. Industrial units of classes B1, B2, B8 with associated access road, infrastructure, heritage area and ecological mitigation.

1.3.2 Pedestrian links are to be provided across Redwither Brook connecting the development to the wider estate.

1.3.3 The site is crossed by 2no. DCWW combined sewers. For details of how the proposals related to the public sewerage system please see **Section 7.**

Table 1 – Existing Site Details

Site name	**The Oaks Wrexham**
Location	Wrexham Industrial Estate, LL13 9RG (nearby Postcode)
Grid Reference	338745, 349271 (SJ387492)
Total Site Area	22.20 ha
Site Development Area (Red Line)	**5.48 ha**
Planning Authority	Wrexham County Borough Council
Lead Local Flood Authority	Wrexham County Borough Council
SuDs Adopting Body	Wrexham County Borough Council
IDB	None
Sewerage Undertaker	Dwr Cymru Welsh Water (DCWW)
Development Advice Maps	Red line Boundary – Zone A Blue Line Boundary – Zone B and Zone C2
Critical Drainage Area	None

2.0 POLICY DOCUMENTS AND PLANNING

2.1 Planning Policy Wales and Technical Advice Note 15 (TAN15)

2.1.1 Planning Policy Wales1 (PPW) sets out the Welsh Assembly Government's national policies on different aspects of land use planning in Wales in relation to flood risk. Planning Policy Wales is supplemented by TAN15 which is also available online2.

2.1.2 TAN15 sets out precautionary framework for to guide planning decisions and ensure that new development is directed away from areas of high risk of flooding and to assess the consequences of flooding both on and off site.

2.1.3 It encourages development to be located in areas of lower flood risk where possible and stresses the importance of preventing increases in flood risk off site to the wider catchment area.

2.1.4 TAN15 also states that alternative sources of flooding, other than fluvial (river flooding), should also be considered when preparing a Flood Risk Assessment.

2.1.5 TAN15 includes a series of tables that define Development Advice Maps, the vulnerability to flooding classification of development land uses summary of planning requirements and acceptability based on the previous 2 criterion.

2.1.6 This Flood Consequence Assessment is written in accordance with the PPW and TAN15.

2.2 Preliminary Flood Risk Assessment

2.2.1 The Dee Valley Preliminary Flood Risk Assessment (Dec 2018) is a high-level screening exercise to identify where the risk of flooding is considered significant. Significant flood risk is identified as:

2.2.1.1 Past flood events affecting 20 or more properties within a postcode or

2.2.1.2 Information and statistics indicate a future flooding risk of 0.1%AEP.

2.2.2 Impact of climate change has been assessed against the Welsh Government Guidance note on adapting to climate change for climate change effects on rivers and sea. For surface water flooding and rainfall intensity the Environment Agency guidance flood risk assessments and climate change has been used.

2.2.3 Wrexham Industrial Estate is **not identified** as an area at Significant Risk of flooding.

2.3 Wrexham County Borough Council (WCBC) Flood Risk Management Plan 2016-2021

2.3.1 The WCBC Flood Risk Management Plan aims to ensure that development is located away from TAN15 zones C1 and C2 and ensure that all development apply the principals of sustainable drainage.

2.3.2 Wrexham Industrial Estate is not identified as a higher risk area, but the general principals of the Flood Risk Management Plan should apply.

[1] Planning Policy Wales, Dec 2018
[2] Welsh Assembly Government Technical Advice Note 15 (TAN15) https://beta.gov.wales/sites/default/files/publications/2018-09/tan15-development-flood-risk.pdf

2.4 Factoring In Climate Change

2.4.1 Welsh Government Guidance note on adapting to climate change for climate change effects on rivers and sea suggests an upper percentile increase in river flood flows of 45% by the 2080's.

2.4.2 Increases in rainfall intensities due to climate change are estimated to be a 40% increase by the 2080's. In line with Welsh Assembly Government Guidance an increase of 40% will be added to the rainfall intensities in the calculation of storm water attenuation and flows.

3.0 FLOOD CONSEQUENCE ASSESSMENT

3.1 Development Advice Maps and TAN15

3.1.1 This report will assess the risks and consequences of flooding on the existing site and suggest appropriate mitigation for the proposed development where required.

3.1.2 The proposed site is classed as Less Vulnerable Development (General Industrial) and all built development is located entirely in Zone A on the Development Advice Maps.

3.1.3 This has been deliberate in the development of the master plan for the development in order to ensure that the consequences of flooding are minimised, and that the development takes due account of the flood risk posed form rivers and sea.

3.1.4 As such the Justification test is not required.

3.1.5 Surface water is discussed in detail below.

3.1.6 TAN15 Acceptability Criteria indicate that it should be shown that the development does not increase flooding elsewhere. This is discussed in detail in **Section 3.7** below.

3.1.7 No development is to take place within Zone B and C2, which are located within the blue line boundary along the edge of Redwither Brook.

3.2 Rivers and Sea (Fluvial)

3.2.1 The blue line boundary is bounded to the south by Redwither Brook and the River Clywedog. The red line boundary is approximately 50m north of the watercourses at the closest point.

3.2.2 Both Redwither Brook and the River Clywedog are part of the Dee river catchment and both are classed as Main Rivers.

3.2.3 River Clywedog is a natural channel with some minor modifications. Redwither Brook is a heavily modified channel, with a culverted section where the Royal Ordinance road crosses the brook.

3.2.4 The culvert is a twin 1.5m diameter concrete culvert (see **Figure 3** below).

3.2.5 Liaisons with Natural Resources Wales (NRW) indicate that there is no detailed river modelling available for either watercourse. It is assumed that the flood modelling outlines were generated using JFLOW.

3.2.6 NRW long term flood risk mapping shows that the River Clywedog and Redwither Brook are at risk of causing flooding and Flood Zones 2 and 3 have been identified in close proximity to the development area.

3.2.7 Although the site is within Zone 1 of the Development Advice Maps, an assessment of the residual risk of flooding, for example, in the event of climate change, has been undertaken.

3.2.8 Data has been downloaded from the Lle Geo-Portal along with LIDAR information (1m grid).

3.2.9 Based on the flood outlines and the LIDAR information, it has been assessed that the Flood Zone 2 and Flood Zone 3 outlines have very similar extents.

Figure 3 – Redwither Brook - Heavily Modified Channel and Culvert

Figure 4 – River Clywedog – Predominantly Natural Channel

3.2.10 The flood outline of Redwither Brook to the west of the site, upstream of the culvert, has extents to a level of approximately 24.5m

3.2.11 The flood extents to the east, close to the confluence of Redwither Brook and the River Clywedog are at a level of approximately 21m AOD.

3.2.12 There is a sharp change in level to the north of Redwither Brook up to the former Royal Ordinance road. The road is at an approximate level of 25.2m AOD.

Upstream of Redwither Culvert

3.2.13 The risk of flooding posed by the Redwither Brook Culvert should be considered in the context of the development. Elevated flood levels upstream of the culvert, through high flows or blockage cannot be discounted.

3.2.14 The available flood zone 2/3 outline estimates a flood level of approximately 24.5m, with the path over the culvert having a local level of 24.8m AOD.

3.2.15 There is no development proposed in the vicinity of the Redwither Culvert. It is assessed that in an extreme event or blockage of the culvert, flood flows would remain within the watercourse valley and overtop the road.

3.2.16 The area within the vicinity of the upstream of culvert section of Redwither Brook will not be altered in terms of level and as such no change in flow or flood routing is envisaged.

3.2.17 Climate change allowances to river flows suggest that the flows in Redwither Brook could increase by 45% by the 2080's. The finished floor level of the proposed development is expected to be no lower than 26.5m taking account of existing ground levels.

3.2.18 The topography of the site suggests that no flood routing, even from increased river flows would impact the proposed development site.

Downstream of Redwither Brook Culvert

3.2.19 Downstream of the Redwither Brook Culvert, the modified Redwither Brook and the River Clywedog converge.

3.2.20 The general area subject to flooding is flat up to the embankment to the Royal Ordinance road.

3.2.21 The site is expected to have a FFL no lower than 26.5m AOD, significantly above the outline modelling flood level (21.0m).

3.2.22 It is considered that there is no residual risk of flooding from the Redwither Brook, River Clywedog or the potential blocking of the Redwither Culvert.

3.3 Rainfall (Pluvial)

3.3.1 Natural Resources flood risk mapping has been studied as part of the assessment of the surface water flood risk.

3.3.2 Based on the extents of surface water flooding and directions of flow, the surface water flood risk at the site is not generated from flows from outside of the site.

3.3.3 Areas identified to be at risk of flooding are general low spots or existing roads within the site boundary.

3.3.4 The depth of surface water flooding identified within the site ranges form, 0.15-0.9m deep and is slow moving (less than 0.25 m/s).

3.3.5 The combination of depth and velocity gives a hazard rating – this hazard rating is a mixture within the site of low, danger for some and danger for all.

3.3.6 As part of the proposed redevelopment at the site, a surface water drainage system will be put in place.

3.3.7 The surface water drainage design should ensure that surface water is managed appropriately on site and not to pose a hazard to site users.

3.3.8 On the basis of the above, whilst there is a medium risk of surface water flooding in the sites current state this is due to the onsite topography and not overland flow from outside the site. The risk of surface water flooding post development would be considered **low.**

3.4 Groundwater

3.4.1 The DEE Valley preliminary flood risk assessment, issued in December 2018 states that groundwater flooding in Wales is rare and no incidents have been recorded within the Dee Valley Catchment since the previous PFRA in 2011.

3.4.2 The ground investigation carried out by TerraConsult shows that the site is underlain by stiff clays. These stiff clays are likely to act as an aquitard.

3.4.3 Based on the above the risk of flooding from groundwater sources is considered **low.**

3.5 Artificial (Canals and Reservoirs)

3.5.1 The Natural Resources long term flood risk maps indicate that there is a risk of reservoir flooding within the valley of the River Clywedog. Flood waters in the event modelled would be fast moving (0.5-2.0m/s) and moderately deep (0.3-2.0m).

3.5.2 The reservoir flooding extents are outside of the proposed development with finished floor levels >2m above the existing ground level within the areas shown to be at risk.

3.5.3 There are no other artificial water sources in the vicinity of the site.

3.5.4 The risk of flooding from artificial sources is considered **low**.

3.6 Sewers

3.6.1 The risk of sewer flooding cannot be discounted at the site. There are 2no. Welsh Water sewers crossing the site and a drainage system will be installed to serve the development.

3.6.2 The drainage system serving the site should either be offered for adoption to DCWW / Wrexham SuDS Adopting Body (WSAB), or a suitable management plan put in place to ensure the system is maintained.

3.6.3 Whether adoption is acceptable to DCWW / WSAB will depend upon the disposal strategy at the site any whether the development is considered as a single site.

3.6.4 There are no basements proposed as part of the development.

3.6.5 The development should follow best practice and ensure external hard standing areas fall away from buildings and pedestrian entry points are 150mm above surrounding ground levels to prevent water ingress.

3.6.6 On the basis that best practice is followed the risk of flooding from sewer, whilst not to be discounted would be of a low impact and as such can be considered a **low risk**.

3.7 Wider Catchment/Downstream Flood Risk

3.7.1 The risks of flooding in the vicinity of the site and therefore the wider catchment area is from fluvial and pluvial sources.

Fluvial Flood Risk

3.7.2 No changes to ground level or structures are proposed in either the DAM Zones B or C or within Flood Zones 2 or 3. As such no change in flood risk within the wider catchment would occur as a result of development.

Surface Water Flood Risk

3.7.3 An increase in impermeable area has the potential to increase surface water runoff and therefore flood risk within the wider area.

3.7.4 It is proposed that a surface water system is constructed to control run off from the site to existing greenfield run off rates or lower.

3.7.5 Any reduction to existing run off rates would mean an improvement of offsite flood risk.

3.7.6 For details of the surface water drainage strategy please see **Section 5.0.**

4.0 FLOOD MITIGATION

4.1 Proposed Pluvial Mitigation

4.1.1 As part of the proposed development all buildings, roads, parking, and service yards are located in Zone A of the Development Advice maps

4.1.2 The development site is not likely to have a FFL of less than 26.5m (between 1.5m and 5.5m above the levels of the modelled flood outline). Therefore, the development is not thought to be at risk of fluvial flooding.

4.2 Proposed Fluvial Mitigation

4.2.1 The site will be served by a drainage network designed to accommodate and control flows up to and including the 100-year storm plus climate change allowance of 40%.

4.2.2 The site should allow for hardstanding areas to fall away from buildings in order to prevent water ingress.

4.3 Further Mitigation

4.3.1 No further mitigation is proposed.

5.0 DRAINAGE STRATEGY

5.1 Existing Site Run Off

5.1.1 The topographical survey undertaken at the site shows a number of manholes potentially serving the existing former Royal Ordinance buildings.

5.1.2 For the purposes of this report, it has been assumed that these drains are not in appropriate locations and depths to serve the new development. The system has not been actively maintained and may not be in a fully serviceable condition.

5.1.3 It has been conservatively assumed that the development site is drained via greenfield run off. A partial factor of urbanisation has been included in the Greenfield run off calculations (carried out my factoring IH124 greenfield run off methodology in line with CIRIA 753) to account for the existing roads and buildings present within the site. The urbanisation factor has been set at 0.1.

5.1.4 For existing run off rates see **Table 3** below and **Appendix 4**.

Table 2 – Existing Run-off Rates

Return Period	Run off Rate (l/s/ha)	Total @ 5.43ha
1 year	**5.0 l/s/ha**	**27.2 l/s**
QBAR	**5.7 l/s/ha**	**31.0 l/s**
30 Year	**9.9 l/s/ha**	**53.8 l/s**
100 Year	**11.9 l/s/ha**	**64.6 l/s**
	Volume (m^3/ha)	
100-year 6-hour Volume run off	**292 m^3/ha**	**1,585 m^3**

5.2 Drainage Hierarchy

5.2.1 The Sustainable Drainage Systems Standards for Wales; Standard S1 states;

> ***Standard S1*** **– Surface water runoff destination**
>
> **This Standard addresses the use of surface water by the development and where it should be discharged. The aim is to ensure that runoff is treated as a resource and managed in a way that minimises negative impact of the development on flood risk, the morphology and water quality of receiving waters and the associated ecology. This will ensure that early consideration is given to the use of rainwater harvesting systems to both manage runoff and deliver a source of non-potable water for the site where practical. Where it is not, prioritisation should be given to infiltration. Discharges to sewerage systems should be limited where possible.**
>
> **S1 Surface water runoff destination**

Priority Level 1: Surface water runoff is collected for use;
Priority Level 2: Surface water runoff is infiltrated to ground;
Priority Level 3: Surface water runoff is discharged to a surface water body;
Priority Level 4: Surface water runoff is discharged to a surface water sewer, highway drain, or another drainage system;
Priority Level 5: Surface water runoff is discharged to a combined sewer.

Re-use

5.2.2 It is likely that rainwater harvesting at the site would have a limited impact on surface water discharge.

5.2.3 Office locations within the units proposed would likely be limited to toilet flushing as the only non-potable use.

5.2.4 It may be possible that larger volumes of surface water could be used for irrigation and landscape watering and this should be considered further at detailed design.

5.2.5 For the purposes of this report, water reuse has been discounted from the calculations in order to maintain a conservative approach to surface water management across the site.

Infiltration

5.2.6 The ground investigation carried out by TerraConsult shows that the site is underlain by Stiff Clay.

5.2.7 2no. infiltration tests were undertaken at the site. The tests were undertaken in accordance with BRE365 – test results are included in **Appendix 5**.

5.2.8 The infiltration testing did not conclude (water did not drain from the trial pits). As such infiltration is not considered suitable at this site.

Drain to Watercourse

5.2.9 The site has the Redwither Brook and the River Clywedog to the south (50m at its closest point). The developer has sufficient rights over the land to the south to ensure that a connection can be made to the either watercourse.

5.2.10 Based on the above, the most appropriate method for the disposal of surface water at the site is to discharge to watercourse at an attenuated rate.

5.3 Proposed Run-off Rates

5.3.1 In order to comply with the Sustainable Drainage System Standards for Wales and to ensure that surface water discharge mimics natural drainage discharge rates have been designed so as not exceed existing greenfield rates for the for the corresponding return period.

5.3.2 For proposed run-off rates see **Table 3** below.

Table 3 – Proposed Run off Rates

Maximum peak discharge by return period based on matching greenfield runoff rates for the same return period.

Outfall	Impermeable Area	1 year	30 year	100 year +40% (CC)
Outfall 1	3.52 ha	17.6 l/s	34.8 l/s	41.9l/s
Outfall 2	1.91 ha	9.6 l/s	18.9 l/s	22.7 l/s
Overall	**5.43 ha**	**27.2 l/s**	**53.7 l/s**	**64.6 l/s**

5.4 Climate Change

5.4.1 Based on a proposed design life for the development of 50 years and a proposed completion date post 2020 the site is thought to be active in the "2080's" and a climate change allowance of 40% has therefore been used in the production of this drainage strategy.

5.4.2 The 40% allowance has been added to the 100-year return period events in accordance with Welsh Planning Policy.

5.5 Attenuation Requirements

5.5.1 In order to limit the discharge from site to that proposed in **Table 3** above it is proposed to provide attenuation in the form of ponds.

5.5.2 The flow will be controlled by the use of flow control devices such as vortex flow controls or Orifice Plates. The design of the flow control should be such that discharge rates do not exceed those proposed in **Table 3** for the corresponding Return Period. This will involve the use of complex controls with more than one flow control at each discharge point set with different inverts to give varying discharges with depth of storage. Calculations have been carried out using Micro-drainage source control which uses rainfall profiles generated using the Flood Studies Report Method. Calculations are included in **Appendix 7.**

5.5.3 Calculations in **Appendix 7** have been provided for Swales and Ponds. The swales have been modelled as simple conveyance swales with no storage assumed. These collect flows from the filter drains and piped systems around the proposed plots and convey flows to the ponds. The potential storage in the filter drains and piped systems has been ignored for the purposes of these initial calculations. The swale/pond systems have been modelled using the cascade facility in Micro-drainage Source Control to give initial storage volumes, depths, and flows. On site filter drains should be designed in accordance with the SuDS manual at detailed design.

Table 4 – Calculated Attenuation Volumes

Attenuation storage volumes based on discharge at matching greenfield rates.

Pond	30-year return period volume (m^3)	100 year +CC return period volume (m^3)
Pond 1 system	1,700	2,125
Pond 2 system	850	1,110

5.5.4 Attenuation volumes are to be confirmed at the detailed design phase. The volumes of attenuation should be such that:

- All surface water flows up to and including the 1 in 30-year storm will be attenuated below ground (including within ponds and swales)
- Any events greater than 1 in 30 year (up to 1 in 100 year +CC) can be allowed to pond on the surface. This must occur in a controlled manner, must not flood buildings, leave site, or prevent access and egress to the site.
- Events in exceedance of the 100 year + CC return period will be classed as an exceedance event. Flows should be mapped once finished levels are available for the site.

5.6 Pollution Prevention

5.6.1 In the interest of pollution prevention, the areas of the site have been split into 3 risk zones with the potential pollution hazards for each use taken from the CIRIA 753 SUDS Manual simple index method:

Table 5 – Pollution Hazard Table

Land Use	Pollution Hazard Level	Total Suspended Solids (TSS)	Metals	Hydro-carbons
Commercial Roofs	Very Low Risk	0.3	0.2	0.05
Car Parks and minor access roads	Low Risk	0.5	0.4	0.4
Access Road with >300 trips per day and commercial yards	Medium Risk	0.7	0.6	0.7

5.6.2 Based on the above zone types a Suds Treatment Train has been proposed for the site general infrastructure and access roads. On plot pollution mitigation should be considered at detailed design to improve on the site infrastructure water quality.

5.6.3 The treatment train has been considered using the simple index approach outlined in CIRIA753. The treatment train will incorporate filter drains, swales and ponds and will have a mitigation index in excess of the pollution hazard index.

5.6.4 On plot drainage systems should incorporate catchpits to reduce the loading of suspended solids entering filter drains. Consideration to permeable paving and proprietary treatment should be considered as part of the on-plot drainage systems. The on-plot drainage systems should also address any particular uses that give greater pollution or sediment risks to protect the water quality of the downstream system. The final design of on plot systems will depend upon the final use of the units and as such have not been considered in this report.

5.6.5 Where impermeable concrete service yards are required, pre-treatment should be undertaken using catchpits to reduce the TSS sediment load within the flows before being discharged to the wider site drainage system treatment train.

5.6.6 The off-plot drainage system will utilise a treatment train of Filter Drains > Swales > Ponds. This gives an off-plot pollution mitigation index of:

Table 6 – Pollution Mitigation Index and Treatment Train

	Filter Drain	Swale*	Pond*	Total
TSS	0.4**	0.25	0.35	**1.00**
Metals	0.4	0.3	0.35	**1.05**
Hydrocarbons	0.4	0.3	0.25	**1.05**

*Mitigation index reduced by 50% as feature to be used as secondary/tertiary treatment.
**Catchpits required on plot to reduce the loading of TSS on the filter drain network.

5.6.7 As shown in **Table 5** and **Table 6**, the worst-case pollution hazard index is lower than the mitigation index –

- TSS Pollution index 0.7 < 1.00 mitigation index
- Metals Pollution index 0.6 < 1.05 mitigation index
- Hydrocarbons Pollution index 0.7 < 1.05 mitigation index

5.6.8 Detailed design of these features will need to be undertaken at the detailed design stage and approved by the Wrexham SUDS Adopting Body (SAB).

5.6.9 All SuDs features to be designed in accordance with CIRIA 753 The SUDS Manual at detailed design.

5.7 Sustainable Drainage Systems

5.7.1 Infiltration is unsuitable at the proposed site due to the nature of the clayey sub soil, as such all-infiltration techniques, along with those unsuitable for high density urban environments, have been discounted.

5.7.2 It is proposed that a series of measures are incorporated within the proposed layout to provide an element of treatment a control surface water runoff, these include:

- Silt traps/catchpits
- Sump outfall units/gullies
- Filter Drains
- Swales
- Ponds

5.7.3 The plots are to be drained by filter drainage and a piped network discharging to swales. The swales will convey the flow to the two attenuation ponds located in the ecological zone of development. The ponds will have complex flow controls on their outfalls

consisting of multiple vortex flow control or orifice plates set at different levels to give varying discharges for differing storm return periods.

5.7.4 The ponds will provide attenuation storage volume, water treatment and biodiversity benefits. The ponds are to be planted and managed to maintain these benefits.

5.8 Residual Risk and Designing for Exceedance

5.8.1 In the event that the capacity of the attenuation is exceeded, flood water will be retained on site within the service yards, dock levellers and car parks to the 100 year + Climate Change event. Local levels, kerbing and such details on the plots are to be set to control the location, retention, and depth of any such surface storage.

5.8.2 Access and Egress routes will be maintained for persons and vehicles always.

5.8.3 Site levels should fall away from buildings to prevent water ingress.

5.8.4 The residual risks and designing for exceedance should be considered further at reserved matters stage.

5.9 Maintenance

5.9.1 Requirements for ongoing maintenance of the drainage network will form part of the Operation and Maintenance manual for the site and will be undertaken by the building management. Any specialist or proprietary products that are specified at detailed design will have a manufacturer specific maintenance regime which will be included within the document.

5.9.2 All drainage features should be located in open areas which are accessible.

5.9.3 All surface water arrangements outlined above are subject to detailed design.

6.0 MANAGEMENT AND MAINTENANCE PLAN

6.1.1 Based on Chapter 32 on the CIRIA report C753 The SuDS Manual and manufacturer recommendations a maintenance strategy will be designed for the schemes final design. The responsibility for maintenance will lie with a combination of the Facilities management leaseholders, the Park Management Company or Wrexham SAB, if adoption is sought for the SuDS system.

7.0 FOUL WATER STRATEGY

7.1 Existing Site Drainage and Pre-Planning Discussion

7.1.1 The site is crossed by 2no. Foul Combined Sewers owned by Dwr Cymru Welsh Water (DCWW) shown in **Figure 5** below.

7.1.2 No surveys of the position and depth of the combined sewers were able to be undertaken due to the significant vegetation on site.

7.1.3 Discussions with DCWW indicate that the sewers on site have capacity to accept domestic type effluent from the proposed development. At this stage, no information is available as to the uses of the potential future units on the site. Any requirement for trade effluent discharge must be discussed with DCWW and an agreement reached between the undertaker and the tenant.

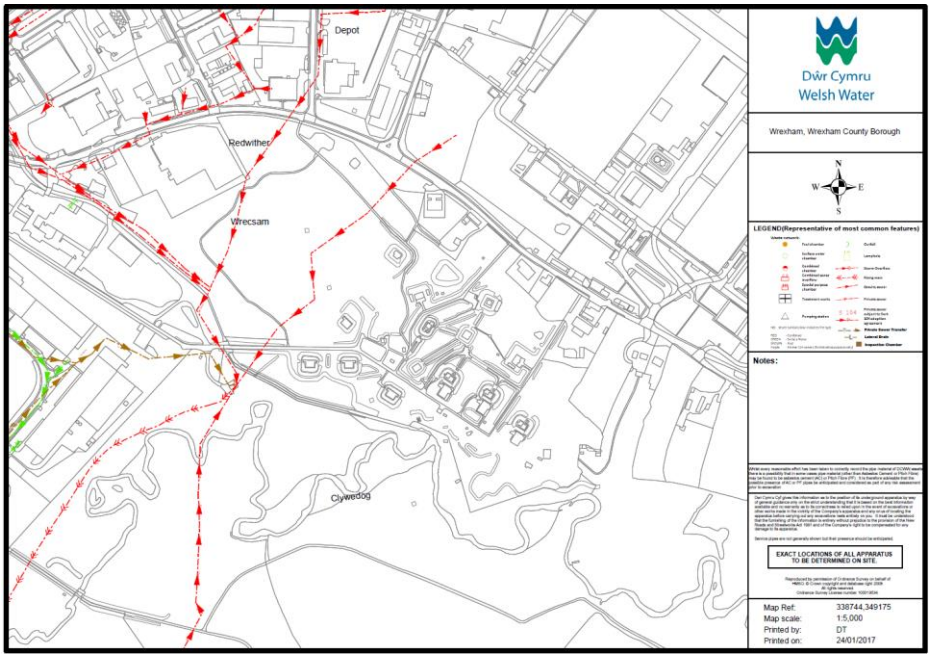


Figure 5 – DCWW Sewer Map

7.1.4 DCWW have indicated that the sewers are subject to an implied 6m easement (3m either side of the centreline) across the site and any alterations to the locations of the sewers would be subject to a S185 application for diversion of the public sewer and any alterations will be carried out at the developer expense.

7.1.5 It is proposed that the site is developed in such a way that Welsh Water have access to their apparatus at all times, either in open highway, open car parks or public access routes.

7.1.6 In order to ensure that adequate protection is provided to DCWW assets the following is proposed –

- *Once site clearance has been undertaken, a CCTV survey, including manhole location and depth, pipe sizes and condition, is undertaken to ascertain the exact location and depth of the DCWW combined sewer network crossing the site.*
- *No construction of buildings is to be undertaken within 3m of a DCWW asset with access for DCWW to be maintained at all times.*

- *Where the construction of roads and parking areas is undertaken, appropriate measures to ensure the protection of DCWW pipework should be undertaken, such as ensuring adequate cover is maintained to the DCWW asset (in accordance with The Welsh Ministers Standards, 4.1 R10).*
- *Where adequate cover cannot be maintained or where works to manhole cover levels are required, protection of the assets (in accordance with The Welsh Ministers Standards, Section 7 R3) or diversion of DCWW assets under S185 of the WIA1991 should be proposed and submitted to DCWW for approval.*
- *Access for Welsh Water to maintain their assets should be maintained at all times.*
- *Swale crossing points to be designed so sufficient cover and protection of the combined sewer network is maintained.*

7.1.7 A drawing based on the current masterplan has been produced which indicates a diversion to ensure that DCWW assets are accessible. The drawing is included in **Appendix 6**.

7.2 Proposed Foul Drainage

7.2.1 The site is proposed to discharge foul water to the public combined sewer network.

7.2.2 This will be done through a system of private drainage across the site with multiple connections to the sewers.

7.2.3 It is currently unknown whether the site will require pumping. Until such a time that proposed finished levels and a survey of the existing DCWW assets is finalised the pumping requirement will be To Be Confirmed.

8.0 Summary

8.1 Flood Consequence

8.1.1 The proposed site is classed as Less Vulnerable Development (General Industrial) and all built development is located entirely in Zone A on the Development Advice Maps.

8.1.2 No development is to take place within Zone B and C2, which are located within the blue line boundary along the edge of Redwither Brook.

8.1.3 The site is expected to have a FFL no lower than 26.5m AOD, significantly above the outline modelling flood level (21.0m).

8.1.4 It is considered that there is no residual risk of flooding from the Redwither Brook, River Clywedog or the potential blocking of the Redwither Culvert.

8.1.5 Based on the extents of surface water flooding and directions of flow, the surface water flood risk at the site is not generated from flows from outside of the site.

8.1.6 As part of the proposed redevelopment at the site, a surface water drainage system will be put in place.

8.1.7 The surface water drainage design should ensure that surface water is managed appropriately on site and not to pose a hazard to site users.

8.1.8 On the basis of the above, whilst there is a medium risk of surface water flooding in the sites current state, this is due to the onsite topography and not overland flow from outside the site. The risk of surface water flooding post development would be considered **low.**

8.1.9 The risk of flooding from groundwater sources is considered **low.**

8.1.10 The risk of flooding from artificial sources is considered **low**.

8.1.11 The risk of flooding from sewer, whilst not to be discounted would be of a low impact and as such can be considered a **low risk**.

8.1.12 No changes to ground level or structures are proposed in either the DAM Zones B or C or within Flood Zones 2 or 3. As such no change in flood risk within the wider catchment would occur as a result of development.

8.1.13 An increase in impermeable area has the potential to increase surface water runoff and therefore flood risk within the wider area.

8.1.14 It is proposed that a surface water system is constructed to control run off from the site to existing greenfield run off rates or lower.

8.1.15 Any reduction to existing run off rates would mean an improvement of offsite flood risk.

8.2 Flood Risk Mitigation

8.2.1 The development site is not likely to have a FFL of less than 26.5m (between 1.5m and 5.5m above the levels of the modelled flood outline). Therefore, the development is not thought to be at risk of fluvial flooding.

8.2.2 The site will be served by a drainage network designed to accommodate and control flows up to and including the 100-year storm plus climate change allowance of 40%.

8.2.3 The site should allow for hardstanding areas to fall away from buildings in order to prevent water ingress.

8.3 Surface Water

8.3.1 The proposed developed area on the existing site is predominantly drained via greenfield run off. A partial factor of urbanisation has been included in the Greenfield run off calculations (carried out by factoring IH124 greenfield run off methodology in line with CIRIA 753) to account for the existing roads and buildings present within the site. The urbanisation factor has been set at 0.1.

8.3.2 It is likely that rainwater harvesting and reuse within the buildings at the site would have a limited impact on surface water discharge.

8.3.3 It may be possible that larger volumes of surface water could be used for irrigation and landscape watering and this should be considered further at detailed design.

8.3.4 For the purposes of this report, water reuse has been discounted from the calculations in order to maintain a conservative approach to surface water management across the site.

8.3.5 2no. infiltration tests were undertaken at the site. The tests were undertaken in accordance with BRE365 – test results are included in **Appendix 5**.

8.3.6 The infiltration testing did not conclude (water did not drain from the trial pits). As such infiltration is not considered suitable at this site.

8.3.7 The site has the Redwither Brook and the River Clywedog to the south (50m at its closest point). The developer has sufficient rights over the land to the south to ensure that a connection can be made to the either watercourse.

8.3.8 Based on the above, the most appropriate method for the disposal of surface water at the site is to discharge to watercourse.

8.3.9 The 40% allowance has been added to the 100-year return period events in accordance with Welsh Planning Policy.

8.3.10 The plots are to be drained by filter drainage and a piped network discharging to swales. The swales will convey the flow to the two attenuation ponds located in the ecological zone of development. The ponds will have complex flow controls on their outfalls consisting of multiple vortex flow control or orifice plates set at different levels to give varying discharges for differing storm return periods.

8.3.11 The ponds will provide attenuation storage volume, water treatment and biodiversity benefits. The ponds are to be planted and managed to maintain these benefits.

8.3.12 Attenuation volumes are to be confirmed at the detailed design phase. The volumes of attenuation should be such that:

- All surface water flows up to and including the 1 in 30-year storm will be attenuated below ground (including within ponds and swales)
- Any events greater than 1 in 30 year (up to 1 in 100 year +CC) can be allowed to pond on the surface. This must occur in a controlled manner, must not flood buildings, leave site, or prevent access and egress to the site.

- Events in exceedance of the 100 year + CC return period will be classed as an exceedance event. Flows should be mapped once finished levels are available for the site.

8.3.13 A Suds Treatment Train has been proposed for the site general infrastructure and access roads. On plot pollution mitigation should be considered at detailed design to improve on the site infrastructure water quality and to address any particular pollution or sediment issues arising from the particular use of the site.

8.3.14 The treatment train has been considered using the simple index approach outlined in CIRIA753. The treatment train will incorporate filter drains, swales and ponds and will have a mitigation index in excess of the pollution hazard index.

8.3.15 As shown in **Table 5** and **Table 6**, the worst-case pollution hazard index is lower than the mitigation index –

- TSS Pollution index 0.7 < 1.00 mitigation index
- Metals Pollution index 0.6 < 1.05 mitigation index
- Hydrocarbons Pollution index 0.7 < 1.05 mitigation index

8.3.16 Detailed design of these features will need to be undertaken at detailed design and approved by the Wrexham SUDS Adopting Body (SAB).

8.3.17 All SuDs features to be designed in accordance with CIRIA 753 the suds manual at detailed design.

8.3.18 It is proposed that a series of measures are incorporated within the proposed layout to provide an element of treatment a control surface water runoff, these include:

- Silt traps/catchpits
- Sump outfall units/gullies
- Filter Drains
- Swales
- Ponds

8.3.19 Access and Egress routes will be maintained for persons and vehicles always.

8.3.20 Site levels should fall away from buildings to prevent water ingress.

8.3.21 The residual risks and designing for exceedance should be considered further at reserved matters stage.

8.3.22 The responsibility for maintenance will lie with either the Facilities management leaseholders, the park Management Company or Wrexham SAB, if adoption is sought for the SuDS system.

8.4 Foul Water

8.4.1 The site is crossed by 2no. Foul Combined Sewers owned by Dwr Cymru Welsh Water (DCWW) shown in **Figure 5**.

8.4.2 No surveys of the position and depth of the combined sewers were able to be undertaken due to the significant vegetation on site.

8.4.3 Discussions with DCWW indicate that the sewers on site have capacity to accept domestic type effluent from the proposed development. At this stage, no information is available as to the potential future units on the site. Any requirement for trade effluent

discharge must be discussed with DCWW and an agreement reached between the undertaker and the tenant.

8.4.4 In order to ensure that adequate protection is provided to DCWW assets the following is proposed –

- *Once site clearance has been undertaken, a CCTV survey, including manhole location and depth, pipe sizes and condition, is undertaken to ascertain the exact location and depth of the DCWW combined sewer network crossing the site.*
- *No construction of buildings is to be undertaken within 3m of a DCWW asset with access for DCWW to be maintained at all times. This may involve sewer diversions that will need to be agreed with DCWW.*
- *Where the construction of roads and parking areas is undertaken, appropriate measures to ensure the protection of DCWW pipework should be undertaken, such as ensuring adequate cover is maintained to the DCWW asset (in accordance with The Welsh Ministers Standards, 4.1 R10).*
- *Where adequate cover cannot be maintained or where works to manhole cover levels are required, protection of the assets (in accordance with The Welsh Ministers Standards, Section 7 R3) or diversion of DCWW assets under S185 of the WIA1991 should be proposed and submitted to DCWW for approval.*
- *Access for Welsh Water to maintain their assets should be maintained at all times.*
- *Swale crossing points to be designed so sufficient cover and protection of the combined sewer network is maintained.*

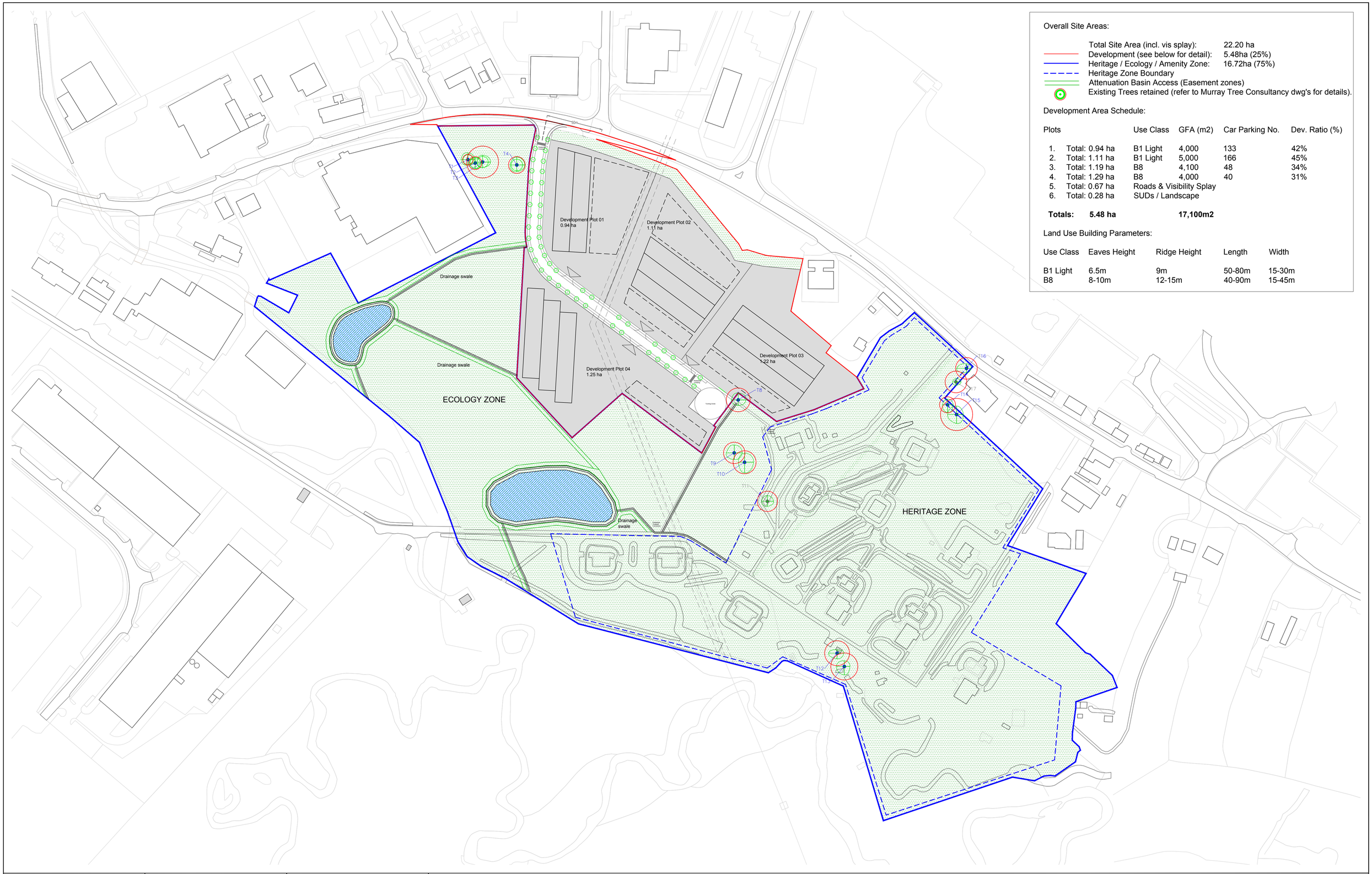
8.4.5 The site is proposed to discharge foul water to the public combined sewer network.

8.4.6 This will be done through a system of private drainage across the site.

8.4.7 It is currently unknown whether the site will require pumping. Until such a time that proposed finished levels and a survey of the existing DCWW assets is finalised the pumping requirement will be To Be Confirmed.

APPENDIX 1

Site Layout



Overall Site Areas:

	Total Site Area (incl. vis splay):	22.20 ha
	Development (see below for detail):	5.48ha (25%)
	Heritage / Ecology / Amenity Zone:	16.72ha (75%)
	Heritage Zone Boundary	
	Attenuation Basin Access (Easement zones)	
	Existing Trees retained (refer to Murray Tree Consultancy dwg's for details).	

Development Area Schedule:

Plots		Use Class	GFA (m2)	Car Parking No.	Dev. Ratio (%)
1.	Total: 0.94 ha	B1 Light	4,000	133	42%
2.	Total: 1.11 ha	B1 Light	5,000	166	45%
3.	Total: 1.19 ha	B8	4,100	48	34%
4.	Total: 1.29 ha	B8	4,000	40	31%
5.	Total: 0.67 ha	Roads & Visibility Splay			
6.	Total: 0.28 ha	SUDs / Landscape			
Totals:	**5.48 ha**		**17,100m2**		

Land Use Building Parameters:

Use Class	Eaves Height	Ridge Height	Length	Width
B1 Light	6.5m	9m	50-80m	15-30m
B8	8-10m	12-15m	40-90m	15-45m

REVISIONS

Rev.	Description	Date	By	Chk'd
A	Areas revised to incl. Heritage & new jct.	22.03.19	SR	SR
B	Road alignment, Ecology increase, GFA added	26.03.19	SR	SR
C	Areas and site boundaries revised	28.03.19	SR	SR
D	Plots 4 & 5 combined, plot 5 access removed	23.04.19	SR	SR
E	Internal access road minor amends.	03.05.19	SR	SR
F	Footpath connections added, notes added	16.05.19	SR	SR

REVISIONS

Rev.	Description	Date	By	Chk'd
G	Heritage Area amended	16.10.19	SR	SR
H	Parking numbers to plot 5 amended.	19.11.19	SR	SR
I	Land Use Building Parameters added	28.11.19	SR	SR
J	Heritage Zone Extended	05.02.20	SR	SR
K	Heritage Zone Extended	07.02.20	SR	SR
L	Eastern SUDs pond moved from Heritage Area	12.02.20	SR	SR

REVISIONS

Rev.	Description	Date	By	Chk'd
M	Attenuation pond locations updated	07.05.20	SR	SR
N	Attenuation swales added to layout	19.10.20	SR	SR
O	Plots 4 & 5 reduced, trees to be retained added	19.11.20	SR	SR

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PRELIMINARY

client:
CEFN PARK DEVELOPMENT LTD
project:
THE OAKS
drawing title:
PROPOSED SITE
PARAMETERS PLAN

land | studio

scale: @ A1 1:1500
date: 15.02.2019
drn: SR
chk'd: SR

003
O

APPENDIX 2

DCWW Correspondence

Philip Barrett

From: Philip Barrett
Sent: 12 March 2019 11:11
To: Developer.Services@dwrcymru.com
Subject: RE: Re.PPA0003864. Notification

Thank you for the pre development enquiry response.

I have noted the points made in relation to Sewerage (including advice on Trade Effluent), Sewage Treatment and Surface Water.

With regards to Asset Protection - you have stated - *No operational development including the raising or lowering of ground levels will be permitted within 3 metres either side of the centreline of the public sewers. Our strong recommendation is that your site layout takes into account the location of the assets crossing the site and should be referred to in any master-planning exercises or site layout plans submitted as part of any subsequent planning application. Further information regarding Asset Protection is provided in the attached Advice & Guidance note.*

We feel that a condition meaning no change in level within 3m of the DCWW sewers would be overly restrictive and sterilise significant sections of the site from development. The proposals have been put together with due regard to the layout of the DCWW sewer system to ensure that no buildings will interfere with DCWW assets, understanding that no over agreement would be granted. An initial levels assessment has indicated that where proposed highways/parking crosses the combined sewers on site, levels will either be maintained or may need to be raised upto 1.5m.

Until such a time as the site is cleared (the site is currently covered in dense scrub) we will not be able to ascertain the exact depth and location of your assets within the site.

We have carried out a phase 2 SI at the site, and have found that the site is underlain by stiff clay. As such, the raising of ground levels within the range proposed would not be likely to be of detriment to the DCWW assets through settlement.

Increased loading of the pipework due to the installation of roads and parking on top of the DCWW sewers is not thought to be of detriment to the structural stability of the pipes. The material of the pipework laid across the site should be confirmed, though the DCWW layout drawing provided indicate that the sewers are Vitrified Clay or Concrete construction. As long as cover is maintained (in accordance with The Welsh Ministers Standards, 4.1 R10) and an appropriate construction build-up of roads and parking is installed, we believe that the risks to the sewer can be mitigated.

Is it possible to reconsider the constraints imposed in relation to alterations in ground level so that as long as the asset is protected and accessible, and depths of cover are in accordance with the design standards set out in The Welsh Ministers Standards and Sewers for Adoption 7th Edition are maintained that the development would be acceptable? The development is currently to go in for outline planning and this would mean, as a statutory consultee, DCWW would have access to the development proposals as they evolve.

It would be proposed as part of the drainage strategy that -

Once site clearance has been undertaken, a CCTV survey, including manhole location and depth, pipe sizes and condition, is undertaken to ascertain the exact location and depth of the DCWW combined sewer network crossing the site.

No construction of buildings is to be undertaken within 3m of a DCWW asset with access for DCWW to be maintained at all times. Where the construction of roads and parking areas is undertaken, appropriate measures to ensure the protection of DCWW pipework should be undertaken, such as ensuring adequate cover is maintained to

the DCWW asset (in accordance with The Welsh Ministers Standards, 4.1 R10). *Where adequate cover cannot be maintained or where works to manhole cover levels are required, protection of the assets (in accordance with* The Welsh Ministers Standards, Section 7 R3) or *diversion of DCWW assets under S185 of the WIA1991 should be proposed and submitted to DCWW for approval.*

Access for Welsh Water to maintain their assets should be maintained at all times.

Regards
Philip Barrett
Principal Engineer
Surface Water Department
Office: 01925 291111
Mobile: 07718 476735

St Helens: Bold Business Centre, Bold Lane, Sutton, St. Helens, WA9 4TX Tel: +44 (0)1925 291111
Colchester: Dugard House, Peartree Road, Colchester, Essex, CO3 0UL Tel: +44 (0)1206 585600
Email: mailbox@terraconsult.co.uk Website: www.terraconsult.co.uk

-----Original Message-----
From: donotreply@dwrcymru.com [mailto:donotreply@dwrcymru.com]
Sent: 12 March 2019 09:50
To: Philip Barrett
Cc: BPMCopies@dwrcymru.com
Subject: Re.PPA0003864. Notification

Dear Customer,

Please find attached important information relating to your application.

Should you wish to contact us for any reason, you must use the contact information shown on the attachment(s).

Please do not reply directly to this message.

Best regards,

Developer Services
Dwr Cymru Welsh Water
_____ Dwr Cymru Welsh Water is firmly committed to water conservation and promoting water efficiency. Please log on to our website to find out how you can become water wise. Mae Dwr Cymru Welsh Water wedi ymrwymo i warchod adnoddau dwr a hyrwyddo defnydd dwr effeithiol. Mae cyngor i' ch helpu i ddefnyddio dwr yn ddoeth yn www.dwrcymru.com/waterefficiency
_____
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Philip Barrett

From: Philip Barrett
Sent: 19 March 2019 11:34
To: 'Jones Alaw'
Subject: RE: PPA0003864 [Filed 19 Mar 2019 11:33]

Hi Alaw,

To confirm our conversation –

Any changes in level over a DCWW sewer will require a scheme to be submitted to Welsh Water to ensure that suitable protection measures are put in place. I will include this within the recommendations of the FCA/Outline drainage Design and this will enable Welsh Water to support the application and recommend a condition on that basis.

Below are the recommendations relating to DCWW assets that will be included in my report.

Once site clearance has been undertaken, a CCTV survey, including manhole location and depth, pipe sizes and condition, is undertaken to ascertain the exact location and depth of the DCWW combined sewer network crossing the site.

No construction of buildings is to be undertaken within 3m of a DCWW asset with access for DCWW to be maintained at all times. Where the construction of roads and parking areas is undertaken, appropriate measures to ensure the protection of DCWW pipework should be undertaken, such as ensuring adequate cover is maintained to the DCWW asset (in accordance with The Welsh Ministers Standards, 4.1 R10). *Where adequate cover cannot be maintained or where works to manhole cover levels are required, protection of the assets (in accordance with* The Welsh Ministers Standards, Section 7 R3) or *diversion of DCWW assets under S185 of the WIA1991 should be proposed and submitted to DCWW for approval.*

Access for Welsh Water to maintain their assets should be maintained at all times.

Regards

Philip Barrett

Principal Engineer

Surface Water Department

Office: 01925 291111
Mobile: 07718 476735

TerraConsult

St Helens: Bold Business Centre, Bold Lane, Sutton, St. Helens, WA9 4TX **Tel:** +44 (0)1925 291111

Colchester: Dugard House, Peartree Road, Colchester, Essex, CO3 0UL **Tel:** +44 (0)1206 585600

Email: mailbox@terraconsult.co.uk **Website:** www.terraconsult.co.uk

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From: Jones Alaw [mailto:Alaw.Jones@dwrcymru.com]
Sent: 12 March 2019 17:46
To: Philip Barrett
Subject: PPA0003864

Hi Philip,

Further to our recent telephone conversation, please accept my apologies, I have been unable to discuss the matter with my line manager today. However, I will give you a call on Thursday afternoon to discuss if that's convenient with yourself?

Kind regards,
Alaw

Alaw Jones
Development Control Officer | Developer Services | Wholesale Business Services | Services Dwr Cymru Welsh Water
Kinmel Park | Bodelwyddan | LL18 5TQ | T: 0800 917 2652| www.dwrcymru.com

Developer Services have an on-line service at www.dwrcymru.com. Here you can find all the services available, complete application forms and also make payments. If you have a quotation you can pay for this on-line or alternatively by telephoning 0800 917 2652 using a credit/debit card.

*We will respond to your email as soon as possible but you should allow up to **10 working days** to receive a response. For most of the services we offer we set out the timescales that we work to on our Developer Services section of our website. Just follow this link http://www.dwrcymru.com/en/Developer-Services.aspx and select the service you require where you will find more information and guidance notes which should assist you. If you cannot find the information you are looking for then please call us on 0800 917 2652 as we can normally deal with any questions you have during the call.*

If we've gone the extra mile to provide you with excellent service, let us know. You can nominate an individual or team for a Diolch award through our website.

_____ Dwr Cymru Welsh Water is firmly committed to water conservation and promoting water efficiency. Please log on to our website www.dwrcymru.com/waterefficiency to find out how you can become water wise. Mae Dwr Cymru Welsh Water wedi ymrwymo i warchod adnoddau dwr a hyrwyddo defnydd dwr effeithiol. Mae cyngor i' ch helpu i ddefnyddio dwr yn ddoeth yn www.dwrcymru.com/waterefficiency

_____
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Philip Barrett

From: Jones Alaw <Alaw.Jones@dwrcymru.com>
Sent: 12 March 2019 08:33
To: Philip Barrett
Subject: RE: PPA0003864 - The Oaks, Wrexham Industrial Estate

Hi Philip,

Thank you for your e-mail.

The above pre-planning advice response will be issued today.

Should you have any queries, please do not hesitate to contact me.

Kind regards,
Alaw

Alaw Jones
Development Control Officer | Developer Services | Wholesale Business Services | Services Dwr Cymru Welsh Water
Kinmel Park | Bodelwyddan | LL18 5TQ | T: 0800 917 2652| www.dwrcymru.com

Developer Services have an on-line service at www.dwrcymru.com. Here you can find all the services available, complete application forms and also make payments. If you have a quotation you can pay for this on-line or alternatively by telephoning 0800 917 2652 using a credit/debit card.

*We will respond to your email as soon as possible but you should allow up to **10 working days** to receive a response. For most of the services we offer we set out the timescales that we work to on our Developer Services section of our website. Just follow this link http://www.dwrcymru.com/en/Developer-Services.aspx and select the service you require where you will find more information and guidance notes which should assist you. If you cannot find the information you are looking for then please call us on 0800 917 2652 as we can normally deal with any questions you have during the call.*

From: Philip Barrett [mailto:philipbarrett@terraconsult.co.uk]
Sent: 12 March 2019 08:31
To: Jones Alaw <Alaw.Jones@dwrcymru.com>
Subject: RE: PPA0003864 - The Oaks, Wrexham Industrial Estate

******** External Mail ********
Hi Alaw,

Do you know when the DCWW pre developer response will be ready?

Regards

Regards

Philip Barrett

Principal Engineer

Surface Water Department

Office: 01925 291111
Mobile: 07718 476735

TerraConsult

St Helens: Bold Business Centre, Bold Lane, Sutton, St. Helens, WA9 4TX **Tel:** +44 (0)1925 291111

Colchester: Dugard House, Peartree Road, Colchester, Essex, CO3 0UL **Tel:** +44 (0)1206 585600

Email: mailbox@terraconsult.co.uk **Website:** www.terraconsult.co.uk

---

From: Jones Alaw [mailto:Alaw.Jones@dwrcymru.com]
Sent: 22 February 2019 11:59
To: Philip Barrett
Subject: RE: PPA0003864 - The Oaks, Wrexham Industrial Estate

Hi Philip,

Thank you for the additional information.

Kind regards,
Alaw

Dwr Cymru Welsh Water

Alaw Jones
Development Control Officer | Developer Services | Wholesale Business Services | Services Dwr Cymru Welsh Water
Kinmel Park | Bodelwyddan | LL18 5TQ | T: 0800 917 2652| www.dwrcymru.com

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If we've gone the extra mile to provide you with excellent service, let us know. You can nominate an individual or team for a Diolch award through our website.

From: Philip Barrett [mailto:philipbarrett@terraconsult.co.uk]
Sent: 22 February 2019 11:34
To: Jones Alaw <Alaw.Jones@dwrcymru.com>
Subject: RE: PPA0003864 - The Oaks, Wrexham Industrial Estate

******** External Mail ********
Hi Alaw

Unfortunately as we are only at outline stage the development staff numbers are unknown. The development application will be for B2 (general light industry) and B8 (storage and distribution) space. The split is not yet defined.

Approximate areas are included for the units below –

Unit	m^2	ha	Foul Discharge	
			Domestic	Trade

Plot 1	3500	0.35	0.210	0.245
Plot 2	3500	0.35	0.210	0.245
Plot 3	3900	0.39	0.234	0.273
Plot 4	3600	0.36	0.216	0.252
Plot 5	3300	0.33	0.198	0.231
Plot 6	2200	0.22	0.132	0.154
Plot 7	5000	0.50	0.30	0.350
Plot 8	5300	0.53	0.318	0.371
Plot 9	2300	0.23	0.138	0.161
Plot 10	5000	0.50	0.30	0.350
Plot 11	2200	0.22	0.132	0.154
Total	39,800m2	3.98ha	2.388 l/s	2.786 l/s

Total Domestic and Foul – 5.17 l/s

2. The following design flows for industrial developments should be used where the actual details of flows are unknown:

a) domestic flow element calculated in accordance with BS EN 752 or, in the absence of appropriate information, 0.6 litres per second per hectare of developable land;

b) trade effluent flow based on a metered water supply to premises similar to that proposed, or assumed as 0.5 litres per second per hectare for normal industry and 1 litre per second per hectare for wet industry. Where the proportion of wet industry is unknown, an average flow of 0.7 litres per second per hectare should be used; and

c) to obtain the total design flow, the domestic design flow should be added to the trade effluent design flow.

Based on SfA I would anticipate 5.2 l/s.

Regards

Regards

Philip Barrett

Principal Engineer

Surface Water Department

Office: 01925 291111
Mobile: 07718 476735

TerraConsult

St Helens: Bold Business Centre, Bold Lane, Sutton, St. Helens, WA9 4TX **Tel:** +44 (0)1925 291111

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Email: mailbox@terraconsult.co.uk **Website:** www.terraconsult.co.uk

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From: Jones Alaw [mailto:Alaw.Jones@dwrcymru.com]
Sent: 22 February 2019 11:12
To: Philip Barrett
Subject: PPA0003864 - The Oaks, Wrexham Industrial Estate

Good morning Mr Barrett,

I write in respect of the above pre-planning advice request received on the 19/02/2019.

To assist us in assessing whether there is sufficient capacity within the network to accommodate the proposed development, would it be possible to receive further information on the nature of the proposal, breakdown of the types of units and anticipated number of employment please?

Should you have any queries, please do not hesitate to contact me.

Kind regards,
Alaw

Alaw Jones
Development Control Officer | Developer Services | Wholesale Business Services | Services Dwr Cymru Welsh Water
Kinmel Park | Bodelwyddan | LL18 5TQ | T: 0800 917 2652| www.dwrcymru.com

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APPENDIX 3

NRW Correspondence

Philip Barrett

From: Data Distribution <datadistribution@cyfoethnaturiolcymru.gov.uk>
Sent: 21 February 2019 11:18
To: Philip Barrett
Subject: ATI 17013A - Flood Product - The Oaks, Wrexham, LL13 9LU

Hello Philip

Unfortunately we can't provide any flood products as we don't hold any detailed flood risk information for this location.

All the information we have available can be obtained from our free self-service open data as detailed below:

Self Service Open Data:

You can now make the most of open data provided **free online:**

- **NRW Flood Risk Map Viewer**: create and export an A4 or A3 PDF map at a scale of 1:5000. You will find many spatial risk layers, including the Development Advice Map, flood zones, surface water and reservoir hazard data.
- **"Llе" the Welsh Government Portal for Open Spatial data**: Spatial data is free to download, view and use within your own GIS system. The flood datasets includes Flood Zones, Flood Defences, Historic Flood Outlines, Areas Benefiting Defences, Surface Water, Development Advice Map, and LiDAR Composite Dataset. You can also download the 'Coastal Design – Extreme Sea Levels' report and data covering still water levels for the Welsh Coastline (wave overtopping is **not** calculated).

Please Note the Following:

- All information supplied will need to be verified by the recipient **PRIOR** to using in a Flood Consequences Assessment (FCA). We would expect to see a review of hydrology, in-channel survey, floodplain topography etc. to demonstrate the data is suitable for the purposes of producing an FCA.
- As of 1st of December, 2016 you will need to apply climate change allowances carefully to ensure compliance with Welsh Government climate change clarification letter.
- For Coastal and Estuarine sites NRW will require assessment of wave overtopping. It is up to the developer to justify why an assessment *isn't* required.
- **Pre-application Advice:** NRW are changing the way in which we provide advice to developers. We will continue to meet our duties as an adviser. In addition, we will offer a free initial opinion on your proposal. However, in cases where you would like to access any extra advice that falls outside of our statutory duties, we can only offer this as part of our Discretionary Planning Advice Service (DPA Service). For more information regarding free service and our discretionary planning can be found in the following links: Welsh Version / English version.

Your request for our free or charged discretionary advice service needs to be accompanied by the relevant 'Request Form' which is available to download from our website. You will then need to send the form to northplanning@cyfoethnaturiolcymru.gov.uk who will coordinate our response.

Regards

Kathy Banner
Swyddog Cysylltiadu Allanol / External Relations Officer
Cyfoeth Naturiol Cymru / Natural Resources Wales
03000 653568
Llys Afon, Hwlffordd / River Court, Haverfordwest
Dysgwr Cymraeg

www.cyfoethnaturiol.cymru / www.naturalresources.wales

Yn falch o arwain y ffordd at ddyfodol gwell i Gymru trwy reoli'r amgylchedd ac adnoddau naturiol yn gynaliadwy.

Proud to be leading the way to a better future for Wales by managing the environment and natural resources sustainably.

Croesewir gohebiaeth yn Gymraeg a byddwn yn ymateb yn Gymraeg, heb i hynny arwain at oedi

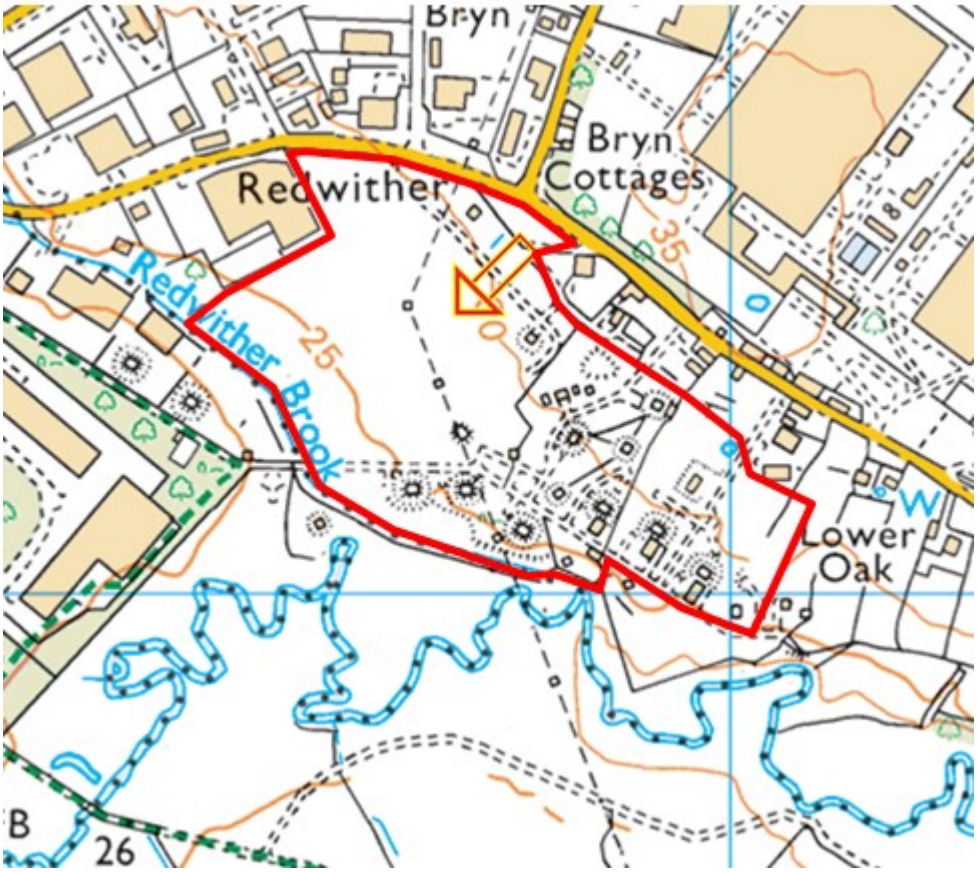
Correspondence in Welsh is welcomed, and we will respond in Welsh without it leading to a delay

---

From: Philip Barrett <philipbarrett@terraconsult.co.uk>
Sent: 19 February 2019 10:22
To: Data Distribution <datadistribution@cyfoethnaturiolcymru.gov.uk>
Subject: 4292 - The Oaks

Please find attached a data request –

Map of the area required is shown below.



Regards

Philip Barrett

Principal Engineer

Surface Water Department

Office: 01925 291111
Mobile: 07718 476735

TerraConsult

St Helens: Bold Business Centre, Bold Lane, Sutton, St. Helens, WA9 4TX **Tel:** +44 (0)1925 291111

Colchester: Dugard House, Peartree Road, Colchester, Essex, CO3 0UL **Tel:** +44 (0)1206 585600

Email: mailbox@terraconsult.co.uk **Website:** www.terraconsult.co.uk

APPENDIX 4

Greenfield Run Off

Greenfield Runoff Volume

FSR Data

Return Period (years)	100
Storm Duration (mins)	360
Region	England and Wales
M5-60 (mm)	18.000
Ratio R	0.347
Areal Reduction Factor	1.00
Area (ha)	1.000
SAAR (mm)	763
CWI	113.129
Urban	0.100
SPR	47.000

Results

Percentage Runoff (%)	48.41
Greenfield Runoff Volume (m^3)	292.228

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ICP SUDS Mean Annual Flood

Input

Return Period (years)	1	Soil	0.450
Area (ha)	1.000	Urban	0.100
SAAR (mm)	767	Region Number	Region 9

Results	**l/s**
QBAR Rural	4.9
QBAR Urban	5.7
Q1 year	5.0
Q1 year	5.0
Q30 years	9.9
Q100 years	11.9

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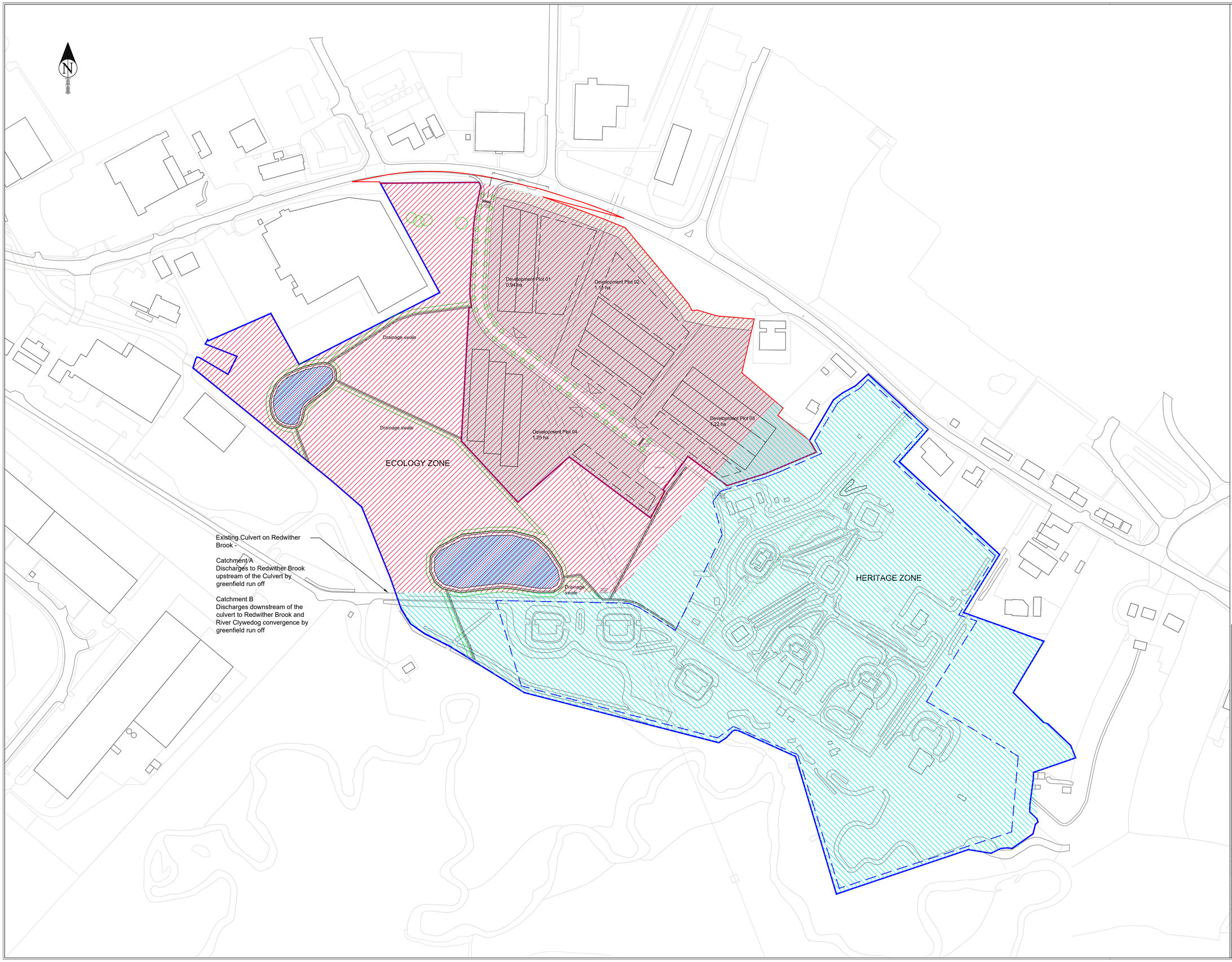


Notes

1. Do not scale from drawing. Not issued for construction
2. Location and exact alignment of drainage and water strategy requirements requires confirmation on site.
3. Surface water sewer and drainage locations are indicative only and not to be used for construction
4. Topographic site levels have been ulitised for development of this drainage design. Levels may be subject to change based on development finishing and layout amendments.

Catchment A
Catchment B

TerraConsult

Bold Business Centre, Bold Lane, Sutton, St Helens WA9 4TX

Client

Site
The Oaks Wrexham

Title
Existing Drainage Catchments Plan

Scale	1:1,500 @ A1	
Drawing No.	TOW-TCL-HDG-XX-DR-D-0505	
Rev	Date	Description
A	04/20	New Layout & Drainage Amendments
B	04/21	New Layout
File	TOW-TCL-HDG-XX-DR-D-0505 RevB.dwg	
Date 04/21		Engineer TCL
Drawn PP GH		Checked FINAL

APPENDIX 5

Infiltration Tests

Infiltration Test Report

TerraConsult

Carried out by:	Date:	Method:				Trial pit dimensions:	Before:	After:	Location:	Grid: OSGB
DK	20/02/19	BRE Digest DG 365: 2016				Length (m):	2.60	2.60	mE:	
Chkd by:	Test no:	Granular infill:	Datum height (m agl):	Depth to water: Start:	End:	Width (m):	0.70	0.70	mN:	
	SA01	None	0.00	1.81	1.90	Depth (m):	2.30	2.30	m OD:	

Elapsed time (mins):	Water depth (m below datum):	Elapsed time (mins):	Water depth (m below datum):
0	1.81		
0.5	1.81		
1.0	1.81		
3.0	1.81		
4.0	1.82		
5.0	1.83		
10	1.84		
20	1.90		
25	1.90		
50	1.90		
73	1.90		
111	1.90		
180	1.90		

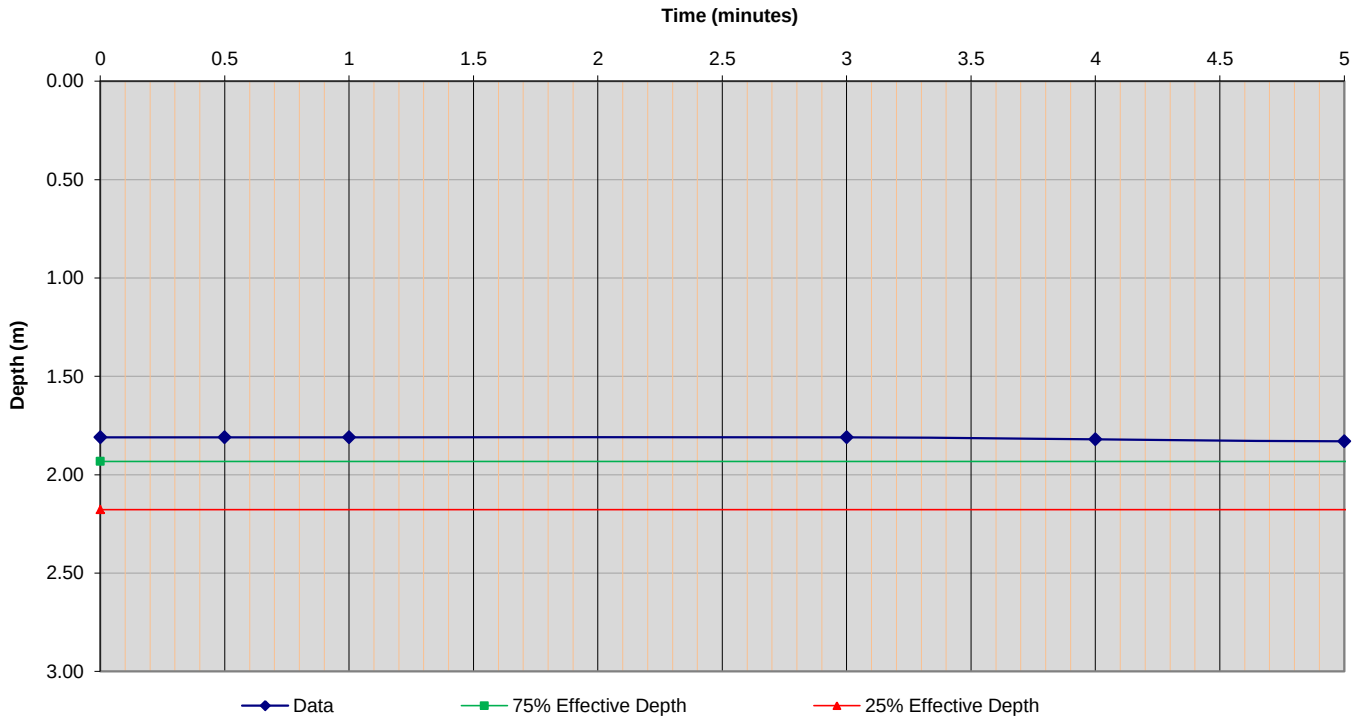
Effective depth (m):		Elapsed time (mins) (from graph):		Invert level:	
75%	1.93	75%		1.81	Assumed
50%	2.06				
25%	2.18	25%			

Base area of pit	1.82	m^2
Mean surface area through which outflow occurs	3.44	m^2
Volume outflow between 75 and 25% effective depth	0.45	m^3

Soil infiltration rate, f	N/A	$m^3/m^2/s$
Soil infiltration rate, f	N/A	m/hr
Percolation Value, vp	N/A	s/mm

INSUFFICEINT INFILTRATION TO CALCULATE RATE

Notes:
1. Water drained 0.09m after 180mins
2. See accompanying trial pit log;



AGS

Notes: For explanation of symbols and abbreviations see Key Sheet.
All depths in meters.

Issue: Draft

Project: The Oaks, Wrexham
Proj. No: 4292
Client: J10 Planning Ltd

Test reference:

Infiltration Test Report

TerraConsult

Carried out by:	Date:	Method:				Trial pit dimensions:	Before:	After:	Location:	Grid: OSGB
BA	17/01/19	BRE Digest DG 365: 2016				Length (m):	2.31	2.31	mE:	
Chkd by:	Test no:	Granular infill:	Datum height (m agl):	Depth to water: Start:	End:	Width (m):	0.81	0.81	mN:	
	1	None	0.00	1.68	1.68	Depth (m):	2.25	2.25	m OD:	

Elapsed time (mins):	Water depth (m below datum):	Elapsed time (mins):	Water depth (m below datum):
0	1.68		
1	1.68		
2	1.68		
4	1.68		
10	1.68		
20	1.68		
30	1.68		
67	1.68		
115	1.68		
180	1.68		

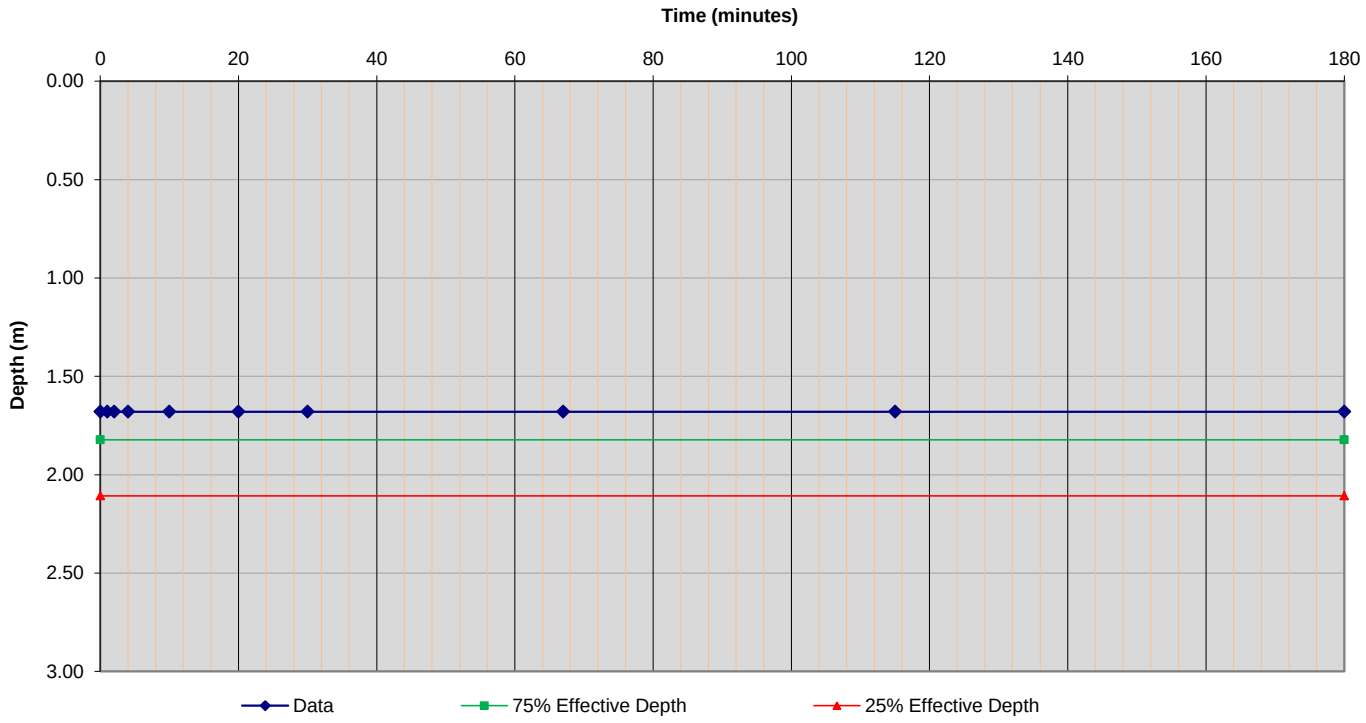
Effective depth (m):		Elapsed time (mins) (from graph):		Invert level:	
75%	1.82	75%		1.68	Assumed
50%	1.97				
25%	2.11	25%			

Base area of pit	1.87	m^2
Mean surface area through which outflow occurs	3.65	m^2
Volume outflow between 75 and 25% effective depth	0.53	m^3

Soil infiltration rate, f	N/A	$m^3/m^2/s$
Soil infiltration rate, f	N/A	m/hr
Percolation Value, vp	N/A	s/mm

INSUFFICEINT INFILTRATION TO CALCULATE RATE

Notes:
1. Water failed to drain after 180mins
2. See accompanying trial pit log;



AGS

Notes: For explanation of symbols and abbreviations see Key Sheet.
All depths in meters.

Issue: Draft

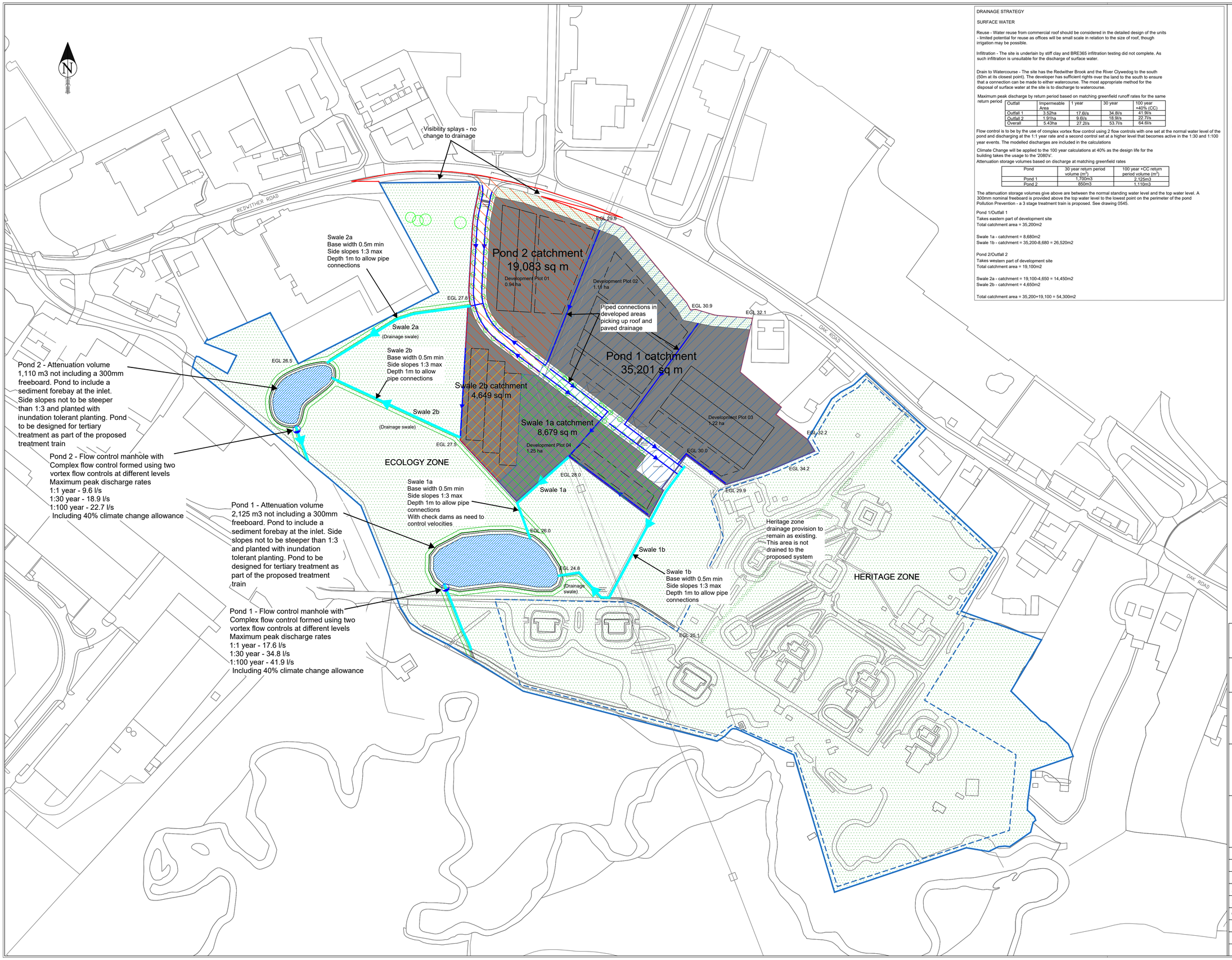
Project: The Oaks, Wrexham
Proj. No: 4292
Client: J10 Planning Ltd

Test reference:

SA02

APPENDIX 6

Surface Water Strategy Drawing



DRAINAGE STRATEGY

SURFACE WATER

Reuse - Water reuse from commercial roof should be considered in the detailed design of the units - limited potential for reuse as offices will be small scale in relation to the size of roof, though irrigation may be possible.

Infiltration - The site is underlain by stiff clay and BRE365 infiltration testing did not complete. As such infiltration is unsuitable for the discharge of surface water.

Drain to Watercourse - The site has the Redwither Brook and the River Clywedog to the south (50m at its closest point). The developer has sufficient rights over the land to the south to ensure that a connection can be made to either watercourse. The most appropriate method for the disposal of surface water at the site is to discharge to watercourse.

Maximum peak discharge by return period based on matching greenfield runoff rates for the same return period

Outfall	Impermeable Area	1 year	30 year	100 year +40% (CC)
Outfall 1	3.52ha	17.6l/s	34.8l/s	41.9l/s
Outfall 2	1.91ha	9.6l/s	18.9l/s	22.7l/s
Overall	5.43ha	27.2l/s	53.7l/s	64.6l/s

Flow control is to be by the use of complex vortex flow control using 2 flow controls with one set at the normal water level of the pond and discharging at the 1:1 year rate and a second control set at a higher level that becomes active in the 1:30 and 1:100 year events. The modelled discharges are included in the calculations

Climate Change will be applied to the 100 year calculations at 40% as the design life for the building takes the usage to the '2080's'.

Attenuation storage volumes based on discharge at matching greenfield rates

Pond	30 year return period volume (m^3)	100 year +CC return period volume (m^3)
Pond 1	1,700m3	2,125m3
Pond 2	850m3	1,110m3

The attenuation storage volumes give above are between the normal standing water level and the top water level. A 300mm nominal freeboard is provided above the top water level to the lowest point on the perimeter of the pond
Pollution Prevention - a 3 stage treatment train is proposed. See drawing 0545.

Pond 1/Outfall 1
Takes eastern part of development site
Total catchment area = 35,200m2

Swale 1a - catchment = 8,680m2
Swale 1b - catchment = 35,200-8,680 = 26,520m2

Pond 2/Outfall 2
Takes western part of development site
Total catchment area = 19,100m2

Swale 2a - catchment = 19,100-4,650 = 14,450m2
Swale 2b - catchment = 4,650m2

Total catchment area = 35,200+19,100 = 54,300m2

Notes

1. Do not scale from drawing. Not issued for construction
2. Location and exact alignment of drainage and water strategy requirements requires confirmation on site.
3. Surface water sewer and drainage locations are indicative only and not to be used for construction
4. Topographic site levels have been ulitised for development of this be subject to change based on development finishing and layout amendments.

TerraConsult

Bold Business Centre, Bold Lane, Sutton, St Helens WA9 4TX

Client

Site
The Oaks Wrexham

Title
Proposed Drainage Strategy

Scale	1:1,500 @ A1		
Drawing No.	TOW-TCL-HDG-XX-DR-D-0510		
Rev	Date	Description	
A	04/20	New Layout & Drainage Amendments	
B	10/20	Maintenance Access Routes Added	
C	04/21	Amendments	
File	TOW-TCL-HDG-XX-DR-D-0510 RevC.dwg		
Date	04/21	Engineer	TCL
Drawn	PP GH	Checked	Final

APPENDIX 7

Surface Water Calculations

Cascade Summary of Results for Pond 1 1-1 complex hydrobrakes control rev 01.SRCX

Upstream Structures	Outflow To	Overflow To
Swale 1a 1-1 Rev 01.SRCX	(None)	(None)
Swale 1b 1-1 Rev 01.SRCX		

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	24.059	0.059	2.6	242.2	O K
30 min Summer	24.078	0.078	4.3	319.8	O K
60 min Summer	24.100	0.100	6.7	408.1	O K
120 min Summer	24.123	0.123	9.5	504.2	O K
180 min Summer	24.136	0.136	11.2	559.7	O K
240 min Summer	24.145	0.145	12.2	595.8	O K
360 min Summer	24.154	0.154	13.4	636.7	O K
480 min Summer	24.161	0.161	14.1	662.4	O K
600 min Summer	24.165	0.165	14.6	682.5	O K
720 min Summer	24.169	0.169	15.0	698.3	O K
960 min Summer	24.174	0.174	15.6	719.8	O K
1440 min Summer	24.179	0.179	16.0	738.8	O K
2160 min Summer	24.179	0.179	16.0	737.9	O K
2880 min Summer	24.175	0.175	15.6	722.5	O K
4320 min Summer	24.165	0.165	14.6	682.5	O K
5760 min Summer	24.156	0.156	13.6	644.4	O K
7200 min Summer	24.148	0.148	12.7	611.6	O K
8640 min Summer	24.142	0.142	11.8	583.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	36.998	0.0	119.7	27
30 min Summer	24.589	0.0	179.9	41
60 min Summer	15.926	0.0	321.8	70
120 min Summer	10.157	0.0	429.8	126
180 min Summer	7.777	0.0	504.3	184
240 min Summer	6.430	0.0	563.3	242
360 min Summer	4.905	0.0	654.5	328
480 min Summer	4.025	0.0	721.6	382
600 min Summer	3.453	0.0	777.3	442
720 min Summer	3.046	0.0	825.1	506
960 min Summer	2.501	0.0	904.2	644
1440 min Summer	1.895	0.0	1020.1	914
2160 min Summer	1.437	0.0	1282.7	1308
2880 min Summer	1.179	0.0	1399.3	1704
4320 min Summer	0.893	0.0	1562.6	2464
5760 min Summer	0.734	0.0	1811.3	3184
7200 min Summer	0.631	0.0	1939.1	3960
8640 min Summer	0.557	0.0	2043.1	4672

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Cascade Summary of Results for Pond 1 1-1 complex hydrobrakes control rev 01.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
10080 min Summer	24.136	0.136	11.1	558.0	O K
15 min Winter	24.066	0.066	3.2	271.1	O K
30 min Winter	24.087	0.087	5.3	357.8	O K
60 min Winter	24.111	0.111	8.1	456.6	O K
120 min Winter	24.137	0.137	11.3	564.1	O K
180 min Winter	24.152	0.152	13.1	626.3	O K
240 min Winter	24.162	0.162	14.2	667.3	O K
360 min Winter	24.173	0.173	15.5	714.6	O K
480 min Winter	24.179	0.179	16.0	739.0	O K
600 min Winter	24.184	0.184	16.5	759.0	O K
720 min Winter	24.187	0.187	16.8	772.4	O K
960 min Winter	24.190	0.190	17.1	786.5	O K
1440 min Winter	24.190	0.190	17.1	787.2	O K
2160 min Winter	24.184	0.184	16.5	761.5	O K
2880 min Winter	24.176	0.176	15.7	726.4	O K
4320 min Winter	24.160	0.160	14.1	660.6	O K
5760 min Winter	24.148	0.148	12.6	608.1	O K
7200 min Winter	24.138	0.138	11.3	566.7	O K
8640 min Winter	24.130	0.130	10.4	533.1	O K
10080 min Winter	24.123	0.123	9.5	504.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Summer	0.501	0.0	2115.1	5360
15 min Winter	36.998	0.0	141.3	26
30 min Winter	24.589	0.0	210.7	40
60 min Winter	15.926	0.0	369.1	68
120 min Winter	10.157	0.0	491.0	124
180 min Winter	7.777	0.0	575.0	180
240 min Winter	6.430	0.0	641.5	236
360 min Winter	4.905	0.0	744.0	342
480 min Winter	4.025	0.0	819.6	388
600 min Winter	3.453	0.0	882.3	462
720 min Winter	3.046	0.0	936.1	538
960 min Winter	2.501	0.0	1025.5	690
1440 min Winter	1.895	0.0	1156.8	982
2160 min Winter	1.437	0.0	1444.9	1392
2880 min Winter	1.179	0.0	1576.6	1792
4320 min Winter	0.893	0.0	1762.8	2556
5760 min Winter	0.734	0.0	2034.1	3296
7200 min Winter	0.631	0.0	2178.3	4040
8640 min Winter	0.557	0.0	2296.6	4760
10080 min Winter	0.501	0.0	2380.7	5544

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Cascade Rainfall Details for Pond 1 1-1 complex hydrobrakes control rev 01.SRCX

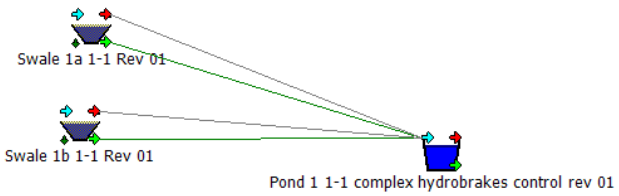
Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	1	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Shortest Storm (mins)	15
Ratio R	0.344	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.000

Time (mins) From:	To:	Area (ha)
0	4	0.000

Drained areas discharge to swales and swales discharge to pond.
Drained area to system = 0.868ha (swale 1a) + 2.652ha (swale 1b) = 3.52ha



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Cascade Model Details for Pond 1 1-1 complex hydrobrakes control rev 01.SRCX

Storage is Online Cover Level (m) 24.800

Tank or Pond Structure

Invert Level (m) 24.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	4060.0	0.700	4644.0	0.800	4864.0

Complex Outflow Control

Hydro-Brake® Optimum

Unit Reference	MD-SHE-0194-1760-0500-1760
Design Head (m)	0.500
Design Flow (l/s)	17.6
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	194
Invert Level (m)	24.000
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.500	17.6
Flush-Flo™	0.273	17.6
Kick-Flo®	0.423	16.3
Mean Flow over Head Range	-	13.3

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	6.7	1.200	26.7	3.000	41.5	7.000	62.5
0.200	17.2	1.400	28.8	3.500	44.8	7.500	64.8
0.300	17.6	1.600	30.7	4.000	47.8	8.000	66.9
0.400	16.7	1.800	32.5	4.500	50.6	8.500	69.0
0.500	17.6	2.000	34.2	5.000	53.2	9.000	71.0
0.600	19.2	2.200	35.8	5.500	55.3	9.500	73.0
0.800	22.0	2.400	37.3	6.000	57.8		
1.000	24.5	2.600	38.8	6.500	60.2		

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Hydro-Brake® Optimum

Unit Reference	MD-SHE-0224-2400-0350-2400
Design Head (m)	0.350
Design Flow (l/s)	24.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	224
Invert Level (m)	24.250
Minimum Outlet Pipe Diameter (mm)	300
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.350	24.0
Flush-Flo™	0.286	24.0
Kick-Flo®	0.340	23.7
Mean Flow over Head Range	-	15.2

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	7.5	1.200	43.3	3.000	67.6	7.000	102.2
0.200	22.3	1.400	46.7	3.500	72.8	7.500	105.9
0.300	23.9	1.600	49.8	4.000	76.8	8.000	109.4
0.400	25.6	1.800	52.7	4.500	81.6	8.500	112.8
0.500	28.5	2.000	55.5	5.000	86.1	9.000	116.1
0.600	31.0	2.200	58.1	5.500	90.4	9.500	119.3
0.800	35.6	2.400	60.6	6.000	94.5		
1.000	39.7	2.600	63.0	6.500	98.4		

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Cascade Summary of Results for Swale 1a 1-1 Rev 01.SRCX

Upstream Structures	Outflow To	Overflow To
(None)	Pond 1 1-1 complex hydrobrakes control rev 01.SRCX	Pond 1 1-1 complex hydrobrakes control rev (

Half Drain Time : 0 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	27.000	0.000	0.0	102.3	102.3	0.0	O K
30 min Summer	27.000	0.000	0.0	104.8	104.8	0.0	O K
60 min Summer	27.000	0.000	0.0	88.7	88.7	0.0	O K
120 min Summer	27.000	0.000	0.0	64.9	64.9	0.0	O K
180 min Summer	27.000	0.000	0.0	52.1	52.1	0.0	O K
240 min Summer	27.000	0.000	0.0	44.0	44.0	0.0	O K
360 min Summer	27.000	0.000	0.0	34.5	34.5	0.0	O K
480 min Summer	27.000	0.000	0.0	28.5	28.5	0.0	O K
600 min Summer	27.000	0.000	0.0	24.5	24.5	0.0	O K
720 min Summer	27.000	0.000	0.0	21.6	21.6	0.0	O K
960 min Summer	27.000	0.000	0.0	17.7	17.7	0.0	O K
1440 min Summer	27.000	0.000	0.0	13.4	13.4	0.0	O K
2160 min Summer	27.000	0.000	0.0	10.2	10.2	0.0	O K
2880 min Summer	27.000	0.000	0.0	8.4	8.4	0.0	O K
4320 min Summer	27.000	0.000	0.0	6.3	6.3	0.0	O K
5760 min Summer	27.000	0.000	0.0	5.2	5.2	0.0	O K
7200 min Summer	27.000	0.000	0.0	4.5	4.5	0.0	O K
8640 min Summer	27.000	0.000	0.0	4.0	4.0	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	36.998	0.0	60.2	0
30 min Summer	24.589	0.0	80.0	0
60 min Summer	15.926	0.0	103.7	0
120 min Summer	10.157	0.0	132.2	0
180 min Summer	7.777	0.0	151.9	0
240 min Summer	6.430	0.0	167.4	0
360 min Summer	4.905	0.0	191.6	0
480 min Summer	4.025	0.0	209.6	0
600 min Summer	3.453	0.0	224.8	0
720 min Summer	3.046	0.0	238.0	0
960 min Summer	2.501	0.0	260.5	0
1440 min Summer	1.895	0.0	296.1	0
2160 min Summer	1.437	0.0	336.7	0
2880 min Summer	1.179	0.0	368.4	0
4320 min Summer	0.893	0.0	418.7	0
5760 min Summer	0.734	0.0	458.8	0
7200 min Summer	0.631	0.0	492.9	0
8640 min Summer	0.557	0.0	522.5	0

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Cascade Summary of Results for Swale 1a 1-1 Rev 01.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
10080 min Summer	27.000	0.000	0.0	3.5	3.5	0.0	O K
15 min Winter	27.000	0.000	0.0	114.1	114.1	0.0	O K
30 min Winter	27.000	0.000	0.0	104.7	104.7	0.0	O K
60 min Winter	27.000	0.000	0.0	76.7	76.7	0.0	O K
120 min Winter	27.000	0.000	0.0	51.0	51.0	0.0	O K
180 min Winter	27.000	0.000	0.0	39.5	39.5	0.0	O K
240 min Winter	27.000	0.000	0.0	32.8	32.8	0.0	O K
360 min Winter	27.000	0.000	0.0	25.1	25.1	0.0	O K
480 min Winter	27.000	0.000	0.0	20.6	20.6	0.0	O K
600 min Winter	27.000	0.000	0.0	17.7	17.7	0.0	O K
720 min Winter	27.000	0.000	0.0	15.6	15.6	0.0	O K
960 min Winter	27.000	0.000	0.0	12.8	12.8	0.0	O K
1440 min Winter	27.000	0.000	0.0	9.7	9.7	0.0	O K
2160 min Winter	27.000	0.000	0.0	7.4	7.4	0.0	O K
2880 min Winter	27.000	0.000	0.0	6.0	6.0	0.0	O K
4320 min Winter	27.000	0.000	0.0	4.6	4.6	0.0	O K
5760 min Winter	27.000	0.000	0.0	3.8	3.8	0.0	O K
7200 min Winter	27.000	0.000	0.0	3.2	3.2	0.0	O K
8640 min Winter	27.000	0.000	0.0	2.9	2.9	0.0	O K
10080 min Winter	27.000	0.000	0.0	2.6	2.6	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Summer	0.501	0.0	547.4	0
15 min Winter	36.998	0.0	67.4	0
30 min Winter	24.589	0.0	89.6	0
60 min Winter	15.926	0.0	116.1	0
120 min Winter	10.157	0.0	148.1	0
180 min Winter	7.777	0.0	170.1	0
240 min Winter	6.430	0.0	187.5	0
360 min Winter	4.905	0.0	214.6	0
480 min Winter	4.025	0.0	234.8	0
600 min Winter	3.453	0.0	251.7	0
720 min Winter	3.046	0.0	266.5	0
960 min Winter	2.501	0.0	291.7	0
1440 min Winter	1.895	0.0	331.6	0
2160 min Winter	1.437	0.0	377.1	0
2880 min Winter	1.179	0.0	412.6	0
4320 min Winter	0.893	0.0	468.9	0
5760 min Winter	0.734	0.0	513.9	0
7200 min Winter	0.631	0.0	552.0	0
8640 min Winter	0.557	0.0	585.2	0
10080 min Winter	0.501	0.0	613.1	0

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Cascade Rainfall Details for Swale 1a 1-1 Rev 01.SRCX

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	1	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Shortest Storm (mins)	15
Ratio R	0.344	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.868

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.434	4	8	0.434

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Cascade Model Details for Swale 1a 1-1 Rev 01.SRCX

Storage is Online Cover Level (m) 28.000

Swale Structure

Infiltration Coefficient Base (m/hr)	0.00000	Length (m)	100.0
Infiltration Coefficient Side (m/hr)	0.00000	Side Slope (1:X)	3.0
Safety Factor	2.0	Slope (1:X)	50.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	27.000	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5		

Orifice Outflow Control

Diameter (m) 0.723 Discharge Coefficient 0.600 Invert Level (m) 25.400

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Cascade Summary of Results for Swale 1b 1-1 Rev 01.SRCX

Upstream Structures	Outflow To	Overflow To
(None)	Pond 1 1-1 complex hydrobrakes control rev 01.SRCX	Pond 1 1-1 complex hydrobrakes control rev (

Half Drain Time : 0 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	29.000	0.000	0.0	237.5	237.5	0.0	O K
30 min Summer	29.000	0.000	0.0	251.7	251.7	0.0	O K
60 min Summer	29.000	0.000	0.0	237.0	237.0	0.0	O K
120 min Summer	29.000	0.000	0.0	185.3	185.3	0.0	O K
180 min Summer	29.000	0.000	0.0	151.7	151.7	0.0	O K
240 min Summer	29.000	0.000	0.0	129.8	129.8	0.0	O K
360 min Summer	29.000	0.000	0.0	102.5	102.5	0.0	O K
480 min Summer	29.000	0.000	0.0	85.6	85.6	0.0	O K
600 min Summer	29.000	0.000	0.0	74.7	74.7	0.0	O K
720 min Summer	29.000	0.000	0.0	65.9	65.9	0.0	O K
960 min Summer	29.000	0.000	0.0	54.1	54.1	0.0	O K
1440 min Summer	29.000	0.000	0.0	41.0	41.0	0.0	O K
2160 min Summer	29.000	0.000	0.0	31.1	31.1	0.0	O K
2880 min Summer	29.000	0.000	0.0	25.5	25.5	0.0	O K
4320 min Summer	29.000	0.000	0.0	19.3	19.3	0.0	O K
5760 min Summer	29.000	0.000	0.0	15.9	15.9	0.0	O K
7200 min Summer	29.000	0.000	0.0	13.7	13.7	0.0	O K
8640 min Summer	29.000	0.000	0.0	12.1	12.1	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	36.998	0.0	183.8	0
30 min Summer	24.589	0.0	244.4	0
60 min Summer	15.926	0.0	316.5	0
120 min Summer	10.157	0.0	403.8	0
180 min Summer	7.777	0.0	463.7	0
240 min Summer	6.430	0.0	511.2	0
360 min Summer	4.905	0.0	584.9	0
480 min Summer	4.025	0.0	640.0	0
600 min Summer	3.453	0.0	686.2	0
720 min Summer	3.046	0.0	726.6	0
960 min Summer	2.501	0.0	795.3	0
1440 min Summer	1.895	0.0	903.9	0
2160 min Summer	1.437	0.0	1027.8	0
2880 min Summer	1.179	0.0	1124.7	0
4320 min Summer	0.893	0.0	1278.2	0
5760 min Summer	0.734	0.0	1400.8	0
7200 min Summer	0.631	0.0	1504.8	0
8640 min Summer	0.557	0.0	1595.3	0

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Cascade Summary of Results for Swale 1b 1-1 Rev 01.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
10080 min Summer	29.000	0.000	0.0	10.8	10.8	0.0	O K
15 min Winter	29.000	0.000	0.0	268.6	268.6	0.0	O K
30 min Winter	29.000	0.000	0.0	273.7	273.7	0.0	O K
60 min Winter	29.000	0.000	0.0	221.6	221.6	0.0	O K
120 min Winter	29.000	0.000	0.0	153.0	153.0	0.0	O K
180 min Winter	29.000	0.000	0.0	119.3	119.3	0.0	O K
240 min Winter	29.000	0.000	0.0	99.4	99.4	0.0	O K
360 min Winter	29.000	0.000	0.0	76.3	76.3	0.0	O K
480 min Winter	29.000	0.000	0.0	62.8	62.8	0.0	O K
600 min Winter	29.000	0.000	0.0	54.0	54.0	0.0	O K
720 min Winter	29.000	0.000	0.0	47.6	47.6	0.0	O K
960 min Winter	29.000	0.000	0.0	39.1	39.1	0.0	O K
1440 min Winter	29.000	0.000	0.0	29.6	29.6	0.0	O K
2160 min Winter	29.000	0.000	0.0	22.5	22.5	0.0	O K
2880 min Winter	29.000	0.000	0.0	18.4	18.4	0.0	O K
4320 min Winter	29.000	0.000	0.0	14.0	14.0	0.0	O K
5760 min Winter	29.000	0.000	0.0	11.5	11.5	0.0	O K
7200 min Winter	29.000	0.000	0.0	9.9	9.9	0.0	O K
8640 min Winter	29.000	0.000	0.0	8.7	8.7	0.0	O K
10080 min Winter	29.000	0.000	0.0	7.8	7.8	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Summer	0.501	0.0	1671.3	0
15 min Winter	36.998	0.0	205.9	0
30 min Winter	24.589	0.0	273.7	0
60 min Winter	15.926	0.0	354.5	0
120 min Winter	10.157	0.0	452.2	0
180 min Winter	7.777	0.0	519.3	0
240 min Winter	6.430	0.0	572.5	0
360 min Winter	4.905	0.0	655.1	0
480 min Winter	4.025	0.0	716.8	0
600 min Winter	3.453	0.0	768.6	0
720 min Winter	3.046	0.0	813.8	0
960 min Winter	2.501	0.0	890.7	0
1440 min Winter	1.895	0.0	1012.4	0
2160 min Winter	1.437	0.0	1151.2	0
2880 min Winter	1.179	0.0	1259.6	0
4320 min Winter	0.893	0.0	1431.6	0
5760 min Winter	0.734	0.0	1568.9	0
7200 min Winter	0.631	0.0	1685.3	0
8640 min Winter	0.557	0.0	1786.7	0
10080 min Winter	0.501	0.0	1871.8	0

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Cascade Rainfall Details for Swale 1b 1-1 Rev 01.SRCX

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	1	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Shortest Storm (mins)	15
Ratio R	0.344	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 2.650

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.883	4	8	0.883	8	12	0.884

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Cascade Model Details for Swale 1b 1-1 Rev 01.SRCX

Storage is Online Cover Level (m) 30.000

Swale Structure

Infiltration Coefficient Base (m/hr)	0.00000	Length (m)	190.0
Infiltration Coefficient Side (m/hr)	0.00000	Side Slope (1:X)	3.0
Safety Factor	2.0	Slope (1:X)	40.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	29.000	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5		

Orifice Outflow Control

Diameter (m) 0.723 Discharge Coefficient 0.600 Invert Level (m) 24.100

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Cascade Summary of Results for Pond 1 1-30 complex hydrobrakes control rev 01.SRCX

Upstream Structures	Outflow To	Overflow To
Swale 1a 1-30 rev 01.SRCX	(None)	(None)
Swale 1b 1-30 rev 01.SRCX		

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	24.143	0.143	12.0	588.2	O K
30 min Summer	24.188	0.188	16.9	778.0	O K
60 min Summer	24.237	0.237	17.5	983.3	O K
120 min Summer	24.286	0.286	18.7	1196.1	O K
180 min Summer	24.313	0.313	20.7	1311.2	O K
240 min Summer	24.329	0.329	22.3	1380.1	O K
360 min Summer	24.345	0.345	24.1	1447.9	O K
480 min Summer	24.352	0.352	25.0	1478.0	O K
600 min Summer	24.357	0.357	25.6	1500.4	O K
720 min Summer	24.360	0.360	26.1	1516.6	O K
960 min Summer	24.365	0.365	26.7	1535.6	O K
1440 min Summer	24.365	0.365	26.8	1538.1	O K
2160 min Summer	24.357	0.357	25.7	1502.5	O K
2880 min Summer	24.345	0.345	24.2	1450.7	O K
4320 min Summer	24.319	0.319	21.3	1336.7	O K
5760 min Summer	24.292	0.292	19.1	1222.2	O K
7200 min Summer	24.266	0.266	17.8	1106.9	O K
8640 min Summer	24.240	0.240	17.5	995.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	90.472	0.0	407.4	26
30 min Summer	60.426	0.0	581.9	40
60 min Summer	38.715	0.0	896.8	70
120 min Summer	24.112	0.0	1135.3	128
180 min Summer	18.086	0.0	1285.6	186
240 min Summer	14.679	0.0	1396.2	244
360 min Summer	10.878	0.0	1557.4	360
480 min Summer	8.795	0.0	1681.0	422
600 min Summer	7.453	0.0	1780.4	480
720 min Summer	6.508	0.0	1863.5	540
960 min Summer	5.250	0.0	1995.9	670
1440 min Summer	3.874	0.0	2172.3	942
2160 min Summer	2.854	0.0	2612.6	1360
2880 min Summer	2.296	0.0	2794.1	1764
4320 min Summer	1.688	0.0	3038.7	2560
5760 min Summer	1.355	0.0	3381.3	3352
7200 min Summer	1.143	0.0	3555.0	4112
8640 min Summer	0.994	0.0	3693.8	4840

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Cascade Summary of Results for Pond 1 1-30 complex hydrobrakes control rev 01.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
10080 min Summer	24.218	0.218	17.4	903.7	O K
15 min Winter	24.160	0.160	14.0	658.5	O K
30 min Winter	24.210	0.210	17.3	872.3	O K
60 min Winter	24.265	0.265	17.8	1104.9	O K
120 min Winter	24.320	0.320	21.4	1342.4	O K
180 min Winter	24.350	0.350	24.7	1468.8	O K
240 min Winter	24.367	0.367	27.0	1543.5	O K
360 min Winter	24.383	0.383	29.2	1617.0	O K
480 min Winter	24.390	0.390	30.2	1646.1	O K
600 min Winter	24.395	0.395	30.9	1665.4	O K
720 min Winter	24.398	0.398	31.3	1679.6	O K
960 min Winter	24.399	0.399	31.5	1687.1	O K
1440 min Winter	24.393	0.393	30.7	1659.7	O K
2160 min Winter	24.376	0.376	28.3	1584.3	O K
2880 min Winter	24.357	0.357	25.7	1501.5	O K
4320 min Winter	24.319	0.319	21.3	1338.7	O K
5760 min Winter	24.281	0.281	18.4	1172.3	O K
7200 min Winter	24.239	0.239	17.5	992.5	O K
8640 min Winter	24.205	0.205	17.2	848.9	O K
10080 min Winter	24.185	0.185	16.6	763.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Summer	0.884	0.0	3797.5	5544
15 min Winter	90.472	0.0	469.8	26
30 min Winter	60.426	0.0	665.5	40
60 min Winter	38.715	0.0	1014.1	68
120 min Winter	24.112	0.0	1281.3	124
180 min Winter	18.086	0.0	1450.3	182
240 min Winter	14.679	0.0	1574.8	238
360 min Winter	10.878	0.0	1756.3	348
480 min Winter	8.795	0.0	1895.4	448
600 min Winter	7.453	0.0	2007.4	478
720 min Winter	6.508	0.0	2101.0	552
960 min Winter	5.250	0.0	2250.0	706
1440 min Winter	3.874	0.0	2447.8	1004
2160 min Winter	2.854	0.0	2935.1	1436
2880 min Winter	2.296	0.0	3138.1	1876
4320 min Winter	1.688	0.0	3414.5	2728
5760 min Winter	1.355	0.0	3792.8	3576
7200 min Winter	1.143	0.0	3989.0	4320
8640 min Winter	0.994	0.0	4147.1	4928
10080 min Winter	0.884	0.0	4268.7	5552

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Cascade Rainfall Details for Pond 1 1-30 complex hydrobrakes control rev 01.SRCX

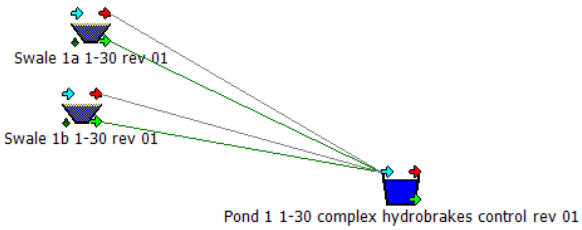
Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Shortest Storm (mins)	15
Ratio R	0.344	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.000

Time (mins) From:	To:	Area (ha)
0	4	0.000

Drained areas discharge to swales and swales discharge to pond.
Drained area to system = 0.868ha (swale 1a) + 2.652ha (swale 1b) = 3.52ha



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Cascade Model Details for Pond 1 1-30 complex hydrobrakes control rev 01.SRCX

Storage is Online Cover Level (m) 24.800

Tank or Pond Structure

Invert Level (m) 24.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	4060.0	0.700	4644.0	0.800	4864.0

Complex Outflow Control

Hydro-Brake® Optimum

Unit Reference	MD-SHE-0194-1760-0500-1760
Design Head (m)	0.500
Design Flow (l/s)	17.6
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	194
Invert Level (m)	24.000
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.500	17.6
Flush-Flo™	0.273	17.6
Kick-Flo®	0.423	16.3
Mean Flow over Head Range	-	13.3

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	6.7	1.200	26.7	3.000	41.5	7.000	62.5
0.200	17.2	1.400	28.8	3.500	44.8	7.500	64.8
0.300	17.6	1.600	30.7	4.000	47.8	8.000	66.9
0.400	16.7	1.800	32.5	4.500	50.6	8.500	69.0
0.500	17.6	2.000	34.2	5.000	53.2	9.000	71.0
0.600	19.2	2.200	35.8	5.500	55.3	9.500	73.0
0.800	22.0	2.400	37.3	6.000	57.8		
1.000	24.5	2.600	38.8	6.500	60.2		

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Hydro-Brake® Optimum

Unit Reference	MD-SHE-0224-2400-0350-2400
Design Head (m)	0.350
Design Flow (l/s)	24.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	224
Invert Level (m)	24.250
Minimum Outlet Pipe Diameter (mm)	300
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.350	24.0
Flush-Flo™	0.286	24.0
Kick-Flo®	0.340	23.7
Mean Flow over Head Range	-	15.2

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	7.5	1.200	43.3	3.000	67.6	7.000	102.2
0.200	22.3	1.400	46.7	3.500	72.8	7.500	105.9
0.300	23.9	1.600	49.8	4.000	76.8	8.000	109.4
0.400	25.6	1.800	52.7	4.500	81.6	8.500	112.8
0.500	28.5	2.000	55.5	5.000	86.1	9.000	116.1
0.600	31.0	2.200	58.1	5.500	90.4	9.500	119.3
0.800	35.6	2.400	60.6	6.000	94.5		
1.000	39.7	2.600	63.0	6.500	98.4		

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Cascade Summary of Results for Swale 1a 1-30 rev 01.SRCX

Upstream Structures	Outflow To	Overflow To
(None)	Pond 1 1-30 complex hydrobrakes control rev 01.SRCX	Pond 1 1-30 complex hydrobrakes control rev

Half Drain Time : 0 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	27.000	0.000	0.0	250.3	250.3	0.0	O K
30 min Summer	27.000	0.000	0.0	257.6	257.6	0.0	O K
60 min Summer	27.000	0.000	0.0	215.7	215.7	0.0	O K
120 min Summer	27.000	0.000	0.0	154.1	154.1	0.0	O K
180 min Summer	27.000	0.000	0.0	121.1	121.1	0.0	O K
240 min Summer	27.000	0.000	0.0	100.4	100.4	0.0	O K
360 min Summer	27.000	0.000	0.0	76.4	76.4	0.0	O K
480 min Summer	27.000	0.000	0.0	62.3	62.3	0.0	O K
600 min Summer	27.000	0.000	0.0	52.8	52.8	0.0	O K
720 min Summer	27.000	0.000	0.0	46.1	46.1	0.0	O K
960 min Summer	27.000	0.000	0.0	37.2	37.2	0.0	O K
1440 min Summer	27.000	0.000	0.0	27.5	27.5	0.0	O K
2160 min Summer	27.000	0.000	0.0	20.2	20.2	0.0	O K
2880 min Summer	27.000	0.000	0.0	16.3	16.3	0.0	O K
4320 min Summer	27.000	0.000	0.0	12.0	12.0	0.0	O K
5760 min Summer	27.000	0.000	0.0	9.6	9.6	0.0	O K
7200 min Summer	27.000	0.000	0.0	8.1	8.1	0.0	O K
8640 min Summer	27.000	0.000	0.0	7.0	7.0	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	90.472	0.0	147.2	0
30 min Summer	60.426	0.0	196.7	0
60 min Summer	38.715	0.0	252.0	0
120 min Summer	24.112	0.0	313.9	0
180 min Summer	18.086	0.0	353.2	0
240 min Summer	14.679	0.0	382.2	0
360 min Summer	10.878	0.0	424.9	0
480 min Summer	8.795	0.0	458.1	0
600 min Summer	7.453	0.0	485.2	0
720 min Summer	6.508	0.0	508.4	0
960 min Summer	5.250	0.0	546.8	0
1440 min Summer	3.874	0.0	605.3	0
2160 min Summer	2.854	0.0	668.9	0
2880 min Summer	2.296	0.0	717.5	0
4320 min Summer	1.688	0.0	791.0	0
5760 min Summer	1.355	0.0	847.0	0
7200 min Summer	1.143	0.0	892.8	0
8640 min Summer	0.994	0.0	931.9	0

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Cascade Summary of Results for Swale 1a 1-30 rev 01.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
10080 min Summer	27.000	0.000	0.0	6.3	6.3	0.0	O K
15 min Winter	27.000	0.000	0.0	278.9	278.9	0.0	O K
30 min Winter	27.000	0.000	0.0	257.3	257.3	0.0	O K
60 min Winter	27.000	0.000	0.0	186.5	186.5	0.0	O K
120 min Winter	27.000	0.000	0.0	121.1	121.1	0.0	O K
180 min Winter	27.000	0.000	0.0	91.8	91.8	0.0	O K
240 min Winter	27.000	0.000	0.0	74.8	74.8	0.0	O K
360 min Winter	27.000	0.000	0.0	55.6	55.6	0.0	O K
480 min Winter	27.000	0.000	0.0	45.1	45.1	0.0	O K
600 min Winter	27.000	0.000	0.0	38.2	38.2	0.0	O K
720 min Winter	27.000	0.000	0.0	33.3	33.3	0.0	O K
960 min Winter	27.000	0.000	0.0	26.9	26.9	0.0	O K
1440 min Winter	27.000	0.000	0.0	19.8	19.8	0.0	O K
2160 min Winter	27.000	0.000	0.0	14.6	14.6	0.0	O K
2880 min Winter	27.000	0.000	0.0	11.8	11.8	0.0	O K
4320 min Winter	27.000	0.000	0.0	8.6	8.6	0.0	O K
5760 min Winter	27.000	0.000	0.0	6.9	6.9	0.0	O K
7200 min Winter	27.000	0.000	0.0	5.9	5.9	0.0	O K
8640 min Winter	27.000	0.000	0.0	5.1	5.1	0.0	O K
10080 min Winter	27.000	0.000	0.0	4.5	4.5	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Summer	0.884	0.0	966.8	0
15 min Winter	90.472	0.0	164.9	0
30 min Winter	60.426	0.0	220.3	0
60 min Winter	38.715	0.0	282.3	0
120 min Winter	24.112	0.0	351.6	0
180 min Winter	18.086	0.0	395.6	0
240 min Winter	14.679	0.0	428.1	0
360 min Winter	10.878	0.0	475.9	0
480 min Winter	8.795	0.0	513.0	0
600 min Winter	7.453	0.0	543.4	0
720 min Winter	6.508	0.0	569.4	0
960 min Winter	5.250	0.0	612.5	0
1440 min Winter	3.874	0.0	677.9	0
2160 min Winter	2.854	0.0	749.2	0
2880 min Winter	2.296	0.0	803.6	0
4320 min Winter	1.688	0.0	885.9	0
5760 min Winter	1.355	0.0	948.7	0
7200 min Winter	1.143	0.0	999.9	0
8640 min Winter	0.994	0.0	1043.7	0
10080 min Winter	0.884	0.0	1082.8	0

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Cascade Rainfall Details for Swale 1a 1-30 rev 01.SRCX

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Shortest Storm (mins)	15
Ratio R	0.344	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.868

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.434	4	8	0.434

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Cascade Model Details for Swale 1a 1-30 rev 01.SRCX

Storage is Online Cover Level (m) 28.000

Swale Structure

Infiltration Coefficient Base (m/hr)	0.00000	Length (m)	100.0
Infiltration Coefficient Side (m/hr)	0.00000	Side Slope (1:X)	3.0
Safety Factor	2.0	Slope (1:X)	50.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	27.000	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5		

Orifice Outflow Control

Diameter (m) 0.723 Discharge Coefficient 0.600 Invert Level (m) 25.400

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Cascade Summary of Results for Swale 1b 1-30 rev 01.SRCX

Upstream Structures	Outflow To	Overflow To
(None)	Pond 1 1-30 complex hydrobrakes control rev 01.SRCX	Pond 1 1-30 complex hydrobrakes control rev

Half Drain Time : 0 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	29.000	0.000	0.0	580.8	580.8	0.0	O K
30 min Summer	29.000	0.000	0.0	618.6	618.6	0.0	O K
60 min Summer	29.000	0.000	0.0	576.2	576.2	0.0	O K
120 min Summer	29.000	0.000	0.0	439.8	439.8	0.0	O K
180 min Summer	29.000	0.000	0.0	352.9	352.9	0.0	O K
240 min Summer	29.000	0.000	0.0	296.3	296.3	0.0	O K
360 min Summer	29.000	0.000	0.0	227.3	227.3	0.0	O K
480 min Summer	29.000	0.000	0.0	187.0	187.0	0.0	O K
600 min Summer	29.000	0.000	0.0	161.3	161.3	0.0	O K
720 min Summer	29.000	0.000	0.0	140.8	140.8	0.0	O K
960 min Summer	29.000	0.000	0.0	113.6	113.6	0.0	O K
1440 min Summer	29.000	0.000	0.0	83.8	83.8	0.0	O K
2160 min Summer	29.000	0.000	0.0	61.8	61.8	0.0	O K
2880 min Summer	29.000	0.000	0.0	49.7	49.7	0.0	O K
4320 min Summer	29.000	0.000	0.0	36.5	36.5	0.0	O K
5760 min Summer	29.000	0.000	0.0	29.3	29.3	0.0	O K
7200 min Summer	29.000	0.000	0.0	24.7	24.7	0.0	O K
8640 min Summer	29.000	0.000	0.0	21.5	21.5	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	90.472	0.0	449.5	0
30 min Summer	60.426	0.0	600.5	0
60 min Summer	38.715	0.0	769.5	0
120 min Summer	24.112	0.0	958.5	0
180 min Summer	18.086	0.0	1078.4	0
240 min Summer	14.679	0.0	1166.9	0
360 min Summer	10.878	0.0	1297.3	0
480 min Summer	8.795	0.0	1398.4	0
600 min Summer	7.453	0.0	1481.3	0
720 min Summer	6.508	0.0	1552.1	0
960 min Summer	5.250	0.0	1669.5	0
1440 min Summer	3.874	0.0	1847.8	0
2160 min Summer	2.854	0.0	2042.2	0
2880 min Summer	2.296	0.0	2190.4	0
4320 min Summer	1.688	0.0	2415.0	0
5760 min Summer	1.355	0.0	2586.0	0
7200 min Summer	1.143	0.0	2725.7	0
8640 min Summer	0.994	0.0	2845.0	0

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Cascade Summary of Results for Swale 1b 1-30 rev 01.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
10080 min Summer	29.000	0.000	0.0	19.1	19.1	0.0	O K
15 min Winter	29.000	0.000	0.0	656.8	656.8	0.0	O K
30 min Winter	29.000	0.000	0.0	672.5	672.5	0.0	O K
60 min Winter	29.000	0.000	0.0	538.6	538.6	0.0	O K
120 min Winter	29.000	0.000	0.0	363.1	363.1	0.0	O K
180 min Winter	29.000	0.000	0.0	277.3	277.3	0.0	O K
240 min Winter	29.000	0.000	0.0	226.8	226.8	0.0	O K
360 min Winter	29.000	0.000	0.0	169.2	169.2	0.0	O K
480 min Winter	29.000	0.000	0.0	137.2	137.2	0.0	O K
600 min Winter	29.000	0.000	0.0	116.6	116.6	0.0	O K
720 min Winter	29.000	0.000	0.0	101.8	101.8	0.0	O K
960 min Winter	29.000	0.000	0.0	82.1	82.1	0.0	O K
1440 min Winter	29.000	0.000	0.0	60.6	60.6	0.0	O K
2160 min Winter	29.000	0.000	0.0	44.6	44.6	0.0	O K
2880 min Winter	29.000	0.000	0.0	35.9	35.9	0.0	O K
4320 min Winter	29.000	0.000	0.0	26.4	26.4	0.0	O K
5760 min Winter	29.000	0.000	0.0	21.2	21.2	0.0	O K
7200 min Winter	29.000	0.000	0.0	17.9	17.9	0.0	O K
8640 min Winter	29.000	0.000	0.0	15.5	15.5	0.0	O K
10080 min Winter	29.000	0.000	0.0	13.8	13.8	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Summer	0.884	0.0	2951.6	0
15 min Winter	90.472	0.0	503.5	0
30 min Winter	60.426	0.0	672.5	0
60 min Winter	38.715	0.0	861.8	0
120 min Winter	24.112	0.0	1073.5	0
180 min Winter	18.086	0.0	1207.8	0
240 min Winter	14.679	0.0	1307.0	0
360 min Winter	10.878	0.0	1452.9	0
480 min Winter	8.795	0.0	1566.3	0
600 min Winter	7.453	0.0	1659.1	0
720 min Winter	6.508	0.0	1738.3	0
960 min Winter	5.250	0.0	1869.9	0
1440 min Winter	3.874	0.0	2069.6	0
2160 min Winter	2.854	0.0	2287.2	0
2880 min Winter	2.296	0.0	2453.3	0
4320 min Winter	1.688	0.0	2704.8	0
5760 min Winter	1.355	0.0	2896.3	0
7200 min Winter	1.143	0.0	3052.7	0
8640 min Winter	0.994	0.0	3186.4	0
10080 min Winter	0.884	0.0	3305.8	0

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Cascade Rainfall Details for Swale 1b 1-30 rev 01.SRCX

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Shortest Storm (mins)	15
Ratio R	0.344	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 2.650

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.883	4	8	0.883	8	12	0.884

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Cascade Model Details for Swale 1b 1-30 rev 01.SRCX

Storage is Online Cover Level (m) 30.000

Swale Structure

Infiltration Coefficient Base (m/hr)	0.00000	Length (m)	190.0
Infiltration Coefficient Side (m/hr)	0.00000	Side Slope (1:X)	3.0
Safety Factor	2.0	Slope (1:X)	40.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	29.000	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5		

Orifice Outflow Control

Diameter (m) 0.723 Discharge Coefficient 0.600 Invert Level (m) 24.100

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Cascade Summary of Results for Pond 1 1-100 complex hydrobrakes control rev 01.SRCX

Upstream Structures	Outflow To	Overflow To
Swale 1b 1-100 rev 01.SRCX	(None)	(None)
Swale 1a 1-100 rev 01.SRCX		

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	24.183	0.183	16.4	757.9	O K
30 min Summer	24.244	0.244	17.5	1016.2	O K
60 min Summer	24.310	0.310	20.4	1296.2	O K
120 min Summer	24.373	0.373	27.8	1570.5	O K
180 min Summer	24.404	0.404	32.1	1706.1	O K
240 min Summer	24.420	0.420	34.4	1779.0	O K
360 min Summer	24.433	0.433	36.5	1835.4	O K
480 min Summer	24.440	0.440	37.6	1867.4	O K
600 min Summer	24.445	0.445	38.3	1889.5	O K
720 min Summer	24.449	0.449	38.8	1904.2	O K
960 min Summer	24.451	0.451	39.2	1915.6	O K
1440 min Summer	24.447	0.447	38.6	1898.1	O K
2160 min Summer	24.433	0.433	36.4	1833.2	O K
2880 min Summer	24.416	0.416	33.8	1758.0	O K
4320 min Summer	24.383	0.383	29.2	1614.4	O K
5760 min Summer	24.355	0.355	25.4	1491.0	O K
7200 min Summer	24.330	0.330	22.4	1382.1	O K
8640 min Summer	24.306	0.306	20.1	1278.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	116.739	0.0	559.0	26
30 min Summer	78.763	0.0	790.9	41
60 min Summer	50.812	0.0	1202.1	70
120 min Summer	31.715	0.0	1520.0	126
180 min Summer	23.742	0.0	1716.4	184
240 min Summer	19.206	0.0	1856.7	242
360 min Summer	14.133	0.0	2054.7	342
480 min Summer	11.375	0.0	2206.6	392
600 min Summer	9.604	0.0	2327.8	452
720 min Summer	8.359	0.0	2428.1	514
960 min Summer	6.708	0.0	2586.2	650
1440 min Summer	4.910	0.0	2790.7	924
2160 min Summer	3.587	0.0	3303.2	1328
2880 min Summer	2.866	0.0	3508.2	1732
4320 min Summer	2.086	0.0	3779.2	2516
5760 min Summer	1.662	0.0	4157.4	3304
7200 min Summer	1.393	0.0	4345.2	4112
8640 min Summer	1.205	0.0	4494.0	4920

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Cascade Summary of Results for Pond 1 1-100 complex hydrobrakes control rev 01.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
10080 min Summer	24.282	0.282	18.5	1178.8	O K
15 min Winter	24.205	0.205	17.2	849.1	O K
30 min Winter	24.273	0.273	18.1	1140.2	O K
60 min Winter	24.346	0.346	24.2	1452.1	O K
120 min Winter	24.415	0.415	33.7	1756.1	O K
180 min Winter	24.449	0.449	38.9	1906.5	O K
240 min Winter	24.468	0.468	40.5	1988.5	O K
360 min Winter	24.485	0.485	41.0	2063.4	O K
480 min Winter	24.491	0.491	41.2	2090.8	O K
600 min Winter	24.496	0.496	41.3	2112.9	O K
720 min Winter	24.498	0.498	41.4	2122.7	O K
960 min Winter	24.496	0.496	41.3	2115.1	O K
1440 min Winter	24.481	0.481	40.9	2047.2	O K
2160 min Winter	24.452	0.452	39.3	1919.0	O K
2880 min Winter	24.427	0.427	35.4	1807.5	O K
4320 min Winter	24.383	0.383	29.2	1615.9	O K
5760 min Winter	24.347	0.347	24.4	1460.0	O K
7200 min Winter	24.315	0.315	20.9	1317.5	O K
8640 min Winter	24.280	0.280	18.4	1167.0	O K
10080 min Winter	24.240	0.240	17.5	998.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Summer	1.068	0.0	4605.5	5656
15 min Winter	116.739	0.0	640.1	26
30 min Winter	78.763	0.0	895.1	40
60 min Winter	50.812	0.0	1356.4	68
120 min Winter	31.715	0.0	1714.1	124
180 min Winter	23.742	0.0	1934.9	180
240 min Winter	19.206	0.0	2092.6	238
360 min Winter	14.133	0.0	2314.6	346
480 min Winter	11.375	0.0	2484.7	438
600 min Winter	9.604	0.0	2620.3	474
720 min Winter	8.359	0.0	2732.7	550
960 min Winter	6.708	0.0	2910.5	702
1440 min Winter	4.910	0.0	3141.2	996
2160 min Winter	3.587	0.0	3709.5	1408
2880 min Winter	2.866	0.0	3939.4	1824
4320 min Winter	2.086	0.0	4242.1	2644
5760 min Winter	1.662	0.0	4662.0	3472
7200 min Winter	1.393	0.0	4874.1	4328
8640 min Winter	1.205	0.0	5043.8	5184
10080 min Winter	1.068	0.0	5175.1	5856

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Cascade Rainfall Details for Pond 1 1-100 complex hydrobrakes control rev 01.SRCX

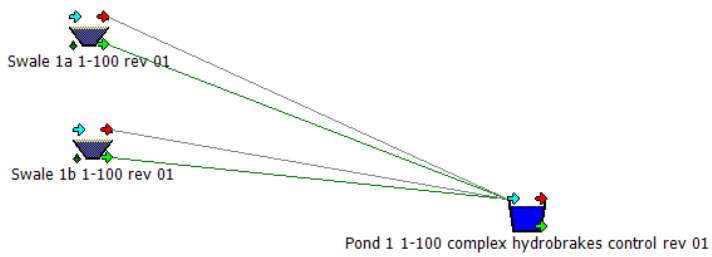
Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Shortest Storm (mins)	15
Ratio R	0.344	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.000

Time (mins) From:	To:	Area (ha)
0	4	0.000

Drained areas discharge to swales and swales discharge to pond.
Drained area to system = 0.868ha (swale 1a) + 2.652ha (swale 1b) = 3.52ha



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Cascade Model Details for Pond 1 1-100 complex hydrobrakes control rev 01.SRCX

Storage is Online Cover Level (m) 24.800

Tank or Pond Structure

Invert Level (m) 24.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	4060.0	0.700	4644.0	0.800	4864.0

Complex Outflow Control

Hydro-Brake® Optimum

Unit Reference	MD-SHE-0194-1760-0500-1760
Design Head (m)	0.500
Design Flow (l/s)	17.6
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	194
Invert Level (m)	24.000
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.500	17.6
Flush-Flo™	0.273	17.6
Kick-Flo®	0.423	16.3
Mean Flow over Head Range	-	13.3

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	6.7	1.200	26.7	3.000	41.5	7.000	62.5
0.200	17.2	1.400	28.8	3.500	44.8	7.500	64.8
0.300	17.6	1.600	30.7	4.000	47.8	8.000	66.9
0.400	16.7	1.800	32.5	4.500	50.6	8.500	69.0
0.500	17.6	2.000	34.2	5.000	53.2	9.000	71.0
0.600	19.2	2.200	35.8	5.500	55.3	9.500	73.0
0.800	22.0	2.400	37.3	6.000	57.8		
1.000	24.5	2.600	38.8	6.500	60.2		

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Hydro-Brake® Optimum

Unit Reference	MD-SHE-0224-2400-0350-2400
Design Head (m)	0.350
Design Flow (l/s)	24.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	224
Invert Level (m)	24.250
Minimum Outlet Pipe Diameter (mm)	300
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.350	24.0
Flush-Flo™	0.286	24.0
Kick-Flo®	0.340	23.7
Mean Flow over Head Range	-	15.2

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	7.5	1.200	43.3	3.000	67.6	7.000	102.2
0.200	22.3	1.400	46.7	3.500	72.8	7.500	105.9
0.300	23.9	1.600	49.8	4.000	76.8	8.000	109.4
0.400	25.6	1.800	52.7	4.500	81.6	8.500	112.8
0.500	28.5	2.000	55.5	5.000	86.1	9.000	116.1
0.600	31.0	2.200	58.1	5.500	90.4	9.500	119.3
0.800	35.6	2.400	60.6	6.000	94.5		
1.000	39.7	2.600	63.0	6.500	98.4		

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Cascade Summary of Results for Swale 1a 1-100 rev 01.SRCX

Upstream Structures	Outflow To	Overflow To
(None)	Pond 1 1-100 complex hydrobrakes control rev 01.SRCX	Pond 1 1-100 complex hydrobrakes control r

Half Drain Time : 0 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	27.000	0.000	0.0	322.9	322.9	0.0	O K
30 min Summer	27.000	0.000	0.0	335.8	335.8	0.0	O K
60 min Summer	27.000	0.000	0.0	283.1	283.1	0.0	O K
120 min Summer	27.000	0.000	0.0	202.7	202.7	0.0	O K
180 min Summer	27.000	0.000	0.0	159.0	159.0	0.0	O K
240 min Summer	27.000	0.000	0.0	131.4	131.4	0.0	O K
360 min Summer	27.000	0.000	0.0	99.3	99.3	0.0	O K
480 min Summer	27.000	0.000	0.0	80.6	80.6	0.0	O K
600 min Summer	27.000	0.000	0.0	68.1	68.1	0.0	O K
720 min Summer	27.000	0.000	0.0	59.3	59.3	0.0	O K
960 min Summer	27.000	0.000	0.0	47.6	47.6	0.0	O K
1440 min Summer	27.000	0.000	0.0	34.8	34.8	0.0	O K
2160 min Summer	27.000	0.000	0.0	25.4	25.4	0.0	O K
2880 min Summer	27.000	0.000	0.0	20.3	20.3	0.0	O K
4320 min Summer	27.000	0.000	0.0	14.8	14.8	0.0	O K
5760 min Summer	27.000	0.000	0.0	11.8	11.8	0.0	O K
7200 min Summer	27.000	0.000	0.0	9.9	9.9	0.0	O K
8640 min Summer	27.000	0.000	0.0	8.5	8.5	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	116.739	0.0	190.0	0
30 min Summer	78.763	0.0	256.4	0
60 min Summer	50.812	0.0	330.8	0
120 min Summer	31.715	0.0	412.9	0
180 min Summer	23.742	0.0	463.7	0
240 min Summer	19.206	0.0	500.1	0
360 min Summer	14.133	0.0	552.1	0
480 min Summer	11.375	0.0	592.4	0
600 min Summer	9.604	0.0	625.2	0
720 min Summer	8.359	0.0	653.0	0
960 min Summer	6.708	0.0	698.7	0
1440 min Summer	4.910	0.0	767.2	0
2160 min Summer	3.587	0.0	840.5	0
2880 min Summer	2.866	0.0	895.6	0
4320 min Summer	2.086	0.0	977.5	0
5760 min Summer	1.662	0.0	1038.8	0
7200 min Summer	1.393	0.0	1088.2	0
8640 min Summer	1.205	0.0	1130.1	0

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Cascade Summary of Results for Swale 1a 1-100 rev 01.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
10080 min Summer	27.000	0.000	0.0	7.6	7.6	0.0	O K
15 min Winter	27.000	0.000	0.0	359.9	359.9	0.0	O K
30 min Winter	27.000	0.000	0.0	335.4	335.4	0.0	O K
60 min Winter	27.000	0.000	0.0	244.8	244.8	0.0	O K
120 min Winter	27.000	0.000	0.0	159.3	159.3	0.0	O K
180 min Winter	27.000	0.000	0.0	120.5	120.5	0.0	O K
240 min Winter	27.000	0.000	0.0	97.8	97.8	0.0	O K
360 min Winter	27.000	0.000	0.0	72.3	72.3	0.0	O K
480 min Winter	27.000	0.000	0.0	58.3	58.3	0.0	O K
600 min Winter	27.000	0.000	0.0	49.2	49.2	0.0	O K
720 min Winter	27.000	0.000	0.0	42.8	42.8	0.0	O K
960 min Winter	27.000	0.000	0.0	34.4	34.4	0.0	O K
1440 min Winter	27.000	0.000	0.0	25.2	25.2	0.0	O K
2160 min Winter	27.000	0.000	0.0	18.4	18.4	0.0	O K
2880 min Winter	27.000	0.000	0.0	14.7	14.7	0.0	O K
4320 min Winter	27.000	0.000	0.0	10.7	10.7	0.0	O K
5760 min Winter	27.000	0.000	0.0	8.5	8.5	0.0	O K
7200 min Winter	27.000	0.000	0.0	7.1	7.1	0.0	O K
8640 min Winter	27.000	0.000	0.0	6.2	6.2	0.0	O K
10080 min Winter	27.000	0.000	0.0	5.5	5.5	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Summer	1.068	0.0	1167.8	0
15 min Winter	116.739	0.0	212.8	0
30 min Winter	78.763	0.0	287.1	0
60 min Winter	50.812	0.0	370.5	0
120 min Winter	31.715	0.0	462.5	0
180 min Winter	23.742	0.0	519.3	0
240 min Winter	19.206	0.0	560.1	0
360 min Winter	14.133	0.0	618.3	0
480 min Winter	11.375	0.0	663.5	0
600 min Winter	9.604	0.0	700.3	0
720 min Winter	8.359	0.0	731.4	0
960 min Winter	6.708	0.0	782.6	0
1440 min Winter	4.910	0.0	859.3	0
2160 min Winter	3.587	0.0	941.4	0
2880 min Winter	2.866	0.0	1003.1	0
4320 min Winter	2.086	0.0	1094.9	0
5760 min Winter	1.662	0.0	1163.5	0
7200 min Winter	1.393	0.0	1218.8	0
8640 min Winter	1.205	0.0	1265.7	0
10080 min Winter	1.068	0.0	1307.9	0

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Cascade Rainfall Details for Swale 1a 1-100 rev 01.SRCX

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Shortest Storm (mins)	15
Ratio R	0.344	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.868

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.434	4	8	0.434

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Cascade Model Details for Swale 1a 1-100 rev 01.SRCX

Storage is Online Cover Level (m) 28.000

Swale Structure

Infiltration Coefficient Base (m/hr)	0.00000	Length (m)	100.0
Infiltration Coefficient Side (m/hr)	0.00000	Side Slope (1:X)	3.0
Safety Factor	2.0	Slope (1:X)	50.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	27.000	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5		

Orifice Outflow Control

Diameter (m) 0.723 Discharge Coefficient 0.600 Invert Level (m) 25.400

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Cascade Summary of Results for Swale 1b 1-100 rev 01.SRCX

Upstream Structures	Outflow To	Overflow To
(None)	Pond 1 1-100 complex hydrobrakes control rev 01.SRCX	Pond 1 1-100 complex hydrobrakes control r

Half Drain Time : 0 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	29.000	0.000	0.0	749.5	749.5	0.0	O K
30 min Summer	29.000	0.000	0.0	806.3	806.3	0.0	O K
60 min Summer	29.000	0.000	0.0	756.2	756.2	0.0	O K
120 min Summer	29.000	0.000	0.0	578.5	578.5	0.0	O K
180 min Summer	29.000	0.000	0.0	463.2	463.2	0.0	O K
240 min Summer	29.000	0.000	0.0	387.7	387.7	0.0	O K
360 min Summer	29.000	0.000	0.0	295.3	295.3	0.0	O K
480 min Summer	29.000	0.000	0.0	241.9	241.9	0.0	O K
600 min Summer	29.000	0.000	0.0	207.8	207.8	0.0	O K
720 min Summer	29.000	0.000	0.0	180.9	180.9	0.0	O K
960 min Summer	29.000	0.000	0.0	145.2	145.2	0.0	O K
1440 min Summer	29.000	0.000	0.0	106.3	106.3	0.0	O K
2160 min Summer	29.000	0.000	0.0	77.6	77.6	0.0	O K
2880 min Summer	29.000	0.000	0.0	62.0	62.0	0.0	O K
4320 min Summer	29.000	0.000	0.0	45.1	45.1	0.0	O K
5760 min Summer	29.000	0.000	0.0	36.0	36.0	0.0	O K
7200 min Summer	29.000	0.000	0.0	30.1	30.1	0.0	O K
8640 min Summer	29.000	0.000	0.0	26.1	26.1	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	116.739	0.0	580.0	0
30 min Summer	78.763	0.0	782.7	0
60 min Summer	50.812	0.0	1009.9	0
120 min Summer	31.715	0.0	1260.7	0
180 min Summer	23.742	0.0	1415.6	0
240 min Summer	19.206	0.0	1526.9	0
360 min Summer	14.133	0.0	1685.4	0
480 min Summer	11.375	0.0	1808.7	0
600 min Summer	9.604	0.0	1908.8	0
720 min Summer	8.359	0.0	1993.7	0
960 min Summer	6.708	0.0	2133.2	0
1440 min Summer	4.910	0.0	2342.3	0
2160 min Summer	3.587	0.0	2566.1	0
2880 min Summer	2.866	0.0	2734.2	0
4320 min Summer	2.086	0.0	2984.4	0
5760 min Summer	1.662	0.0	3171.6	0
7200 min Summer	1.393	0.0	3322.3	0
8640 min Summer	1.205	0.0	3450.1	0

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Cascade Summary of Results for Swale 1b 1-100 rev 01.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
10080 min Summer	29.000	0.000	0.0	23.1	23.1	0.0	O K
15 min Winter	29.000	0.000	0.0	847.4	847.4	0.0	O K
30 min Winter	29.000	0.000	0.0	876.6	876.6	0.0	O K
60 min Winter	29.000	0.000	0.0	706.9	706.9	0.0	O K
120 min Winter	29.000	0.000	0.0	477.6	477.6	0.0	O K
180 min Winter	29.000	0.000	0.0	364.1	364.1	0.0	O K
240 min Winter	29.000	0.000	0.0	296.8	296.8	0.0	O K
360 min Winter	29.000	0.000	0.0	219.8	219.8	0.0	O K
480 min Winter	29.000	0.000	0.0	177.4	177.4	0.0	O K
600 min Winter	29.000	0.000	0.0	150.2	150.2	0.0	O K
720 min Winter	29.000	0.000	0.0	130.7	130.7	0.0	O K
960 min Winter	29.000	0.000	0.0	104.9	104.9	0.0	O K
1440 min Winter	29.000	0.000	0.0	76.8	76.8	0.0	O K
2160 min Winter	29.000	0.000	0.0	56.1	56.1	0.0	O K
2880 min Winter	29.000	0.000	0.0	44.8	44.8	0.0	O K
4320 min Winter	29.000	0.000	0.0	32.6	32.6	0.0	O K
5760 min Winter	29.000	0.000	0.0	26.0	26.0	0.0	O K
7200 min Winter	29.000	0.000	0.0	21.8	21.8	0.0	O K
8640 min Winter	29.000	0.000	0.0	18.9	18.9	0.0	O K
10080 min Winter	29.000	0.000	0.0	16.7	16.7	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Summer	1.068	0.0	3565.2	0
15 min Winter	116.739	0.0	649.7	0
30 min Winter	78.763	0.0	876.6	0
60 min Winter	50.812	0.0	1131.1	0
120 min Winter	31.715	0.0	1412.0	0
180 min Winter	23.742	0.0	1585.5	0
240 min Winter	19.206	0.0	1710.1	0
360 min Winter	14.133	0.0	1887.7	0
480 min Winter	11.375	0.0	2025.7	0
600 min Winter	9.604	0.0	2137.9	0
720 min Winter	8.359	0.0	2232.9	0
960 min Winter	6.708	0.0	2389.2	0
1440 min Winter	4.910	0.0	2623.3	0
2160 min Winter	3.587	0.0	2874.1	0
2880 min Winter	2.866	0.0	3062.3	0
4320 min Winter	2.086	0.0	3342.6	0
5760 min Winter	1.662	0.0	3552.2	0
7200 min Winter	1.393	0.0	3721.0	0
8640 min Winter	1.205	0.0	3864.1	0
10080 min Winter	1.068	0.0	3993.0	0

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Cascade Rainfall Details for Swale 1b 1-100 rev 01.SRCX

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Shortest Storm (mins)	15
Ratio R	0.344	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 2.650

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.883	4	8	0.883	8	12	0.884

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Cascade Model Details for Swale 1b 1-100 rev 01.SRCX

Storage is Online Cover Level (m) 30.000

Swale Structure

Infiltration Coefficient Base (m/hr)	0.00000	Length (m)	190.0
Infiltration Coefficient Side (m/hr)	0.00000	Side Slope (1:X)	3.0
Safety Factor	2.0	Slope (1:X)	40.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	29.000	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5		

Orifice Outflow Control

Diameter (m) 0.723 Discharge Coefficient 0.600 Invert Level (m) 24.100

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Cascade Summary of Results for Pond 2 1-1 year - complex hydrobrake controls rev 01.SRCX

Upstream Structures	Outflow To	Overflow To
Swale 2a 1-1 rev 01.SRCX	(None)	(None)
Swale 2b 1-1 rev 01.SRCX		

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	25.588	0.088	4.4	129.5	O K
30 min Summer	25.615	0.115	6.6	169.1	O K
60 min Summer	25.643	0.143	8.7	211.8	O K
120 min Summer	25.672	0.172	9.5	254.8	O K
180 min Summer	25.687	0.187	9.5	278.4	O K
240 min Summer	25.697	0.197	9.6	293.2	O K
360 min Summer	25.710	0.210	9.6	313.3	O K
480 min Summer	25.717	0.217	9.6	324.4	O K
600 min Summer	25.722	0.222	9.6	331.5	O K
720 min Summer	25.724	0.224	9.6	335.7	O K
960 min Summer	25.726	0.226	9.6	338.5	O K
1440 min Summer	25.722	0.222	9.6	332.0	O K
2160 min Summer	25.708	0.208	9.6	310.0	O K
2880 min Summer	25.691	0.191	9.5	284.7	O K
4320 min Summer	25.663	0.163	9.4	242.1	O K
5760 min Summer	25.646	0.146	8.8	216.0	O K
7200 min Summer	25.634	0.134	8.1	198.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	36.998	0.0	103.1	26
30 min Summer	24.589	0.0	144.2	39
60 min Summer	15.926	0.0	210.7	66
120 min Summer	10.157	0.0	272.7	124
180 min Summer	7.777	0.0	315.2	180
240 min Summer	6.430	0.0	348.8	220
360 min Summer	4.905	0.0	400.9	284
480 min Summer	4.025	0.0	439.5	350
600 min Summer	3.453	0.0	471.8	420
720 min Summer	3.046	0.0	499.9	490
960 min Summer	2.501	0.0	547.2	628
1440 min Summer	1.895	0.0	620.3	900
2160 min Summer	1.437	0.0	728.2	1296
2880 min Summer	1.179	0.0	795.8	1672
4320 min Summer	0.893	0.0	897.6	2380
5760 min Summer	0.734	0.0	1002.0	3064
7200 min Summer	0.631	0.0	1075.0	3816

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Cascade Summary of Results for Pond 2 1-1 year - complex hydrobrake controls rev 01.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
8640 min Summer	25.625	0.125	7.4	185.2	O K
10080 min Summer	25.618	0.118	6.9	174.2	O K
15 min Winter	25.599	0.099	5.3	144.8	O K
30 min Winter	25.628	0.128	7.7	189.2	O K
60 min Winter	25.660	0.160	9.4	237.7	O K
120 min Winter	25.694	0.194	9.6	288.7	O K
180 min Winter	25.712	0.212	9.6	317.1	O K
240 min Winter	25.724	0.224	9.6	335.1	O K
360 min Winter	25.736	0.236	9.6	354.3	O K
480 min Winter	25.743	0.243	9.6	364.5	O K
600 min Winter	25.746	0.246	9.6	369.8	O K
720 min Winter	25.748	0.248	9.6	371.6	O K
960 min Winter	25.745	0.245	9.6	368.3	O K
1440 min Winter	25.732	0.232	9.6	347.7	O K
2160 min Winter	25.705	0.205	9.6	305.8	O K
2880 min Winter	25.678	0.178	9.5	265.3	O K
4320 min Winter	25.645	0.145	8.8	214.6	O K
5760 min Winter	25.628	0.128	7.6	188.4	O K
7200 min Winter	25.616	0.116	6.7	171.1	O K
8640 min Winter	25.608	0.108	6.0	158.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	0.557	0.0	1136.8	4504
10080 min Summer	0.501	0.0	1184.3	5248
15 min Winter	36.998	0.0	118.0	25
30 min Winter	24.589	0.0	164.4	39
60 min Winter	15.926	0.0	237.8	66
120 min Winter	10.157	0.0	307.2	122
180 min Winter	7.777	0.0	354.9	178
240 min Winter	6.430	0.0	392.5	234
360 min Winter	4.905	0.0	450.8	330
480 min Winter	4.025	0.0	494.1	378
600 min Winter	3.453	0.0	530.3	456
720 min Winter	3.046	0.0	561.7	534
960 min Winter	2.501	0.0	614.8	686
1440 min Winter	1.895	0.0	696.9	974
2160 min Winter	1.437	0.0	816.9	1372
2880 min Winter	1.179	0.0	893.0	1736
4320 min Winter	0.893	0.0	1008.1	2424
5760 min Winter	0.734	0.0	1123.2	3120
7200 min Winter	0.631	0.0	1205.2	3824
8640 min Winter	0.557	0.0	1275.0	4584

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Cascade Summary of Results for Pond 2 1-1 year - complex hydrobrake controls rev 01.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
10080 min Winter	25.601	0.101	5.4	148.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Winter	0.501	0.0	1329.5	5344

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Cascade Rainfall Details for Pond 2 1-1 year - complex hydrobrake controls rev 01.SRCX

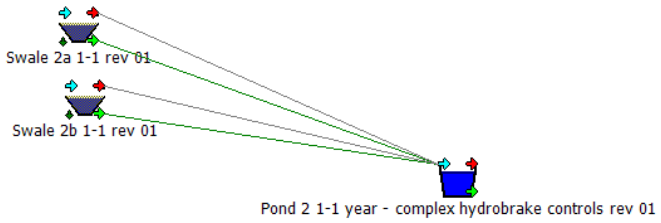
Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	1	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Shortest Storm (mins)	15
Ratio R	0.344	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.000

Time (mins) From:	To:	Area (ha)
0	4	0.000

Drained areas discharge to swales and swales discharge to pond.
Drained area to system = 1.445ha (swale 2a) + 0.465ha (swale 2b) = 1.91ha



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Cascade Model Details for Pond 2 1-1 year - complex hydrobrake controls rev 01.SRCX

Storage is Online Cover Level (m) 26.500

Tank or Pond Structure

Invert Level (m) 25.500

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	1450.0	0.700	1750.0	1.000	1880.0

Complex Outflow Control

Hydro-Brake® Optimum

Unit Reference	MD-SHE-0149-9600-0500-9600
Design Head (m)	0.500
Design Flow (l/s)	9.6
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	149
Invert Level (m)	25.500
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.500	9.6
Flush-Flo™	0.224	9.6
Kick-Flo®	0.395	8.6
Mean Flow over Head Range	-	7.6

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	5.4	1.200	14.5	3.000	22.5	7.000	33.8
0.200	9.6	1.400	15.6	3.500	24.2	7.500	35.0
0.300	9.4	1.600	16.6	4.000	25.8	8.000	36.2
0.400	8.6	1.800	17.6	4.500	27.3	8.500	37.3
0.500	9.6	2.000	18.5	5.000	28.8	9.000	38.4
0.600	10.5	2.200	19.4	5.500	30.0	9.500	39.5
0.800	12.0	2.400	20.2	6.000	31.3		
1.000	13.3	2.600	21.0	6.500	32.6		

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Hydro-Brake® Optimum

Unit Reference	MD-SHE-0148-9000-0275-9000
Design Head (m)	0.275
Design Flow (l/s)	9.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	148
Invert Level (m)	25.825
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	**Head (m)**	**Flow (l/s)**
Design Point (Calculated)	0.275	9.0
Flush-Flo™	0.194	9.0
Kick-Flo®	0.256	8.7
Mean Flow over Head Range	-	6.1

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**
0.100	5.3	1.200	18.1	3.000	27.8	7.000	42.7
0.200	9.0	1.400	19.4	3.500	30.0	7.500	44.2
0.300	9.4	1.600	20.7	4.000	32.2	8.000	45.7
0.400	10.7	1.800	21.9	4.500	34.1	8.500	47.1
0.500	11.9	2.000	23.1	5.000	36.0	9.000	48.5
0.600	13.0	2.200	24.2	5.500	37.8	9.500	49.8
0.800	14.9	2.400	25.2	6.000	39.5		
1.000	16.6	2.600	26.2	6.500	41.1		

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Cascade Summary of Results for Swale 2a 1-1 rev 01.SRCX

Upstream Structures	Outflow To	Overflow To
(None)	Pond 2 1-1 year - complex hydrobrake controls rev 01.SRCX	Pond 2 1-1 year - complex hydrobrake

Half Drain Time : 0 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	26.800	0.000	0.0	129.6	129.6	0.0	O K
30 min Summer	26.800	0.000	0.0	137.3	137.3	0.0	O K
60 min Summer	26.800	0.000	0.0	129.3	129.3	0.0	O K
120 min Summer	26.800	0.000	0.0	101.0	101.0	0.0	O K
180 min Summer	26.800	0.000	0.0	82.7	82.7	0.0	O K
240 min Summer	26.800	0.000	0.0	70.8	70.8	0.0	O K
360 min Summer	26.800	0.000	0.0	55.9	55.9	0.0	O K
480 min Summer	26.800	0.000	0.0	46.7	46.7	0.0	O K
600 min Summer	26.800	0.000	0.0	40.7	40.7	0.0	O K
720 min Summer	26.800	0.000	0.0	36.0	36.0	0.0	O K
960 min Summer	26.800	0.000	0.0	29.5	29.5	0.0	O K
1440 min Summer	26.800	0.000	0.0	22.4	22.4	0.0	O K
2160 min Summer	26.800	0.000	0.0	17.0	17.0	0.0	O K
2880 min Summer	26.800	0.000	0.0	13.9	13.9	0.0	O K
4320 min Summer	26.800	0.000	0.0	10.5	10.5	0.0	O K
5760 min Summer	26.800	0.000	0.0	8.7	8.7	0.0	O K
7200 min Summer	26.800	0.000	0.0	7.4	7.4	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	36.998	0.0	100.2	0
30 min Summer	24.589	0.0	133.2	0
60 min Summer	15.926	0.0	172.6	0
120 min Summer	10.157	0.0	220.2	0
180 min Summer	7.777	0.0	252.8	0
240 min Summer	6.430	0.0	278.7	0
360 min Summer	4.905	0.0	318.9	0
480 min Summer	4.025	0.0	349.0	0
600 min Summer	3.453	0.0	374.2	0
720 min Summer	3.046	0.0	396.2	0
960 min Summer	2.501	0.0	433.7	0
1440 min Summer	1.895	0.0	492.9	0
2160 min Summer	1.437	0.0	560.5	0
2880 min Summer	1.179	0.0	613.3	0
4320 min Summer	0.893	0.0	697.0	0
5760 min Summer	0.734	0.0	763.9	0
7200 min Summer	0.631	0.0	820.5	0

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Cascade Summary of Results for Swale 2a 1-1 rev 01.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	26.800	0.000	0.0	6.6	6.6	0.0	O K
10080 min Summer	26.800	0.000	0.0	5.9	5.9	0.0	O K
15 min Winter	26.800	0.000	0.0	146.5	146.5	0.0	O K
30 min Winter	26.800	0.000	0.0	149.2	149.2	0.0	O K
60 min Winter	26.800	0.000	0.0	120.8	120.8	0.0	O K
120 min Winter	26.800	0.000	0.0	83.4	83.4	0.0	O K
180 min Winter	26.800	0.000	0.0	65.0	65.0	0.0	O K
240 min Winter	26.800	0.000	0.0	54.2	54.2	0.0	O K
360 min Winter	26.800	0.000	0.0	41.6	41.6	0.0	O K
480 min Winter	26.800	0.000	0.0	34.2	34.2	0.0	O K
600 min Winter	26.800	0.000	0.0	29.4	29.4	0.0	O K
720 min Winter	26.800	0.000	0.0	26.0	26.0	0.0	O K
960 min Winter	26.800	0.000	0.0	21.3	21.3	0.0	O K
1440 min Winter	26.800	0.000	0.0	16.2	16.2	0.0	O K
2160 min Winter	26.800	0.000	0.0	12.2	12.2	0.0	O K
2880 min Winter	26.800	0.000	0.0	10.1	10.1	0.0	O K
4320 min Winter	26.800	0.000	0.0	7.6	7.6	0.0	O K
5760 min Winter	26.800	0.000	0.0	6.3	6.3	0.0	O K
7200 min Winter	26.800	0.000	0.0	5.4	5.4	0.0	O K
8640 min Winter	26.800	0.000	0.0	4.8	4.8	0.0	O K
10080 min Winter	26.800	0.000	0.0	4.3	4.3	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	0.557	0.0	869.9	0
10080 min Summer	0.501	0.0	911.3	0
15 min Winter	36.998	0.0	112.3	0
30 min Winter	24.589	0.0	149.2	0
60 min Winter	15.926	0.0	193.3	0
120 min Winter	10.157	0.0	246.6	0
180 min Winter	7.777	0.0	283.2	0
240 min Winter	6.430	0.0	312.2	0
360 min Winter	4.905	0.0	357.2	0
480 min Winter	4.025	0.0	390.8	0
600 min Winter	3.453	0.0	419.1	0
720 min Winter	3.046	0.0	443.7	0
960 min Winter	2.501	0.0	485.7	0
1440 min Winter	1.895	0.0	552.0	0
2160 min Winter	1.437	0.0	627.7	0
2880 min Winter	1.179	0.0	686.9	0
4320 min Winter	0.893	0.0	780.6	0
5760 min Winter	0.734	0.0	855.5	0
7200 min Winter	0.631	0.0	919.0	0
8640 min Winter	0.557	0.0	974.3	0
10080 min Winter	0.501	0.0	1020.7	0

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Cascade Rainfall Details for Swale 2a 1-1 rev 01.SRCX

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	1	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Shortest Storm (mins)	15
Ratio R	0.344	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 1.445

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.481	4	8	0.482	8	12	0.482

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Cascade Model Details for Swale 2a 1-1 rev 01.SRCX

Storage is Online Cover Level (m) 27.800

Swale Structure

Infiltration Coefficient Base (m/hr)	0.00000	Length (m)	170.0
Infiltration Coefficient Side (m/hr)	0.00000	Side Slope (1:X)	3.0
Safety Factor	2.0	Slope (1:X)	130.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	26.800	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5		

Orifice Outflow Control

Diameter (m) 0.723 Discharge Coefficient 0.600 Invert Level (m) 26.200

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Cascade Summary of Results for Swale 2b 1-1 rev 01.SRCX

Upstream Structures	Outflow To	Overflow To
(None)	Pond 2 1-1 year - complex hydrobrake controls rev 01.SRCX	Pond 2 1-1 year - complex hydrobrake

Half Drain Time : 0 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	26.500	0.000	0.0	54.9	54.9	0.0	O K
30 min Summer	26.500	0.000	0.0	56.2	56.2	0.0	O K
60 min Summer	26.500	0.000	0.0	47.5	47.5	0.0	O K
120 min Summer	26.500	0.000	0.0	34.8	34.8	0.0	O K
180 min Summer	26.500	0.000	0.0	27.9	27.9	0.0	O K
240 min Summer	26.500	0.000	0.0	23.6	23.6	0.0	O K
360 min Summer	26.500	0.000	0.0	18.5	18.5	0.0	O K
480 min Summer	26.500	0.000	0.0	15.3	15.3	0.0	O K
600 min Summer	26.500	0.000	0.0	13.1	13.1	0.0	O K
720 min Summer	26.500	0.000	0.0	11.6	11.6	0.0	O K
960 min Summer	26.500	0.000	0.0	9.5	9.5	0.0	O K
1440 min Summer	26.500	0.000	0.0	7.2	7.2	0.0	O K
2160 min Summer	26.500	0.000	0.0	5.5	5.5	0.0	O K
2880 min Summer	26.500	0.000	0.0	4.5	4.5	0.0	O K
4320 min Summer	26.500	0.000	0.0	3.4	3.4	0.0	O K
5760 min Summer	26.500	0.000	0.0	2.8	2.8	0.0	O K
7200 min Summer	26.500	0.000	0.0	2.4	2.4	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	36.998	0.0	32.3	0
30 min Summer	24.589	0.0	42.9	0
60 min Summer	15.926	0.0	55.5	0
120 min Summer	10.157	0.0	70.8	0
180 min Summer	7.777	0.0	81.4	0
240 min Summer	6.430	0.0	89.7	0
360 min Summer	4.905	0.0	102.6	0
480 min Summer	4.025	0.0	112.3	0
600 min Summer	3.453	0.0	120.4	0
720 min Summer	3.046	0.0	127.5	0
960 min Summer	2.501	0.0	139.5	0
1440 min Summer	1.895	0.0	158.6	0
2160 min Summer	1.437	0.0	180.4	0
2880 min Summer	1.179	0.0	197.4	0
4320 min Summer	0.893	0.0	224.3	0
5760 min Summer	0.734	0.0	245.8	0
7200 min Summer	0.631	0.0	264.0	0

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Cascade Summary of Results for Swale 2b 1-1 rev 01.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	26.500	0.000	0.0	2.1	2.1	0.0	O K
10080 min Summer	26.500	0.000	0.0	1.9	1.9	0.0	O K
15 min Winter	26.500	0.000	0.0	61.1	61.1	0.0	O K
30 min Winter	26.500	0.000	0.0	56.1	56.1	0.0	O K
60 min Winter	26.500	0.000	0.0	41.1	41.1	0.0	O K
120 min Winter	26.500	0.000	0.0	27.3	27.3	0.0	O K
180 min Winter	26.500	0.000	0.0	21.1	21.1	0.0	O K
240 min Winter	26.500	0.000	0.0	17.5	17.5	0.0	O K
360 min Winter	26.500	0.000	0.0	13.4	13.4	0.0	O K
480 min Winter	26.500	0.000	0.0	11.0	11.0	0.0	O K
600 min Winter	26.500	0.000	0.0	9.5	9.5	0.0	O K
720 min Winter	26.500	0.000	0.0	8.4	8.4	0.0	O K
960 min Winter	26.500	0.000	0.0	6.9	6.9	0.0	O K
1440 min Winter	26.500	0.000	0.0	5.2	5.2	0.0	O K
2160 min Winter	26.500	0.000	0.0	3.9	3.9	0.0	O K
2880 min Winter	26.500	0.000	0.0	3.2	3.2	0.0	O K
4320 min Winter	26.500	0.000	0.0	2.5	2.5	0.0	O K
5760 min Winter	26.500	0.000	0.0	2.0	2.0	0.0	O K
7200 min Winter	26.500	0.000	0.0	1.7	1.7	0.0	O K
8640 min Winter	26.500	0.000	0.0	1.5	1.5	0.0	O K
10080 min Winter	26.500	0.000	0.0	1.4	1.4	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	0.557	0.0	279.9	0
10080 min Summer	0.501	0.0	293.3	0
15 min Winter	36.998	0.0	36.1	0
30 min Winter	24.589	0.0	48.0	0
60 min Winter	15.926	0.0	62.2	0
120 min Winter	10.157	0.0	79.3	0
180 min Winter	7.777	0.0	91.1	0
240 min Winter	6.430	0.0	100.5	0
360 min Winter	4.905	0.0	115.0	0
480 min Winter	4.025	0.0	125.8	0
600 min Winter	3.453	0.0	134.9	0
720 min Winter	3.046	0.0	142.8	0
960 min Winter	2.501	0.0	156.3	0
1440 min Winter	1.895	0.0	177.6	0
2160 min Winter	1.437	0.0	202.0	0
2880 min Winter	1.179	0.0	221.0	0
4320 min Winter	0.893	0.0	251.2	0
5760 min Winter	0.734	0.0	275.3	0
7200 min Winter	0.631	0.0	295.7	0
8640 min Winter	0.557	0.0	313.5	0
10080 min Winter	0.501	0.0	328.4	0

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Cascade Rainfall Details for Swale 2b 1-1 rev 01.SRCX

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	1	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Shortest Storm (mins)	15
Ratio R	0.344	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.465

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.232	4	8	0.233

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Cascade Model Details for Swale 2b 1-1 rev 01.SRCX

Storage is Online Cover Level (m) 27.500

Swale Structure

Infiltration Coefficient Base (m/hr)	0.00000	Length (m)	160.0
Infiltration Coefficient Side (m/hr)	0.00000	Side Slope (1:X)	3.0
Safety Factor	2.0	Slope (1:X)	160.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	26.500	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5		

Orifice Outflow Control

Diameter (m) 0.723 Discharge Coefficient 0.600 Invert Level (m) 25.500

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Cascade Summary of Results for Pond 2 1-30 year - complex hydrobrake controls rev 01.SRCX

Upstream Structures	Outflow To	Overflow To
Swale 2a 1-30 rev 01.SRCX	(None)	(None)
Swale 2b 1-30 rev 01.SRCX		

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	25.711	0.211	9.6	315.7	O K
30 min Summer	25.778	0.278	9.6	419.1	O K
60 min Summer	25.848	0.348	9.6	530.3	O K
120 min Summer	25.915	0.415	13.3	637.7	O K
180 min Summer	25.945	0.445	16.1	686.3	O K
240 min Summer	25.959	0.459	17.2	709.8	O K
360 min Summer	25.971	0.471	18.1	728.5	O K
480 min Summer	25.978	0.478	18.2	741.4	O K
600 min Summer	25.983	0.483	18.3	749.3	O K
720 min Summer	25.985	0.485	18.3	753.0	O K
960 min Summer	25.985	0.485	18.3	752.1	O K
1440 min Summer	25.974	0.474	18.2	734.3	O K
2160 min Summer	25.953	0.453	16.7	699.6	O K
2880 min Summer	25.933	0.433	15.0	666.7	O K
4320 min Summer	25.896	0.396	11.7	607.1	O K
5760 min Summer	25.855	0.355	9.7	540.9	O K
7200 min Summer	25.803	0.303	9.6	458.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	90.472	0.0	285.8	26
30 min Summer	60.426	0.0	388.3	40
60 min Summer	38.715	0.0	532.9	70
120 min Summer	24.112	0.0	666.9	126
180 min Summer	18.086	0.0	751.9	184
240 min Summer	14.679	0.0	814.7	242
360 min Summer	10.878	0.0	906.7	306
480 min Summer	8.795	0.0	977.8	368
600 min Summer	7.453	0.0	1035.6	432
720 min Summer	6.508	0.0	1084.5	500
960 min Summer	5.250	0.0	1164.4	638
1440 min Summer	3.874	0.0	1278.6	912
2160 min Summer	2.854	0.0	1456.6	1320
2880 min Summer	2.296	0.0	1560.8	1732
4320 min Summer	1.688	0.0	1712.5	2556
5760 min Summer	1.355	0.0	1855.9	3400
7200 min Summer	1.143	0.0	1954.4	4176

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Cascade Summary of Results for Pond 2 1-30 year - complex hydrobrake controls rev 01.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
8640 min Summer	25.758	0.258	9.6	387.3	O K
10080 min Summer	25.721	0.221	9.6	330.7	O K
15 min Winter	25.736	0.236	9.6	354.2	O K
30 min Winter	25.811	0.311	9.6	470.9	O K
60 min Winter	25.889	0.389	11.2	595.0	O K
120 min Winter	25.960	0.460	17.3	710.7	O K
180 min Winter	25.994	0.494	18.5	766.6	O K
240 min Winter	26.013	0.513	18.7	798.4	O K
360 min Winter	26.029	0.529	18.8	825.6	O K
480 min Winter	26.035	0.535	18.9	836.3	O K
600 min Winter	26.039	0.539	18.9	843.1	O K
720 min Winter	26.040	0.540	18.9	843.7	O K
960 min Winter	26.034	0.534	18.9	833.5	O K
1440 min Winter	26.010	0.510	18.7	793.3	O K
2160 min Winter	25.971	0.471	18.1	728.9	O K
2880 min Winter	25.943	0.443	15.9	682.5	O K
4320 min Winter	25.895	0.395	11.6	605.4	O K
5760 min Winter	25.829	0.329	9.6	499.6	O K
7200 min Winter	25.749	0.249	9.6	373.7	O K
8640 min Winter	25.692	0.192	9.5	286.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	0.994	0.0	2036.5	4840
10080 min Summer	0.884	0.0	2104.5	5544
15 min Winter	90.472	0.0	322.7	26
30 min Winter	60.426	0.0	436.5	40
60 min Winter	38.715	0.0	598.5	68
120 min Winter	24.112	0.0	748.9	124
180 min Winter	18.086	0.0	844.3	180
240 min Winter	14.679	0.0	914.5	236
360 min Winter	10.878	0.0	1017.5	342
480 min Winter	8.795	0.0	1097.0	390
600 min Winter	7.453	0.0	1161.7	464
720 min Winter	6.508	0.0	1216.5	542
960 min Winter	5.250	0.0	1306.2	694
1440 min Winter	3.874	0.0	1434.7	984
2160 min Winter	2.854	0.0	1632.8	1388
2880 min Winter	2.296	0.0	1749.5	1816
4320 min Winter	1.688	0.0	1919.8	2728
5760 min Winter	1.355	0.0	2079.6	3632
7200 min Winter	1.143	0.0	2190.3	4264
8640 min Winter	0.994	0.0	2282.9	4920

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Cascade Summary of Results for Pond 2 1-30 year - complex hydrobrake controls rev 01.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
10080 min Winter	25.657	0.157	9.4	233.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Winter	0.884	0.0	2360.9	5440

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Cascade Rainfall Details for Pond 2 1-30 year - complex hydrobrake controls rev 01.SRCX

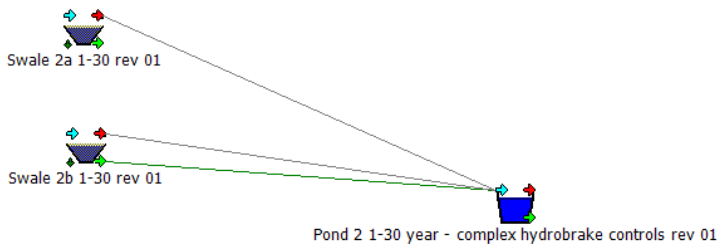
Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Shortest Storm (mins)	15
Ratio R	0.344	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.000

Time (mins) From:	To:	Area (ha)
0	4	0.000

Drained areas discharge to swales and swales discharge to pond.
Drained area to system = 1.445ha (swale 2a) + 0.465ha (swale 2b) = 1.91ha



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Cascade Model Details for Pond 2 1-30 year - complex hydrobrake controls rev 01.SRCX

Storage is Online Cover Level (m) 26.500

Tank or Pond Structure

Invert Level (m) 25.500

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	1450.0	0.700	1750.0	1.000	1880.0

Complex Outflow Control

Hydro-Brake® Optimum

Unit Reference	MD-SHE-0149-9600-0500-9600
Design Head (m)	0.500
Design Flow (l/s)	9.6
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	149
Invert Level (m)	25.500
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.500	9.6
Flush-Flo™	0.224	9.6
Kick-Flo®	0.395	8.6
Mean Flow over Head Range	-	7.6

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	5.4	1.200	14.5	3.000	22.5	7.000	33.8
0.200	9.6	1.400	15.6	3.500	24.2	7.500	35.0
0.300	9.4	1.600	16.6	4.000	25.8	8.000	36.2
0.400	8.6	1.800	17.6	4.500	27.3	8.500	37.3
0.500	9.6	2.000	18.5	5.000	28.8	9.000	38.4
0.600	10.5	2.200	19.4	5.500	30.0	9.500	39.5
0.800	12.0	2.400	20.2	6.000	31.3		
1.000	13.3	2.600	21.0	6.500	32.6		

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Hydro-Brake® Optimum

Unit Reference	MD-SHE-0148-9000-0275-9000
Design Head (m)	0.275
Design Flow (l/s)	9.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	148
Invert Level (m)	25.825
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	**Head (m)**	**Flow (l/s)**
Design Point (Calculated)	0.275	9.0
Flush-Flo™	0.194	9.0
Kick-Flo®	0.256	8.7
Mean Flow over Head Range	-	6.1

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**
0.100	5.3	1.200	18.1	3.000	27.8	7.000	42.7
0.200	9.0	1.400	19.4	3.500	30.0	7.500	44.2
0.300	9.4	1.600	20.7	4.000	32.2	8.000	45.7
0.400	10.7	1.800	21.9	4.500	34.1	8.500	47.1
0.500	11.9	2.000	23.1	5.000	36.0	9.000	48.5
0.600	13.0	2.200	24.2	5.500	37.8	9.500	49.8
0.800	14.9	2.400	25.2	6.000	39.5		
1.000	16.6	2.600	26.2	6.500	41.1		

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Cascade Summary of Results for Swale 2a 1-30 rev 01.SRCX

Upstream Structures	Outflow To	Overflow To
(None)	Pond 2 1-30 year - complex hydrobrake controls rev 01.SRCX	Pond 2 1-30 year - complex hydrobrak

Half Drain Time : 0 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	26.800	0.000	0.0	316.9	316.9	0.0	O K
30 min Summer	26.800	0.000	0.0	337.4	337.4	0.0	O K
60 min Summer	26.800	0.000	0.0	314.2	314.2	0.0	O K
120 min Summer	26.800	0.000	0.0	239.8	239.8	0.0	O K
180 min Summer	26.800	0.000	0.0	192.4	192.4	0.0	O K
240 min Summer	26.800	0.000	0.0	161.6	161.6	0.0	O K
360 min Summer	26.800	0.000	0.0	123.9	123.9	0.0	O K
480 min Summer	26.800	0.000	0.0	102.0	102.0	0.0	O K
600 min Summer	26.800	0.000	0.0	88.0	88.0	0.0	O K
720 min Summer	26.800	0.000	0.0	76.8	76.8	0.0	O K
960 min Summer	26.800	0.000	0.0	62.0	62.0	0.0	O K
1440 min Summer	26.800	0.000	0.0	45.7	45.7	0.0	O K
2160 min Summer	26.800	0.000	0.0	33.7	33.7	0.0	O K
2880 min Summer	26.800	0.000	0.0	27.1	27.1	0.0	O K
4320 min Summer	26.800	0.000	0.0	19.9	19.9	0.0	O K
5760 min Summer	26.800	0.000	0.0	16.0	16.0	0.0	O K
7200 min Summer	26.800	0.000	0.0	13.5	13.5	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	90.472	0.0	245.1	0
30 min Summer	60.426	0.0	327.4	0
60 min Summer	38.715	0.0	419.6	0
120 min Summer	24.112	0.0	522.6	0
180 min Summer	18.086	0.0	588.0	0
240 min Summer	14.679	0.0	636.3	0
360 min Summer	10.878	0.0	707.4	0
480 min Summer	8.795	0.0	762.5	0
600 min Summer	7.453	0.0	807.7	0
720 min Summer	6.508	0.0	846.3	0
960 min Summer	5.250	0.0	910.4	0
1440 min Summer	3.874	0.0	1007.6	0
2160 min Summer	2.854	0.0	1113.6	0
2880 min Summer	2.296	0.0	1194.4	0
4320 min Summer	1.688	0.0	1316.9	0
5760 min Summer	1.355	0.0	1410.1	0
7200 min Summer	1.143	0.0	1486.3	0

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Cascade Summary of Results for Swale 2a 1-30 rev 01.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	26.800	0.000	0.0	11.7	11.7	0.0	O K
10080 min Summer	26.800	0.000	0.0	10.4	10.4	0.0	O K
15 min Winter	26.800	0.000	0.0	358.3	358.3	0.0	O K
30 min Winter	26.800	0.000	0.0	366.8	366.8	0.0	O K
60 min Winter	26.800	0.000	0.0	293.7	293.7	0.0	O K
120 min Winter	26.800	0.000	0.0	198.0	198.0	0.0	O K
180 min Winter	26.800	0.000	0.0	151.2	151.2	0.0	O K
240 min Winter	26.800	0.000	0.0	123.7	123.7	0.0	O K
360 min Winter	26.800	0.000	0.0	92.3	92.3	0.0	O K
480 min Winter	26.800	0.000	0.0	74.8	74.8	0.0	O K
600 min Winter	26.800	0.000	0.0	63.6	63.6	0.0	O K
720 min Winter	26.800	0.000	0.0	55.5	55.5	0.0	O K
960 min Winter	26.800	0.000	0.0	44.8	44.8	0.0	O K
1440 min Winter	26.800	0.000	0.0	33.0	33.0	0.0	O K
2160 min Winter	26.800	0.000	0.0	24.3	24.3	0.0	O K
2880 min Winter	26.800	0.000	0.0	19.6	19.6	0.0	O K
4320 min Winter	26.800	0.000	0.0	14.4	14.4	0.0	O K
5760 min Winter	26.800	0.000	0.0	11.6	11.6	0.0	O K
7200 min Winter	26.800	0.000	0.0	9.7	9.7	0.0	O K
8640 min Winter	26.800	0.000	0.0	8.5	8.5	0.0	O K
10080 min Winter	26.800	0.000	0.0	7.5	7.5	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	0.994	0.0	1551.3	0
10080 min Summer	0.884	0.0	1609.4	0
15 min Winter	90.472	0.0	274.5	0
30 min Winter	60.426	0.0	366.7	0
60 min Winter	38.715	0.0	469.9	0
120 min Winter	24.112	0.0	585.4	0
180 min Winter	18.086	0.0	658.6	0
240 min Winter	14.679	0.0	712.7	0
360 min Winter	10.878	0.0	792.3	0
480 min Winter	8.795	0.0	854.1	0
600 min Winter	7.453	0.0	904.7	0
720 min Winter	6.508	0.0	947.9	0
960 min Winter	5.250	0.0	1019.6	0
1440 min Winter	3.874	0.0	1128.5	0
2160 min Winter	2.854	0.0	1247.2	0
2880 min Winter	2.296	0.0	1337.7	0
4320 min Winter	1.688	0.0	1474.9	0
5760 min Winter	1.355	0.0	1579.3	0
7200 min Winter	1.143	0.0	1664.6	0
8640 min Winter	0.994	0.0	1737.5	0
10080 min Winter	0.884	0.0	1802.6	0

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Cascade Rainfall Details for Swale 2a 1-30 rev 01.SRCX

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Shortest Storm (mins)	15
Ratio R	0.344	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 1.445

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.481	4	8	0.482	8	12	0.482

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Cascade Model Details for Swale 2a 1-30 rev 01.SRCX

Storage is Online Cover Level (m) 27.800

Swale Structure

Infiltration Coefficient Base (m/hr)	0.00000	Length (m)	170.0
Infiltration Coefficient Side (m/hr)	0.00000	Side Slope (1:X)	3.0
Safety Factor	2.0	Slope (1:X)	130.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	26.800	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5		

Orifice Outflow Control

Diameter (m) 0.723 Discharge Coefficient 0.600 Invert Level (m) 26.200

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Cascade Summary of Results for Swale 2b 1-30 rev 01.SRCX

Upstream Structures	Outflow To	Overflow To
(None)	Pond 2 1-30 year - complex hydrobrake controls rev 01.SRCX	Pond 2 1-30 year - complex hydrobrak

Half Drain Time : 0 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	26.500	0.000	0.0	134.1	134.1	0.0	O K
30 min Summer	26.500	0.000	0.0	138.0	138.0	0.0	O K
60 min Summer	26.500	0.000	0.0	115.6	115.6	0.0	O K
120 min Summer	26.500	0.000	0.0	82.6	82.6	0.0	O K
180 min Summer	26.500	0.000	0.0	64.9	64.9	0.0	O K
240 min Summer	26.500	0.000	0.0	53.8	53.8	0.0	O K
360 min Summer	26.500	0.000	0.0	41.0	41.0	0.0	O K
480 min Summer	26.500	0.000	0.0	33.4	33.4	0.0	O K
600 min Summer	26.500	0.000	0.0	28.3	28.3	0.0	O K
720 min Summer	26.500	0.000	0.0	24.7	24.7	0.0	O K
960 min Summer	26.500	0.000	0.0	19.9	19.9	0.0	O K
1440 min Summer	26.500	0.000	0.0	14.7	14.7	0.0	O K
2160 min Summer	26.500	0.000	0.0	10.8	10.8	0.0	O K
2880 min Summer	26.500	0.000	0.0	8.7	8.7	0.0	O K
4320 min Summer	26.500	0.000	0.0	6.4	6.4	0.0	O K
5760 min Summer	26.500	0.000	0.0	5.1	5.1	0.0	O K
7200 min Summer	26.500	0.000	0.0	4.3	4.3	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	90.472	0.0	78.9	0
30 min Summer	60.426	0.0	105.4	0
60 min Summer	38.715	0.0	135.0	0
120 min Summer	24.112	0.0	168.2	0
180 min Summer	18.086	0.0	189.2	0
240 min Summer	14.679	0.0	204.8	0
360 min Summer	10.878	0.0	227.6	0
480 min Summer	8.795	0.0	245.4	0
600 min Summer	7.453	0.0	259.9	0
720 min Summer	6.508	0.0	272.3	0
960 min Summer	5.250	0.0	293.0	0
1440 min Summer	3.874	0.0	324.2	0
2160 min Summer	2.854	0.0	358.3	0
2880 min Summer	2.296	0.0	384.4	0
4320 min Summer	1.688	0.0	423.8	0
5760 min Summer	1.355	0.0	453.8	0
7200 min Summer	1.143	0.0	478.3	0

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Cascade Summary of Results for Swale 2b 1-30 rev 01.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	26.500	0.000	0.0	3.8	3.8	0.0	O K
10080 min Summer	26.500	0.000	0.0	3.4	3.4	0.0	O K
15 min Winter	26.500	0.000	0.0	149.5	149.5	0.0	O K
30 min Winter	26.500	0.000	0.0	137.9	137.9	0.0	O K
60 min Winter	26.500	0.000	0.0	99.9	99.9	0.0	O K
120 min Winter	26.500	0.000	0.0	64.9	64.9	0.0	O K
180 min Winter	26.500	0.000	0.0	49.2	49.2	0.0	O K
240 min Winter	26.500	0.000	0.0	40.1	40.1	0.0	O K
360 min Winter	26.500	0.000	0.0	29.8	29.8	0.0	O K
480 min Winter	26.500	0.000	0.0	24.1	24.1	0.0	O K
600 min Winter	26.500	0.000	0.0	20.5	20.5	0.0	O K
720 min Winter	26.500	0.000	0.0	17.9	17.9	0.0	O K
960 min Winter	26.500	0.000	0.0	14.4	14.4	0.0	O K
1440 min Winter	26.500	0.000	0.0	10.6	10.6	0.0	O K
2160 min Winter	26.500	0.000	0.0	7.8	7.8	0.0	O K
2880 min Winter	26.500	0.000	0.0	6.3	6.3	0.0	O K
4320 min Winter	26.500	0.000	0.0	4.6	4.6	0.0	O K
5760 min Winter	26.500	0.000	0.0	3.7	3.7	0.0	O K
7200 min Winter	26.500	0.000	0.0	3.1	3.1	0.0	O K
8640 min Winter	26.500	0.000	0.0	2.7	2.7	0.0	O K
10080 min Winter	26.500	0.000	0.0	2.4	2.4	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	0.994	0.0	499.2	0
10080 min Summer	0.884	0.0	517.9	0
15 min Winter	90.472	0.0	88.3	0
30 min Winter	60.426	0.0	118.0	0
60 min Winter	38.715	0.0	151.2	0
120 min Winter	24.112	0.0	188.4	0
180 min Winter	18.086	0.0	211.9	0
240 min Winter	14.679	0.0	229.3	0
360 min Winter	10.878	0.0	254.9	0
480 min Winter	8.795	0.0	274.8	0
600 min Winter	7.453	0.0	291.1	0
720 min Winter	6.508	0.0	305.0	0
960 min Winter	5.250	0.0	328.1	0
1440 min Winter	3.874	0.0	363.2	0
2160 min Winter	2.854	0.0	401.3	0
2880 min Winter	2.296	0.0	430.5	0
4320 min Winter	1.688	0.0	474.6	0
5760 min Winter	1.355	0.0	508.2	0
7200 min Winter	1.143	0.0	535.7	0
8640 min Winter	0.994	0.0	559.1	0
10080 min Winter	0.884	0.0	580.1	0

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Cascade Rainfall Details for Swale 2b 1-30 rev 01.SRCX

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Shortest Storm (mins)	15
Ratio R	0.344	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.465

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.232	4	8	0.233

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Cascade Model Details for Swale 2b 1-30 rev 01.SRCX

Storage is Online Cover Level (m) 27.500

Swale Structure

Infiltration Coefficient Base (m/hr)	0.00000	Length (m)	160.0
Infiltration Coefficient Side (m/hr)	0.00000	Side Slope (1:X)	3.0
Safety Factor	2.0	Slope (1:X)	160.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	26.500	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5		

Orifice Outflow Control

Diameter (m) 0.723 Discharge Coefficient 0.600 Invert Level (m) 25.500

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Cascade Summary of Results for Pond 2 1-100 year - complex hydrobrake controls rev 01.SRCX

Upstream Structures	Outflow To	Overflow To
Swale 2b 1-100 rev 01.SRCX	(None)	(None)
Swale 2a 1-100 rev 01.SRCX		

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	25.771	0.271	9.6	408.9	O K
30 min Summer	25.860	0.360	9.9	549.4	O K
60 min Summer	25.949	0.449	16.4	693.1	O K
120 min Summer	26.032	0.532	18.9	830.6	O K
180 min Summer	26.073	0.573	19.0	899.8	O K
240 min Summer	26.095	0.595	19.3	937.1	O K
360 min Summer	26.111	0.611	19.7	963.8	O K
480 min Summer	26.118	0.618	19.9	976.7	O K
600 min Summer	26.122	0.622	20.0	983.3	O K
720 min Summer	26.123	0.623	20.0	985.6	O K
960 min Summer	26.121	0.621	19.9	980.7	O K
1440 min Summer	26.103	0.603	19.5	950.1	O K
2160 min Summer	26.064	0.564	19.0	884.8	O K
2880 min Summer	26.025	0.525	18.8	819.1	O K
4320 min Summer	25.966	0.466	17.8	721.4	O K
5760 min Summer	25.932	0.432	14.9	664.5	O K
7200 min Summer	25.903	0.403	12.2	617.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	116.739	0.0	374.7	26
30 min Summer	78.763	0.0	508.9	41
60 min Summer	50.812	0.0	702.6	68
120 min Summer	31.715	0.0	882.4	126
180 min Summer	23.742	0.0	992.3	184
240 min Summer	19.206	0.0	1071.0	242
360 min Summer	14.133	0.0	1182.7	344
480 min Summer	11.375	0.0	1269.0	398
600 min Summer	9.604	0.0	1338.5	458
720 min Summer	8.359	0.0	1396.9	522
960 min Summer	6.708	0.0	1491.2	658
1440 min Summer	4.910	0.0	1624.0	932
2160 min Summer	3.587	0.0	1833.4	1340
2880 min Summer	2.866	0.0	1951.6	1732
4320 min Summer	2.086	0.0	2120.8	2472
5760 min Summer	1.662	0.0	2277.9	3280
7200 min Summer	1.393	0.0	2384.3	4112

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Cascade Summary of Results for Pond 2 1-100 year - complex hydrobrake controls rev 01.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
8640 min Summer	25.870	0.370	10.3	565.3	O K
10080 min Summer	25.828	0.328	9.6	497.3	O K
15 min Winter	25.803	0.303	9.6	458.5	O K
30 min Winter	25.901	0.401	12.1	615.4	O K
60 min Winter	26.000	0.500	18.6	776.8	O K
120 min Winter	26.095	0.595	19.3	937.3	O K
180 min Winter	26.142	0.642	20.4	1017.7	O K
240 min Winter	26.167	0.667	21.0	1061.7	O K
360 min Winter	26.188	0.688	21.4	1097.6	O K
480 min Winter	26.193	0.693	21.5	1106.8	O K
600 min Winter	26.195	0.695	21.6	1110.4	O K
720 min Winter	26.195	0.695	21.6	1110.0	O K
960 min Winter	26.187	0.687	21.4	1095.7	O K
1440 min Winter	26.156	0.656	20.7	1041.8	O K
2160 min Winter	26.099	0.599	19.4	944.3	O K
2880 min Winter	26.041	0.541	18.9	845.3	O K
4320 min Winter	25.962	0.462	17.4	714.4	O K
5760 min Winter	25.922	0.422	14.0	649.0	O K
7200 min Winter	25.883	0.383	10.9	586.4	O K
8640 min Winter	25.817	0.317	9.6	480.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.205	0.0	2472.3	4936
10080 min Summer	1.068	0.0	2545.9	5752
15 min Winter	116.739	0.0	421.1	26
30 min Winter	78.763	0.0	569.9	40
60 min Winter	50.812	0.0	790.3	68
120 min Winter	31.715	0.0	990.1	124
180 min Winter	23.742	0.0	1113.2	180
240 min Winter	19.206	0.0	1201.3	238
360 min Winter	14.133	0.0	1326.3	348
480 min Winter	11.375	0.0	1422.8	446
600 min Winter	9.604	0.0	1500.5	478
720 min Winter	8.359	0.0	1565.7	554
960 min Winter	6.708	0.0	1670.8	708
1440 min Winter	4.910	0.0	1816.4	1010
2160 min Winter	3.587	0.0	2054.9	1436
2880 min Winter	2.866	0.0	2187.3	1840
4320 min Winter	2.086	0.0	2376.4	2592
5760 min Winter	1.662	0.0	2552.2	3408
7200 min Winter	1.393	0.0	2671.8	4392
8640 min Winter	1.205	0.0	2771.1	5272

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Cascade Summary of Results for Pond 2 1-100 year - complex hydrobrake controls rev 01.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
10080 min Winter	25.743	0.243	9.6	364.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Winter	1.068	0.0	2855.4	5856

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Cascade Rainfall Details for Pond 2 1-100 year - complex hydrobrake controls rev 01.SRCX

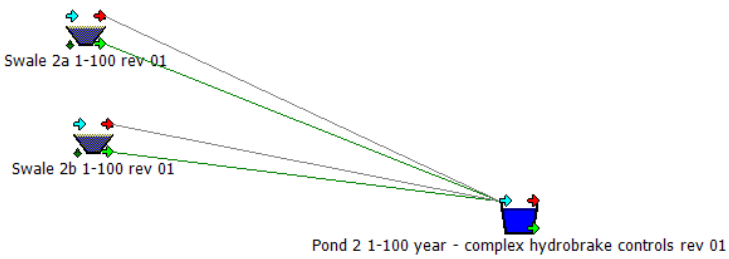
Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Shortest Storm (mins)	15
Ratio R	0.344	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.000

Time (mins) From:	To:	Area (ha)
0	480	0.000

Drained areas discharge to swales and swales discharge to pond.
Drained area to system = 1.445ha (swale 2a) + 0.465ha (swale 2b) = 1.91ha



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Cascade Model Details for Pond 2 1-100 year - complex hydrobrake controls rev 01.SRCX

Storage is Online Cover Level (m) 26.500

Tank or Pond Structure

Invert Level (m) 25.500

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	1450.0	0.700	1750.0	1.000	1880.0

Complex Outflow Control

Hydro-Brake® Optimum

Unit Reference	MD-SHE-0149-9600-0500-9600
Design Head (m)	0.500
Design Flow (l/s)	9.6
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	149
Invert Level (m)	25.500
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.500	9.6
Flush-Flo™	0.224	9.6
Kick-Flo®	0.395	8.6
Mean Flow over Head Range	-	7.6

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	5.4	1.200	14.5	3.000	22.5	7.000	33.8
0.200	9.6	1.400	15.6	3.500	24.2	7.500	35.0
0.300	9.4	1.600	16.6	4.000	25.8	8.000	36.2
0.400	8.6	1.800	17.6	4.500	27.3	8.500	37.3
0.500	9.6	2.000	18.5	5.000	28.8	9.000	38.4
0.600	10.5	2.200	19.4	5.500	30.0	9.500	39.5
0.800	12.0	2.400	20.2	6.000	31.3		
1.000	13.3	2.600	21.0	6.500	32.6		

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Hydro-Brake® Optimum

Unit Reference	MD-SHE-0148-9000-0275-9000
Design Head (m)	0.275
Design Flow (l/s)	9.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	148
Invert Level (m)	25.825
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	**Head (m)**	**Flow (l/s)**
Design Point (Calculated)	0.275	9.0
Flush-Flo™	0.194	9.0
Kick-Flo®	0.256	8.7
Mean Flow over Head Range	-	6.1

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**
0.100	5.3	1.200	18.1	3.000	27.8	7.000	42.7
0.200	9.0	1.400	19.4	3.500	30.0	7.500	44.2
0.300	9.4	1.600	20.7	4.000	32.2	8.000	45.7
0.400	10.7	1.800	21.9	4.500	34.1	8.500	47.1
0.500	11.9	2.000	23.1	5.000	36.0	9.000	48.5
0.600	13.0	2.200	24.2	5.500	37.8	9.500	49.8
0.800	14.9	2.400	25.2	6.000	39.5		
1.000	16.6	2.600	26.2	6.500	41.1		

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Cascade Summary of Results for Swale 2a 1-100 rev 01.SRCX

Upstream Structures	Outflow To	Overflow To
(None)	Pond 2 1-100 year - complex hydrobrake controls rev 01.SRCX	Pond 2 1-100 year - complex hydrobr

Half Drain Time : 0 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	26.823	0.023	0.0	412.6	412.6	0.0	O K
30 min Summer	26.847	0.047	0.0	439.8	439.8	0.1	O K
60 min Summer	26.833	0.033	0.0	423.3	423.3	0.0	O K
120 min Summer	26.800	0.000	0.0	315.5	315.5	0.0	O K
180 min Summer	26.800	0.000	0.0	252.6	252.6	0.0	O K
240 min Summer	26.800	0.000	0.0	211.4	211.4	0.0	O K
360 min Summer	26.800	0.000	0.0	161.0	161.0	0.0	O K
480 min Summer	26.800	0.000	0.0	131.9	131.9	0.0	O K
600 min Summer	26.800	0.000	0.0	113.3	113.3	0.0	O K
720 min Summer	26.800	0.000	0.0	98.6	98.6	0.0	O K
960 min Summer	26.800	0.000	0.0	79.2	79.2	0.0	O K
1440 min Summer	26.800	0.000	0.0	57.9	57.9	0.0	O K
2160 min Summer	26.800	0.000	0.0	42.3	42.3	0.0	O K
2880 min Summer	26.800	0.000	0.0	33.8	33.8	0.0	O K
4320 min Summer	26.800	0.000	0.0	24.6	24.6	0.0	O K
5760 min Summer	26.800	0.000	0.0	19.6	19.6	0.0	O K
7200 min Summer	26.800	0.000	0.0	16.4	16.4	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	116.739	0.0	316.2	14
30 min Summer	78.763	0.0	426.8	21
60 min Summer	50.812	0.0	549.4	36
120 min Summer	31.715	0.0	687.4	0
180 min Summer	23.742	0.0	771.9	0
240 min Summer	19.206	0.0	832.6	0
360 min Summer	14.133	0.0	919.0	0
480 min Summer	11.375	0.0	986.2	0
600 min Summer	9.604	0.0	1040.8	0
720 min Summer	8.359	0.0	1087.1	0
960 min Summer	6.708	0.0	1163.2	0
1440 min Summer	4.910	0.0	1277.2	0
2160 min Summer	3.587	0.0	1399.3	0
2880 min Summer	2.866	0.0	1490.9	0
4320 min Summer	2.086	0.0	1627.4	0
5760 min Summer	1.662	0.0	1729.4	0
7200 min Summer	1.393	0.0	1811.6	0

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Cascade Summary of Results for Swale 2a 1-100 rev 01.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	26.800	0.000	0.0	14.2	14.2	0.0	O K
10080 min Summer	26.800	0.000	0.0	12.6	12.6	0.0	O K
15 min Winter	26.875	0.075	0.0	471.0	471.0	0.2	O K
30 min Winter	26.879	0.079	0.0	476.1	476.1	0.3	O K
60 min Winter	26.800	0.000	0.0	385.5	385.5	0.0	O K
120 min Winter	26.800	0.000	0.0	260.4	260.4	0.0	O K
180 min Winter	26.800	0.000	0.0	198.5	198.5	0.0	O K
240 min Winter	26.800	0.000	0.0	161.8	161.8	0.0	O K
360 min Winter	26.800	0.000	0.0	119.9	119.9	0.0	O K
480 min Winter	26.800	0.000	0.0	96.7	96.7	0.0	O K
600 min Winter	26.800	0.000	0.0	81.9	81.9	0.0	O K
720 min Winter	26.800	0.000	0.0	71.3	71.3	0.0	O K
960 min Winter	26.800	0.000	0.0	57.2	57.2	0.0	O K
1440 min Winter	26.800	0.000	0.0	41.9	41.9	0.0	O K
2160 min Winter	26.800	0.000	0.0	30.6	30.6	0.0	O K
2880 min Winter	26.800	0.000	0.0	24.4	24.4	0.0	O K
4320 min Winter	26.800	0.000	0.0	17.8	17.8	0.0	O K
5760 min Winter	26.800	0.000	0.0	14.2	14.2	0.0	O K
7200 min Winter	26.800	0.000	0.0	11.9	11.9	0.0	O K
8640 min Winter	26.800	0.000	0.0	10.3	10.3	0.0	O K
10080 min Winter	26.800	0.000	0.0	9.1	9.1	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.205	0.0	1881.3	0
10080 min Summer	1.068	0.0	1944.0	0
15 min Winter	116.739	0.0	353.8	13
30 min Winter	78.763	0.0	477.7	20
60 min Winter	50.812	0.0	616.8	0
120 min Winter	31.715	0.0	769.9	0
180 min Winter	23.742	0.0	864.6	0
240 min Winter	19.206	0.0	932.5	0
360 min Winter	14.133	0.0	1029.3	0
480 min Winter	11.375	0.0	1104.6	0
600 min Winter	9.604	0.0	1165.7	0
720 min Winter	8.359	0.0	1217.6	0
960 min Winter	6.708	0.0	1302.8	0
1440 min Winter	4.910	0.0	1430.5	0
2160 min Winter	3.587	0.0	1567.2	0
2880 min Winter	2.866	0.0	1669.8	0
4320 min Winter	2.086	0.0	1822.6	0
5760 min Winter	1.662	0.0	1936.9	0
7200 min Winter	1.393	0.0	2029.0	0
8640 min Winter	1.205	0.0	2107.0	0
10080 min Winter	1.068	0.0	2177.3	0

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Cascade Rainfall Details for Swale 2a 1-100 rev 01.SRCX

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Shortest Storm (mins)	15
Ratio R	0.344	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 1.445

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.481	4	8	0.482	8	12	0.482

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Cascade Model Details for Swale 2a 1-100 rev 01.SRCX

Storage is Online Cover Level (m) 27.800

Swale Structure

Infiltration Coefficient Base (m/hr)	0.00000	Length (m)	170.0
Infiltration Coefficient Side (m/hr)	0.00000	Side Slope (1:X)	3.0
Safety Factor	2.0	Slope (1:X)	130.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	26.800	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5		

Orifice Outflow Control

Diameter (m) 0.723 Discharge Coefficient 0.600 Invert Level (m) 26.200

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Cascade Summary of Results for Swale 2b 1-100 rev 01.SRCX

Upstream Structures	Outflow To	Overflow To
(None)	Pond 2 1-100 year - complex hydrobrake controls rev 01.SRCX	Pond 2 1-100 year - complex hydrobr

Half Drain Time : 0 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	26.500	0.000	0.0	173.1	173.1	0.0	O K
30 min Summer	26.500	0.000	0.0	179.9	179.9	0.0	O K
60 min Summer	26.500	0.000	0.0	151.7	151.7	0.0	O K
120 min Summer	26.500	0.000	0.0	108.6	108.6	0.0	O K
180 min Summer	26.500	0.000	0.0	85.2	85.2	0.0	O K
240 min Summer	26.500	0.000	0.0	70.4	70.4	0.0	O K
360 min Summer	26.500	0.000	0.0	53.2	53.2	0.0	O K
480 min Summer	26.500	0.000	0.0	43.2	43.2	0.0	O K
600 min Summer	26.500	0.000	0.0	36.5	36.5	0.0	O K
720 min Summer	26.500	0.000	0.0	31.7	31.7	0.0	O K
960 min Summer	26.500	0.000	0.0	25.5	25.5	0.0	O K
1440 min Summer	26.500	0.000	0.0	18.6	18.6	0.0	O K
2160 min Summer	26.500	0.000	0.0	13.6	13.6	0.0	O K
2880 min Summer	26.500	0.000	0.0	10.9	10.9	0.0	O K
4320 min Summer	26.500	0.000	0.0	7.9	7.9	0.0	O K
5760 min Summer	26.500	0.000	0.0	6.3	6.3	0.0	O K
7200 min Summer	26.500	0.000	0.0	5.3	5.3	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	116.739	0.0	101.8	0
30 min Summer	78.763	0.0	137.3	0
60 min Summer	50.812	0.0	177.2	0
120 min Summer	31.715	0.0	221.2	0
180 min Summer	23.742	0.0	248.4	0
240 min Summer	19.206	0.0	267.9	0
360 min Summer	14.133	0.0	295.7	0
480 min Summer	11.375	0.0	317.4	0
600 min Summer	9.604	0.0	334.9	0
720 min Summer	8.359	0.0	349.8	0
960 min Summer	6.708	0.0	374.3	0
1440 min Summer	4.910	0.0	411.0	0
2160 min Summer	3.587	0.0	450.3	0
2880 min Summer	2.866	0.0	479.8	0
4320 min Summer	2.086	0.0	523.7	0
5760 min Summer	1.662	0.0	556.5	0
7200 min Summer	1.393	0.0	583.0	0

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Cascade Summary of Results for Swale 2b 1-100 rev 01.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	26.500	0.000	0.0	4.6	4.6	0.0	O K
10080 min Summer	26.500	0.000	0.0	4.1	4.1	0.0	O K
15 min Winter	26.500	0.000	0.0	192.9	192.9	0.0	O K
30 min Winter	26.500	0.000	0.0	179.7	179.7	0.0	O K
60 min Winter	26.500	0.000	0.0	131.1	131.1	0.0	O K
120 min Winter	26.500	0.000	0.0	85.3	85.3	0.0	O K
180 min Winter	26.500	0.000	0.0	64.5	64.5	0.0	O K
240 min Winter	26.500	0.000	0.0	52.4	52.4	0.0	O K
360 min Winter	26.500	0.000	0.0	38.7	38.7	0.0	O K
480 min Winter	26.500	0.000	0.0	31.2	31.2	0.0	O K
600 min Winter	26.500	0.000	0.0	26.4	26.4	0.0	O K
720 min Winter	26.500	0.000	0.0	22.9	22.9	0.0	O K
960 min Winter	26.500	0.000	0.0	18.4	18.4	0.0	O K
1440 min Winter	26.500	0.000	0.0	13.5	13.5	0.0	O K
2160 min Winter	26.500	0.000	0.0	9.8	9.8	0.0	O K
2880 min Winter	26.500	0.000	0.0	7.9	7.9	0.0	O K
4320 min Winter	26.500	0.000	0.0	5.7	5.7	0.0	O K
5760 min Winter	26.500	0.000	0.0	4.6	4.6	0.0	O K
7200 min Winter	26.500	0.000	0.0	3.8	3.8	0.0	O K
8640 min Winter	26.500	0.000	0.0	3.3	3.3	0.0	O K
10080 min Winter	26.500	0.000	0.0	2.9	2.9	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.205	0.0	605.4	0
10080 min Summer	1.068	0.0	625.6	0
15 min Winter	116.739	0.0	114.0	0
30 min Winter	78.763	0.0	153.8	0
60 min Winter	50.812	0.0	198.5	0
120 min Winter	31.715	0.0	247.8	0
180 min Winter	23.742	0.0	278.2	0
240 min Winter	19.206	0.0	300.1	0
360 min Winter	14.133	0.0	331.2	0
480 min Winter	11.375	0.0	355.5	0
600 min Winter	9.604	0.0	375.1	0
720 min Winter	8.359	0.0	391.8	0
960 min Winter	6.708	0.0	419.2	0
1440 min Winter	4.910	0.0	460.3	0
2160 min Winter	3.587	0.0	504.3	0
2880 min Winter	2.866	0.0	537.4	0
4320 min Winter	2.086	0.0	586.5	0
5760 min Winter	1.662	0.0	623.3	0
7200 min Winter	1.393	0.0	652.9	0
8640 min Winter	1.205	0.0	678.0	0
10080 min Winter	1.068	0.0	700.7	0

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Cascade Rainfall Details for Swale 2b 1-100 rev 01.SRCX

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Shortest Storm (mins)	15
Ratio R	0.344	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.465

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.232	4	8	0.233

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Cascade Model Details for Swale 2b 1-100 rev 01.SRCX

Storage is Online Cover Level (m) 27.500

Swale Structure

Infiltration Coefficient Base (m/hr)	0.00000	Length (m)	160.0
Infiltration Coefficient Side (m/hr)	0.00000	Side Slope (1:X)	3.0
Safety Factor	2.0	Slope (1:X)	160.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	26.500	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5		

Orifice Outflow Control

Diameter (m) 0.723 Discharge Coefficient 0.600 Invert Level (m) 25.500

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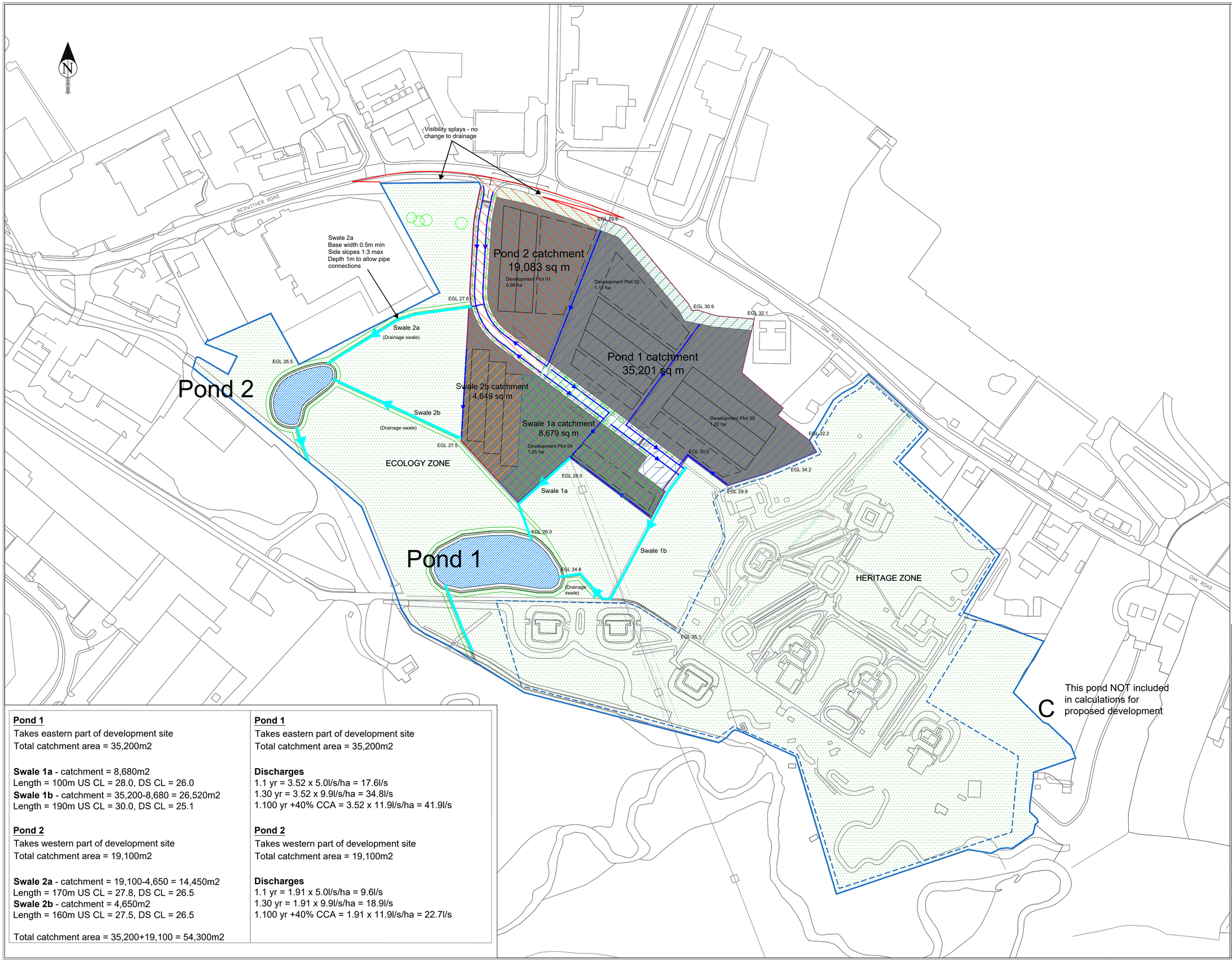


Pond 1
Takes eastern part of development site
Total catchment area = 35,200m2

Swale 1a - catchment = 8,680m2
Length = 100m US CL = 28.0, DS CL = 26.0
Swale 1b - catchment = 35,200-8,680 = 26,520m2
Length = 190m US CL = 30.0, DS CL = 25.1

Pond 2
Takes western part of development site
Total catchment area = 19,100m2

Swale 2a - catchment = 19,100-4,650 = 14,450m2
Length = 170m US CL = 27.8, DS CL = 26.5
Swale 2b - catchment = 4,650m2
Length = 160m US CL = 27.5, DS CL = 26.5

Total catchment area = 35,200+19,100 = 54,300m2

Pond 1
Takes eastern part of development site
Total catchment area = 35,200m2

Discharges
1.1 yr = 3.52 x 5.0l/s/ha = 17.6l/s
1.30 yr = 3.52 x 9.9l/s/ha = 34.8l/s
1.100 yr +40% CCA = 3.52 x 11.9l/s/ha = 41.9l/s

Pond 2
Takes western part of development site
Total catchment area = 19,100m2

Discharges
1.1 yr = 1.91 x 5.0l/s/ha = 9.6l/s
1.30 yr = 1.91 x 9.9l/s/ha = 18.9l/s
1.100 yr +40% CCA = 1.91 x 11.9l/s/ha = 22.7l/s

Notes

1. Do not scale from drawing. Not issued for construction
2. Location and exact alignment of drainage and water strategy requirements requires confirmation on site.
3. Surface water sewer and drainage locations are indicative only and not to be used for construction
4. Topographic site levels have been ulitised for development of this be subject to change based on development finishing and layout amendments.

TerraConsult

Bold Business Centre, Bold Lane, Sutton, St Helens WA9 4TX

Client

Site
The Oaks Wrexham

Title
Proposed Drainage Catchments Plan

Scale	1:1,500 @ A1		
Drawing No.	TOW-TCL-HDG-XX-DR-D-0515		
Rev	Date	Description	
A	04/20	New Layout & Drainage Amendments	
B	04/21	New Layout & Drainage Amendments	
File	TOW-TCL-HDG-XX-DR-D-0515 REVB.DWG		
Date	04/21	Engineer	TCL
Drawn	PP GH	Checked	Final

APPENDIX 8

Pollution Hazard Plan

Pollution Hazard Table

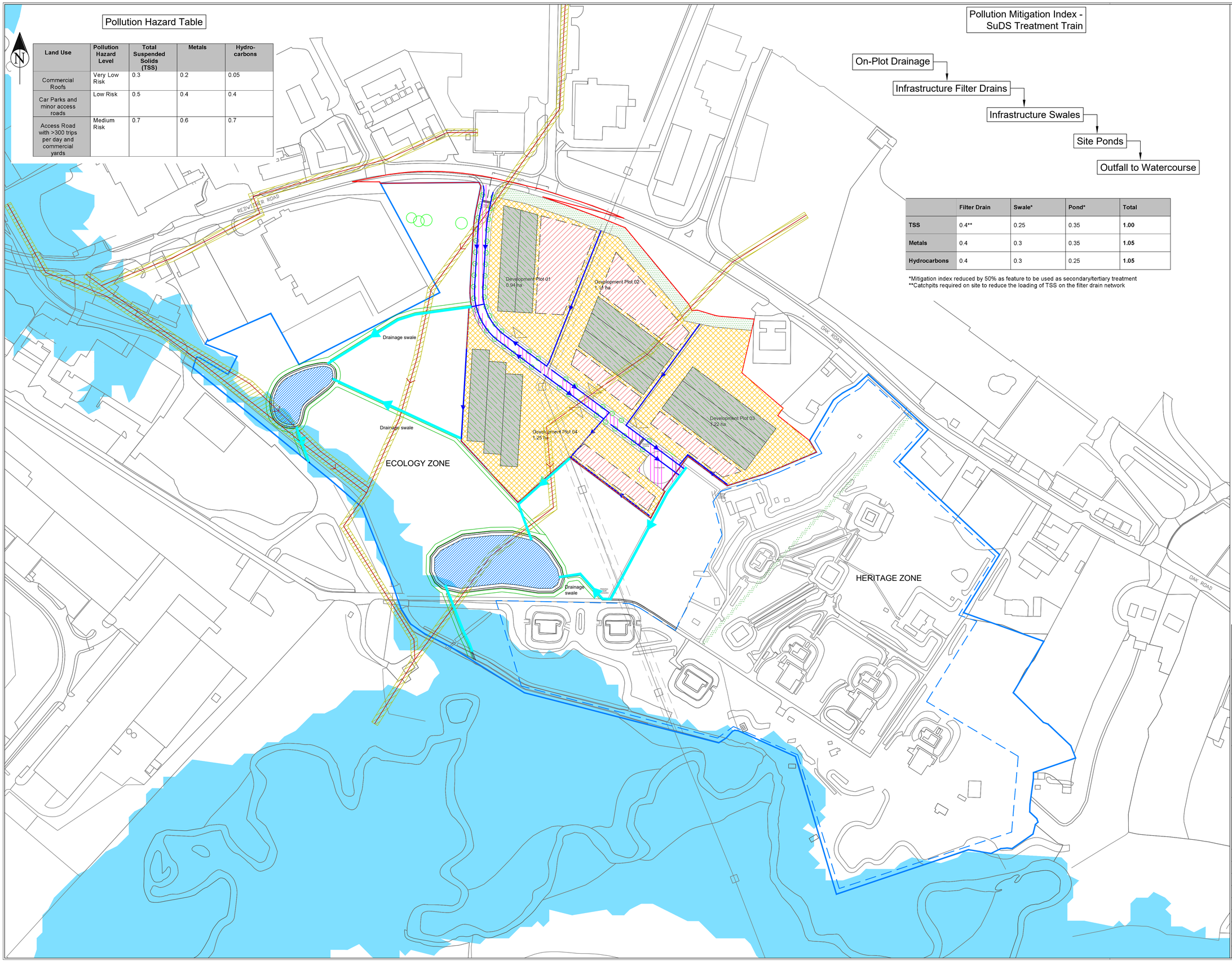
Land Use	Pollution Hazard Level	Total Suspended Solids (TSS)	Metals	Hydro-carbons
Commercial Roofs	Very Low Risk	0.3	0.2	0.05
Car Parks and minor access roads	Low Risk	0.5	0.4	0.4
Access Road with >300 trips per day and commercial yards	Medium Risk	0.7	0.6	0.7

Pollution Mitigation Index - SuDS Treatment Train

On-Plot Drainage → Infrastructure Filter Drains → Infrastructure Swales → Site Ponds → Outfall to Watercourse

	Filter Drain	Swale*	Pond*	Total
TSS	0.4**	0.25	0.35	**1.00**
Metals	0.4	0.3	0.35	**1.05**
Hydrocarbons	0.4	0.3	0.25	**1.05**

*Mitigation index reduced by 50% as feature to be used as secondary/tertiary treatment
**Catchpits required on site to reduce the loading of TSS on the filter drain network



Notes

1. Do not scale from drawing. Not issued for construction
2. Location and exact alignment of drainage and water strategy requirements requires confirmation on site.
3. Surface water sewer and drainage locations are indicative only and not to be used for construction
4. Topographic site levels have been ulitised for development of this drainage design. Levels may be subject to change based on development finishing and layout amendments.

Key

- Pollution Hazard - Med
- 1Pollution Hazard - Med
- Pollution Hazard - Low
- Pollution Hazard - V.Low
- Pond
- Filter Drain
- Swale
- Existing DCWW Easement
- Proposed DCWW Easement
- Existing DCWW Sewer
- Proposed DCWW Sewer
- Lle Flood Zone 2 Outline

TerraConsult

Bold Business Centre, Bold Lane, Sutton, St Helens WA9 4TX

Client

Site

The Oaks Wrexham

Title

Proposed Drainage Pollution Hazards Plan

Scale	1:1,500 @ A1	
Drawing No.	TOW-TCL-HDG-XX-DR-D-0545	
Rev	Date	Description
A	04/20	New Layout & Drainage Amendments
B	04/21	New Layout & Drainage Amendments
File	TOW-TCL-HDG-XX-DR-D-0545 RevB.dwg	
Date 04/21	Engineer TCL	
Drawn PP GH	Checked FINAL	