MONA OFFSHORE WIND PROJECT

Outline Operation Drainage Management Strategy

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This document has been prepared collaboratively between Wardell Armstrong and Mona Offshore Wind Limited and includes text written by Mona Offshore Wind Limited.

Contents

Glossary

Term	Meaning
Applicant	Mona Offshore Wind Limited.
Attenuation Basin	A man-made depression designed to temporarily store surface water run-off for controlled release into a watercourse or sewer network.
Bodelwyddan National Grid Substation	This is the Point of Interconnection (POI) selected by the National Grid for the Mona Offshore Wind Project.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Project (NSIP).
Filter Trench	A stone filled trench used for drainage conveyance, treatment and attenuation.
Greenfield Run-off Rate	The calculated run-off rate for an undeveloped site. Sometimes referred to as the pre-development run-off rate.
Lead Local Flood Authority	Lead Local Flood Authorities (LLFA) are responsible for managing flood risk from surface water, groundwater and ordinary watercourses Lead Local Flood Authorities have responsibility for developing a Local Flood Risk Management Strategy for their area identifying local sources of flooding. The local strategy produced must be consistent with the national strategy. It will set out the local organisations with responsibility for flood risk in the area, partnership arrangements to ensure co-ordination between these organisations, an assessment of the flood risk, and plans and actions for managing the risk.
Mona Offshore Wind Project	The Mona Offshore Wind Project is comprised of both the generation assets, offshore and onshore transmission assets, and associated activities.
Mona Onshore Development Area	The area in which the landfall, onshore cable corridor, onshore substation, mitigation areas, temporary construction facilities (such as access roads and construction compounds), and the connection to National Grid substation will be located
Maximum Design Scenario	The scenario within the design envelope with the potential to result in the greatest impact on a particular topic receptor, and therefore the one that should be assessed for that topic receptor.
Micro Drainage	Industry recognised software for the design of drainage systems.
Ordinary watercourses	The term used to describe a water course owned and operated by a local Drainage Board, a Lead Local Flood Authority or a private landowner.
Sustainable Drainage Systems (SuDS)	A sequence of management practices and control measures designed to mimic natural drainage processes by allowing rainfall to infiltrate, and by attenuating and conveying surface water runoff slowly at peak times.
SuDS Approving Body (SAB)	A service delivered by the Local Authority (Conwy County Borough Council and Denbighshire County Council) to ensure that drainage proposals for all new developments over 100m² of construction area are fit for purpose, designed and built in accordance with the National Standards for Sustainable Drainage published by Welsh Ministers.
The SuDS Manual	CIRIA guidance on SuDS for professionals working with drainage.

Term	Meaning
SuDS Treatment Train	A sequence of SuDS measures designed to mimic the natural surface water run-off from a catchment; by controlling volumes of run-off and reducing pollution (sometimes referred to as the management train).
Swale	A shallow channel with gently sloping sides used for drainage conveyance, treatment and attenuation.

Acronyms

Acronym	Description
CIRIA	Construction Industry Research and Information Association
DCC	Denbighshire County Council
DCO	Development Consent Order
EnBW	Baden-Württemberg AG
LLFA	Lead Local Flood Authority
NRW	Natural Resources Wales
NSIP	Nationally Significant Infrastructure Project
PPW	Planning Policy Wales
SAB	SuDs Approval Body
SuDS	Sustainable Drainage System
TAN	Technical Advice Note

Units

Unit	Description
km	Kilometre
m	Metre
m AOD	Metre Above Ordnance Datum
m/s	Metres per second
m^2	Meters squared
m^3	Metres cubed
mm	Millimetre
MW	Megawatt
%	Percentage

1 OUTLINE OPERATIONAL DRAINAGE MANAGEMENT STRATEGY

1.1 Introduction

1.1.1.1 Wardell Armstrong have been employed by Mona Offshore Wind Limited (the Applicant), a joint venture of bp Alternative Energy Investments Ltd (hereafter referred to as bp) and Baden-Württemberg AG (hereafter referred to as EnBW) to provide civil engineering support for the new Onshore Substation.

1.1.1.2 The purpose of this report is to present the preliminary outline drainage strategy, based on the indicative site layout (Figure 1-1). The scope of this report is to provide a preliminary drainage strategy for the Onshore Substation site.

1.1.1.3 The information presented is indicative and is dependent upon the accuracy and reliability of the information and data available to Wardell Armstrong at the time of writing. Any party developing the drainage strategy should satisfy themselves in that regard.

1.2 Purpose of the Outline Operational Drainage Management Plan

1.2.1.1 This Outline Operational Drainage Management Strategy sets out the information proposed to be included within the Operational Drainage Management Strategy, including:

- Operational surface water management: information on the Sustainable Drainage System (SuDS) measures to be adopted for potential infiltration, attenuation, treatment and conveying of surface water from the Onshore Substation
- Operational foul water management: information on wastewater arising from the Onshore Substation

1.2.1.2 Parameters such as the storage volumes, runoff rates and proposed discharge rates quoted in this Outline Operational Drainage Management Strategy relate to the maximum design scenario for the Mona Offshore Wind Project and will be subject to review during the detailed design stage.

1.2.1.3 In the event that the Development Consent Order (DCO) is granted, a detailed Operational Drainage Management Strategy will be prepared following the principles of this outline Plan and agreed with the relevant planning authority prior to construction.

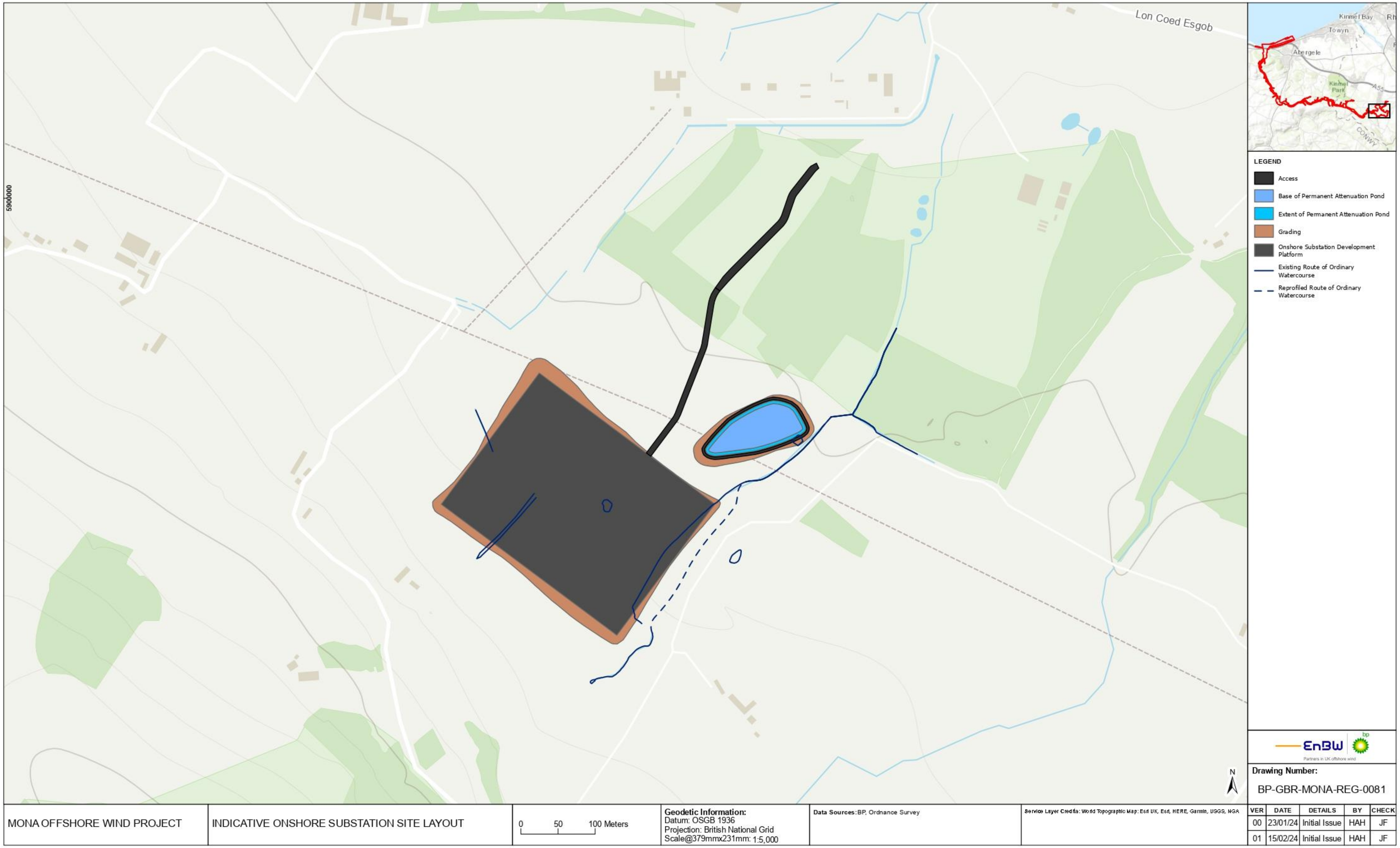


Figure 1-1 Indicative onshore substation site layout

*Permanent access road to continue northwards indicative alignment not shown

1.3 Site location and description

1.3.1.1 The Onshore Substation is centred at National Grid Reference SJ 01500 73049, on agricultural land at Cefnmeiriadog, approximately 1.7 km south west of St Asaph, Denbighshire (Figure 1-2).

1.3.1.2 The site lies to the south of the existing National Grid Bodelwyddan substation and the B5381 Glascoed Road, and approximately 1 km to the west of the Cefn road. Areas of woodland lie to the north of the site boundary, with agricultural land to the south, east and west.

Figure 1-2: Onshore Substation Location

1.4 Relevant legislation and policy

1.4.1 Flood and Water Management Act 2010

1.4.1.1 The proposed Mona Offshore Wind Project comprises an offshore generating station with a capacity of greater than 350 MW and therefore is a Nationally Significant Infrastructure Project (NSIP), as defined by Section 15(3) of the Planning Act 2008. As such, there is a requirement to submit an application for a DCO to the Secretary of State.

1.4.1.2 In Wales, all new developments where the construction area is 100 m^2 or more (such as the onshore elements of the Mona Offshore Wind Project), will require SuDS for surface water. The SuDS must be designed and built in accordance with Statutory SuDS Standards published by the Welsh Ministers and SuDS Schemes must be approved by the local authority acting in its SuDS Approving Body (SAB) role before construction work begins.

1.4.1.3 The Applicant notes that schedule 3 paragraph 7 to the Flood and Water Management Act 2010 contains the requirement for approval, from the relevant approval body, of the SuDS prior to construction of the development. However, paragraph 7(3) contains an exemption for "*work requiring development consent under section 31 of the Planning Act 2008*" (i.e. NSIPs). This is confirmed in the relevant statutory guidance under exemptions from the need for SAB approval.

1.4.1.4 It is therefore intended that relevant SuDS principles will be applied to the Onshore Substation development and secured through a requirement of the DCO. Discharge of the DCO Requirement would require review and approval of SuDS details by Denbighshire County Council (DCC) post-consent and before the commencement of works rather than in parallel to the planning application.

1.4.2 The Statutory Standards for SuDS

1.4.2.1 The Welsh Government's Statutory Standards for SuDS document (2018) includes a list of principles which underpin the design of surface water management schemes. The principles form the objectives for applying the six standards, which are as follows:

- Standard S1: Surface water runoff destination
- Standard S2: Surface water runoff hydrological control
- Standard S3: Water quality
- Standard S4: Amenity
- Standard S5: Biodiversity
- Standard S6: Design of drainage for construction, operation and maintenance

1.4.3 The Principles of SuDS

1.4.3.1 The Statutory Standards for SuDS states that schemes should aim to implement SuDS in order to:

- manage surface water on or as close to the source of the runoff as possible
- treat rainfall as a valuable natural resource
- ensure pollution is prevented at source

- manage rainfall to help protect people from increased flood risk
- take account of likely future pressures on flood risk, the environment and water resources such as climate change and urban creep
- use the SuDS Treatment Train, using drainage components in series across a site to achieve a robust surface water management system
- maximise the delivery of benefits for amenity and biodiversity
- seek to make the best use of available land through multifunctional usage of public spaces and the public realm
- perform safely, reliably, and effectively over the design life of the development considering the need for reasonable levels of maintenance
- avoid the need for pumping where possible; and be affordable, considering both construction and long-term maintenance costs and the additional environmental and social benefits afforded by the system

1.4.4 Other relevant legislation, policy and guidance

1.4.4.1 The design and construction of the Mona Offshore Wind Project will also adhere to other statutory legislation, policy & guidance, Including, but not limited to:

- National Policy Statement for Energy (NPS EN-1)
- National Policy Statement for Renewable Energy Infrastructure (NPS EN-3)
- National Policy Statement for Electricity Networks Infrastructure (NPS EN-5)
- Planning Policy Wales 11 (PPW 11)
- Technical Advice Note 15 (TAN 15) (2004)
- TAN 15 (2021)
- Conwy Local Development Plan, 2013
- Denbighshire Local Development Plan, 2013
- Electricity Safety, Quality and Continuity Regulations 2002
- BS EN 752:2017 Drain and Sewer Systems Outside Buildings
- BS EN 858-1:2002 Separator Systems for Light Liquids
- BS EN 12056-3:2000 Gravity Drainage Systems Inside Buildings
- CIRIA C753 The SuDS Manual (2015)

1.5 Existing conditions

1.5.1 Existing drainage regime

1.5.1.1 The site is undeveloped agricultural land with an unnamed watercourse running south east to north east under the eastern edge of the Onshore Substation.

1.5.1.2 LIDAR data obtained for the area shows the topography of the site tends towards the unnamed watercourse, sloping from a high point of approximately 65 m AOD in the south east to a low point of approximately 50 m AOD in the north east. Appendix A shows the existing contours.

1.5.2 Local ground conditions

1.5.2.1 The BGS Geology of Britain mapping (1:50,000 scale) indicates the entirety of the proposed Onshore Substation is underlain by glacial till (diamicton) superficial deposits. The far west extent of the Onshore Substation is underlain by Clwyd Limestone Group (limestone) while the remainder of the site is underlain by Warwickshire Group (mudstone, siltstone, and sandstone). The glacial till is likely to have low permeability which means infiltration drainage is unlikely to be suitable for the site, this will be reviewed at the detailed design stage.

1.5.3 Hydrological catchment

1.5.3.1 The Onshore Substation is located within the catchment of the River Elwy, a Main River which conveys flows to the east approximately 1.5 km to the south of the substation platform (see Volume 7, Annex 2.2: Surface watercourses and NRW flood zones of the Environmental Statement). The river converges with the River Clwyd some 3.9 km to the northeast of the Onshore Substation platform and discharges to the Irish Sea approximately 7.8 km to the north of the Onshore Substation platform at Rhyl.

1.5.3.2 OS mapping shows the ordinary watercourse located in the east of the Onshore Substation platform rises from a well and conveys flow to the north, eventually discharging to Pengwern Drain, a NRW designated Main River and eventually discharges to the River Clwyd.

1.5.4 Flood risk

1.5.4.1 This section of the report summaries the flood consequences to the proposed Onshore Substation. For more information refer to the Flood Consequences Assessment (document reference F.7.2.1).

Flood risk from rivers and the sea

1.5.4.2 The NRW Flood Map for Planning (Natural Resources Wales, 2022) shows flood risk from rivers and the sea. This data indicates that the site is within Sea and River Flood Zone 1 and therefore the risk of onsite flooding from rivers and the sea is very low (less than 1 in 1000 annual probability including an allowance for climate change).

Flood risk from surface water

1.5.4.3 The NRW Flood Map for Planning (Natural Resources Wales, 2022) shows flood risk from surface water and small watercourses. This data indicates that the majority of the site is in Flood Zone 1 for Surface Water and Small Watercourses and the risk of flooding from surface water is predominately very low (less than 1 in 1000 annual probability including an allowance for climate change), with some areas in Flood Zone 2 and 3 at a high risk (greater than 1 in 100 year annual probability including an allowance for climate change). The areas of Zones 2 and 3 are predominately associated with water flow within the unnamed watercourse and existing drainage ditches and is shown to be contained within their respective channels.

1.5.4.4 The existing unnamed watercourse identified in section 1.3 passes below the proposed Onshore Substation. As such, the existing unnamed watercourse will be diverted. Any proposed diversion will, as a minimum, use the same dimensions as the existing watercourse to ensure existing flow capacities are maintained.

Historic flooding and flood risk from other sources

1.5.4.5 The NRW Flood Map for Planning (Natural Resources Wales, 2022) shows 'Recorded Flood Extents'. The data indicates that there have been no recorded incidents in the past of flooding from rivers, the sea or surface water within or adjacent to the Onshore Substation. There is also no recorded history of significant groundwater flooding on the site (Denbighshire County Council, 2011), which suggests the risk of groundwater flooding is low.

1.5.4.6 Other sources of flooding have been investigated, namely from reservoirs, canals and sewers and it has been concluded that the site is at low risk of flooding from these sources. More information is available in the Flood Consequences Assessment (document reference F.7.2.1).

Future risk

1.5.4.7 The predicted effects of climate change indicate that peak rainfall intensities will increase over the lifetime of the development, and thus increase the risk of surface water flooding at the site. Table 2 of Flood Consequences Assessments: Climate change allowances (Welsh Government, 2021) recommends a national precautionary sensitivity of between 20% (central estimate) and 40% (upper end estimate) for peak rainfall intensity for the time horizon of the year 2070 to 2115 and between 5% (central estimate) and 10% (upper end estimate) for 2015 to 2039. It is recommended that peak rainfall intensities used should be increased in line with this guidance for between 2015 and 2039 for the temporary works, and between 2070-2115 for the permanent works. Although an indicative operational project lifetime of 35 years has been used widely in project assessments, an assessment period of 40 years has been used in this document to allow for increases in the proposed operational life of the substation, therefore the 2070-2115 timescale has been used and a 40% allowance for climate change adopted.

Potential constraints at the site

1.5.4.8 Potential constraints at the Onshore Substation include the capacity of the unnamed watercourse, its location, which passes below the Onshore Substation, and surface water overland flows from higher ground to the south and west. The following control measures are proposed to address these constraints:

- By controlling the run-off from the Onshore Substation to the greenfield run-off rate, there will be no increase in flows to the unnamed watercourse and therefore the potential capacity constraint is effectively mitigated.
- By diverting the unnamed watercourse away from the Onshore Substation, this constraint can be effectively mitigated.
- By incorporating cut-off drains / ditches at the Onshore Substation perimeter, to intercept and divert overland flows, the constraint relating to overland flows from higher ground can be effectively mitigated.

1.5.4.9 It is therefore expected that the risk of surface water flooding to the development can be adequately managed using an appropriately designed and constructed surface water drainage system, in conjunction with carefully considered ground levels. The design of the site surface water drainage system should make allowance for existing watercourses/drains and for the predicted effects of climate change.

1.6 SuDS opportunities and constraints

1.6.1 Overview

1.6.1.1 The Statutory Standards for SuDS sets out six standards which must be complied with when designing surface water drainage systems. Opportunities and constraints for SuDS to be incorporated into the proposed development are discussed with reference to each of the Standards in this section. The specific measures determined during the detailed design stage and presented in the detailed Operational Drainage Management Strategy.

1.6.1.2 The aims of SuDS are to reduce the quantity of surface water runoff, improve the quality of surface water runoff, and provide an amenity and biodiversity value. SuDS seek to mimic natural drainage systems and retain water on or near to the site, when and where rain falls. SuDS offer significant advantages over conventional drainage systems in relation to flood risk by reducing the quantity of surface water runoff from a site and the speed at which it reaches water courses promoting groundwater recharge and improving water quality and amenity.

1.6.1.3 The range of potential SuDS that can be selected for use within the development will largely be dependent upon special constraints, provision of space for permeable development and the composition and permeability of ground conditions.

1.6.2 SuDS components

1.6.2.1 The SuDS Manual (CIRIA, 2015) provides a summary of the types of SuDS components that are available to a designer. Table 1-1 lists these components and provides a summary of their suitability for the Onshore Substation, based on guidance set out the SuDS Manual, the assessment of the SuDS pillars, currently available information, and potential disposal options.

Table 1-1 SuDS components

SuDS Component	Commentary
Rainwater harvesting systems	The need for non-potable water within any site buildings will be minimal and as such this is likely to be an inappropriate use of resources on this site, although further design development will be required to inform this decision.
Green roofs	Due to the small amount of roof space, it is unlikely that green roofs will be utilised as part of the drainage strategy.
Infiltration systems	Desktop studies indicate the underlying strata on site (superficial deposits of Glacial Till) will be unsuitable for infiltration, therefore infiltration systems will not be utilised.
Proprietary treatment systems	Proprietary oil separator treatment systems are likely to be required to treat run-off from bunded transformer bays, where SuDS systems are not feasible to treat surface water draining to watercourses.
Filter strips	The requirements of the development and spatial constraints are unlikely to allow the use of filter strips in the surface water drainage scheme.
Filter drains	It is likely that most of the site (excluding footpaths and access roads) will be surfaced using a permeable stone surface. This permeable surface area can be designed to treat run-off from roads in the same way filter drains treat run-off. Filter drains are likely to be used to drain the access roads.
Swales	There is potential for swales to be used to act as drainage for the access track and along the construction and operational compounds.

SuDS Component	Commentary
Bioretention systems	The requirements of the development and spatial constraints are unlikely to allow the use of bioretention systems in the surface water drainage scheme.
Pervious pavements	The geotechnical constraints are unlikely to allow the use of pervious paving for direct infiltration due to the low permeability of the ground.
Attenuation storage tanks	The requirements of the development and spatial constraints are unlikely to allow the use of attenuation storage tanks in the surface water drainage scheme.
Attenuation basins	There is potential for attenuation basins to be used for water storage within the site.
Ponds and wetlands	There is potential for ponds to be used for water storage within the site.

1.6.3 Standard S1: Surface water runoff destination

1.6.3.1 Standard S1 of the Statutory Standards for SuDS is set out as a hierarchy of discharge destinations. Guidance on Standard S1 includes that "*as much of the runoff as possible (subject to technical or cost constraints) should be discharged to each destination before a lower priority destination (level) is considered*". Standard S1 prioritises the destinations of surface water discharge in the following order:

- 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

Priority Level 1: Surface water runoff is collected for use

1.6.3.2 Standard S1 states that, "*rainwater should be collected (harvested) for non-potable use where practicable*", and that this "*not only reduces potable water demand, but it can also reduce the volume of surface water runoff requiring disposal*".

1.6.3.3 There may be potential for rainfall runoff to be collected and harvested for re-use, but it is unlikely that there will be enough demand on this development. The potential re-use of rainwater for non-potable use could be explored during the detailed design stage.

Priority Level 2: Surface water runoff is infiltrated to ground

1.6.3.4 Standard S1 states that "*surface runoff not collected for use in accordance with Level 1 should be discharged by infiltration (a process that allows water to percolate into the ground) to the maximum extent possible at any location across the site*".

1.6.3.5 Infiltration SuDS features include pervious pavements, soakaways, swales, infiltration basins, and filter drains. However, the proximity of buildings and structures and the limited green space within the site will limit the implementation of some features.

1.6.3.6 A lower priority destination should only be used for any residual runoff that cannot be served by infiltration provided one or more of the following exception criteria can be demonstrated:

- Permeability: the use of infiltration drainage is not practicable due to the lack of permeability of the soil for disposing of runoff
- Ground Instability: the use of infiltration drainage would result in a risk of instability through ground movement or subsidence
- Pollution of groundwater or receiving surface waters: the use of infiltration drainage would pose an unacceptable risk of pollution of groundwater or surface water bodies

1.6.3.7 The guidance to Standard S1 states that the "*disposal of significant events using solutions such as soakaway units or infiltration basins usually requires infiltration rates of the order of 1 x* 10^{-5} *m/s or higher*", but that "*effective infiltration can be achieved with lower rates* [less than 1 x 10^{-5} m/s] *under units such as permeable pavements due to the large storage and infiltrating surface area available and the removal of sediment which would otherwise blind the infiltration surface*".

1.6.3.8 Hardstanding areas (pedestrian footpaths, access roads, parking bays etc.) could incorporate permeable paving depending on results of soakaway testing and ground conditions.

1.6.3.9 Due to the low permeability of the glacial till it is anticipated that infiltration will not be a suitable solution for the site.

Priority Level 3: Surface water runoff is discharged to a surface water body

1.6.3.10 Standard S1 states that "*surface runoff not collected for use in accordance with Level 1 or discharged to ground in accordance with Level 2 should be discharged to a receiving surface water body*".

1.6.3.11 The (diverted) unnamed watercourse identified in section 1.5 has been identified as the primary point of discharge for the disposal of surface water. It is intended that surface water from the stie will drain into a new attenuation basin, and then be discharged at a controlled rate into the unnamed watercourse. This is subject to detailed surveys confirming the capacity of the watercourse. It is also likely to require consultation with statutory bodies and potentially further investigation / modelling into the potential capacity for increased flows.

1.6.3.12 Due to the low permeability of the underlying glacial till, infiltration is unlikely to be an effective solution at the site. It is therefore proposed that a new attenuation basin is constructed and utilised as a sustainable attenuation feature.

Priority Level 4: Surface water runoff is discharged to a surface water sewer, highway drain or another drainage system

1.6.3.13 Standard S1 states that Priority Level 4 should only be used where certain exception criteria are met, and that only if runoff cannot be discharged in accordance with Levels 1, 2, or 3, should the runoff be discharged to a surface water sewer or a highway drain.

1.6.3.14 No surface water sewers have been identified near the Onshore Substation and therefore this is not a suitable solution for the site.

Priority Level 5: Surface water runoff is discharged to a combined sewer

1.6.3.15 Standard S1 states that "*there is a strong presumption against a discharge to combined sewer*", and that "*runoff not discharged in accordance with Levels 1 to 4 may be discharged to a public combined sewer with the agreement of the sewerage undertaker*".

1.6.3.16 No combined sewers have been identified near the Onshore Substation, therefore this is not a suitable solution for the site.

1.6.4 Standard S2: Surface water runoff hydraulic control

1.6.4.1 The guidance to Standard S2 states that its aim is to "*manage the surface water runoff from and on a site to protect people on the site from flooding from the drainage system for events up to a suitable return period, to mitigate any increased flood risk to people and property downstream of the site as a result of the development, and to protect the receiving water body from morphological damage*".

1.6.4.2 Standard S2 states that:

1. Surface water should be managed to prevent, as far as possible, any discharge from the site for the majority of rainfall events of less than 5mm.
2. The surface water runoff rate for the 1 in 1 year return period event (or agreed equivalent) should be controlled to help mitigate the negative impacts of the development runoff on the morphology and associated ecology of a receiving surface water body.
3. The surface water runoff (rate and volume) for the 1% (1 in 100 year) return period event (or agreed equivalent) should be controlled to help mitigate negative impacts of the development on flood risk in a receiving water body.
4. The surface water runoff for events up to the 1% (1 in 100 year) return period (or agreed equivalent) should be managed to protect people and property on and adjacent to the site from flooding from the drainage system.
5. The risks (both on site and off site) associated with the surface water runoff for events greater than the 1% (1 in 100 year) return period should be considered. Where the consequences are excessive in terms of social disruption, damage, or risk to life, mitigating proposals should be developed to reduce these impacts.
6. Drainage design proposals should be examined for the likelihood and consequences of any potential failure scenarios (e.g. structural failure or blockage), and the associated flood risks managed where possible

1.6.4.3 Standard S2 applies primarily to discharges to surface water bodies, surface water sewers, or combined sewerage systems (i.e. Priority Levels 3, 4, or 5 of Standard S1, as described above).

1.6.4.4 Hydraulic control measures could potentially reduce the risk of surface water and sewer flooding both on site and elsewhere. Potential measures are summarised below for the proposed development to intercept rainfall and surface water runoff, remove a proportion of its volume (through evapotranspiration), and attenuate its flow before it reaches an existing drainage system, thereby providing betterment to existing conditions:

- Tree pits – positively drained tree pits positioned within external areas of the surrounding site (subject to constraints) to intercept rainfall and drain surface water runoff. These could incorporate modular pits with engineered soils, and in-built irrigation, aeration, and root management systems

- Pervious pedestrian and shared use pavements with either total or partial infiltration to drain, treat, attenuate, and infiltrate surface water runoff
- Filter drain material – positively drained shallow filter material with land drains to intercept, treat, attenuate, and potentially infiltrate surface water runoff

1.6.4.5 Surface water discharge volumes and peak discharge rates should be controlled so as not to exceed, and where practicable reduce, the existing run-off rates. This could be achieved by using flow control devices in conjunction with attenuation storage.

Climate change

1.6.4.6 The guidance to Standard S2 also states that "*consideration should be given to likely future pressures on the site drainage system in accordance with current guidance, such as increasing intensity of rainfall due to climate change*". Guidance provided on Standard S4 in the Statutory Standards for SuDS, states that SuDS should contribute towards reducing hazards from climate change.

1.6.4.7 This can be achieved by including an allowance for climate change in the design of the SuDS. Peak rainfall intensities should be increased in line with Table 2 of Flood Consequences Assessments: Climate change allowances (Welsh Government, 2021). See section 1.7.10 for more details on the outline drainage strategy.

Control of surface water runoff

1.6.4.8 The proposed Onshore Substation will result in an increase in permanent impermeable area draining to the unnamed watercourse. It is likely that the Lead Local Flood Authority (LLFA) and SAB will require the scope of this project to reduce surface water runoff where practicable.

1.6.4.9 To comply with standard S1, detailed site investigation will be undertaken to confirm if infiltration measures are practicable. Subject to the results of the site investigation, discharge to the nearby unnamed watercourse is proposed.

1.6.4.10 Where infiltration is deemed to be practical on site, an appropriate Factor of Safety (FoS) will be applied to the design of any soakaways.

1.6.4.11 To achieve standard S2, the runoff from the site will need to be managed and controlled to limit the rate and volume of runoff that is discharged to the unnamed watercourse, and to mitigate flood risk to people and property.

1.6.4.12 Where attenuation is required, discharge to the receiving watercourse will be limited to the predevelopment greenfield run-off rate and an allowance for climate change incorporated in the design.

1.6.4.13 This may be achieved using interception and other SuDS storage and flow control devices such as: swales, attenuation basins and ponds.

1.6.4.14 Existing land drainage on site will be retained where possible or routes diverted where practicable. Any reduction or removal of existing storage depressions, if any, will be offset and accommodated within the final SuDS design.

1.6.4.15 Existing watercourses and flow routes will be appropriately managed to ensure continued conveyance around the perimeter of the Onshore Substation.

1.6.4.16 The relative advantages and disadvantages of each type of SuDS are set out in The SuDS Manual (CIRIA, 2015). An assessment will be made at the detailed design stage on the relative merits of each device, as a standalone or in combination with other devices, to satisfy all the Statutory SuDS Standards within the constraints of the development. Some devices, either alone or in combination with others, will contribute to meeting other statutory standards (e.g. water quality, amenity, and biodiversity).

1.6.4.17 The consequences of any potential failure scenarios (e.g. structural failure or blockage) may be mitigated by (for example) providing overflows from preferred/primary surface water discharge points such that an alternative destination for discharge is available.

1.6.4.18 It should be noted that while the benefits of certain SuDS in controlling surface water runoff through evapotranspiration are widely recognised, this benefit cannot yet be accurately modelled or reliably estimated.

1.6.4.19 An initial sizing of the volume of permanent attenuation required has been carried out based on the 1 in 100-year event in accordance with standards. Future sensitivity analysis will be conducted on the performance of the drainage system using the 1 in 1,000 year rainfall event (as required by National Grid standard 2.10.13). It is approximated that during the 1 in 100-year rainfall event with the upper climate change sensitivity of 40%, 5,015 m^3 of attenuation will be required to manage the surface water runoff from the Onshore Substation. This is likely to be provided by an attenuation basin which would discharge into the unnamed watercourse with the outfall constrained to the greenfield run-off rate of the site. See section 1.7.10 for more details on the outline drainage strategy.

1.6.5 Standard S3: Water Quality

1.6.5.1 Standard S3 of the Statutory Standards for SuDS requires that treatment be provided to "*prevent negative impacts on the receiving water quality and/or protect downstream drainage systems, including sewers*".

1.6.5.2 The generic design process for pollution control for a particular site is to provide a SuDS management train comprising:

- pollution prevention (removing the causes of pollution)
- interception (preventing runoff)
- treatment (treating runoff)

1.6.5.3 Where practicable, surface water runoff from impermeable areas shall require varying levels of treatment, depending on the use and potential for contamination. Areas at risk of contamination, such as the transformer bays are likely to require surface water run-off to flow through an oil separator.

1.6.5.4 Chapter 4.3 of the SuDS Manual (CIRIA, 2015) outlines two standards of good practice related to interception and treatment.

Water quality standard 1: Prevent runoff from the site to receiving surface water for the majority of small rainfall events

1.6.5.5 Interception is the capture and retention of the first 5 mm of rainfall events. This mimics greenfield hydraulic response characteristics where small rainfall events do not generally produce any runoff and will provide both water quantity and water quality benefits. Therefore, no runoff should be discharged from the site to receiving surface waters or sewers for the majority of small rainfall events (i.e. the first 5 mm for rainfall).

1.6.5.6 The runoff from small rainfall events can pose problems for water quality in the receiving surface waters because it contains the initial flush of pollutants that have built up on surfaces during the dry period and, due to the greater occurrence of smaller events over larger ones, there is frequent flushing of pollutants from surfaces. Additionally, the combined volume of runoff from all small rainfall events amounts to a significant proportion of the total runoff volume in any given period, and combined with the frequent flushing of pollutants, the total pollutant loadings from the site over a specified time period can be higher due to these smaller events.

1.6.5.7 Opportunities to incorporate these options into the proposed development will be explored during the detailed design stage.

Water quality standard 2: Treat runoff to prevent negative impacts on the receiving water quality

1.6.5.8 Runoff should be adequately treated to protect the receiving water body from:

- Short-term acute pollution that may result from accidental spills or temporary high pollution loadings within the catchment area
- Long-term chronic pollution from the spectrum of runoff pollutant sources within the urban environment

1.6.5.9 The extent of treatment required will depend on the land use, the level of pollution prevention in the catchment, and for groundwater the natural protection afforded by underlying soil layers. The sensitivity of the receiving waterbody should also be considered as some waterbodies are protected, for example those designated for drinking water abstraction or for other environmental reasons.

1.6.5.10 Table G3.1 in Standard S3 shows that, based on the proposed development use, the Pollution Hazard Level of the site could be considered to be ‘High’. This Pollution Hazard Level requires discharges may require an environmental licence or permit. Pre-permitting advice from NRW will be obtained during the detailed design stage and a risk assessment is likely to be required. As recommended by Standard S3, design should follow the approach explained in the SuDS Manual (CIRIA, 2015) Chapter 26, which outlines a robust pollutant removal strategy referred to as a SuDS Management Train.

1.6.5.11 Table G3.3 in Standard S3 summarises the indicative suitability of a range of SuDS components to provide treatment within the SuDS management train. Opportunities to incorporate one or more of these options into the proposed development should be explored during the detailed design stage.

1.6.6 Standard S4: Amenity

1.6.6.1 Standard S4 of the Statutory Standards for SuDS states that “*the design of the surface water management system should maximise amenity benefits*”.

1.6.6.2 The design of SuDS components should ensure that, where possible, they enhance the provision of high quality, attractive public space which can help provide health and wellbeing benefits, improve liveability for local communities and contribute to improving the climate resilience of new developments.

1.6.6.3 The guidance to Standard S4 explains how SuDS can add amenity value by contributing towards:

- making sites pleasant places to live or work
- reducing hazards from climate change
- creation of amenity space – contributing to green space accessibility standards
- promoting the well-being of site users

1.6.6.4 The SuDS Manual (CIRIA, 2015) defines amenity as "*a useful or pleasant facility or service*" which includes both tangible and intangible benefits.

1.6.6.5 The SuDS Manual also details a range of SuDS components which provide designers with flexibility to integrate surface water management within design and provide benefits for amenity.

1.6.6.6 The opportunity to plant vegetation and trees in the area surrounding the Onshore Substation will be explored to enhance visual character and biodiversity, as well as contributing to the control, interception, and treatment of runoff. See the outline Landscape and Environmental Management Plan (document reference J.22) for further detail on the proposed planting around the Onshore Substation.

1.6.7 Standard S5: Biodiversity

1.6.7.1 Standard S5 of the Statutory Standards for SuDS states that "*the design of the surface water management system should maximise biodiversity benefits*".

1.6.7.2 The aim is to ensure that, where possible, SuDS are designed to take advantage of opportunities to create ecologically rich green spaces/ corridors within the proposed development and enrich biodiversity value by linking networks of habitats and ecosystems together.

1.6.7.3 A green space is defined by The SuDS Manual (CIRIA, 2015) as an area of grass, trees, or other vegetation set apart for recreational or other aesthetic purposes in an otherwise industrial environment. A green corridor is defined as a strip of land in an urban area that can support habitats and allows wildlife to move along it.

1.6.7.4 Depending on specific constraints, SuDS can be designed to provide benefits in terms of runoff control, water quality, amenity, and biodiversity.

1.6.8 Standard S6: Design for construction, operation, and maintenance

1.6.8.1 Standard S6 of the Statutory SuDS Standards requires that:

- All elements of the surface water drainage system should be designed so that they can be constructed easily, safely, cost-effectively, in a timely manner, and minimising embedded carbon
- All elements of the surface water drainage system should be designed so that maintenance and operation can be undertaken easily, safely, cost-effectively, in a timely manner, and minimising embedded carbon

- The surface water drainage system should be designed to ensure structural integrity of all elements over the design life

1.6.8.2 The surface water drainage system will be designed and detailed in accordance with current best practice and guidance to meet this standard.

1.6.8.3 There will be ongoing maintenance responsibilities in relation to the SuDs. Section 32.4 of the SuDS Manual categorises maintenance work as follows:

- Regular maintenance – includes basic tasks which should be carried out to a frequent and predictable schedule
- Occasional maintenance – includes tasks that are likely to be required on a regular basis but at a less frequent rate compared to regular maintenance
- Remedial maintenance – includes tasks that may be required to rectify faults associated with the system. Although the amount of remedial maintenance can be reduced via good design and construction, unforeseen issues can occur. Remedial maintenance may be required due to site specific characteristic or unforeseen events

1.6.8.4 As part of the design of the SuDS, a SuDS Asset Maintenance Plan will need to be developed that sets out the regime for their maintenance and a schedule for each of the maintenance tasks.

1.6.9 SuDS Treatment Train

1.6.9.1 In addition to the standards outlined above the outline drainage management strategy has also been designed in accordance with the SuDS Treatment Train. The SuDS treatment train is a logical sequence for implementing SuDS and is based on the following principles:

- Prevention
- Source Control
- Site Control
- Regional Control

1.6.9.2 The outline drainage strategy uses a combination of source control and site control as the most suitable methods for managing surface water for a development of this type. This will be reviewed during the detailed design stage.

1.6.10 Summary of the outline drainage strategy for the management of surface water

1.6.10.1 The outline drainage strategy for the management of surface water for the Onshore Substation and associated hardstanding areas is summarised below.

Unnamed Watercourse - Channel Realignment

1.6.10.2 Where it passes below the Onshore Substation, the existing unnamed watercourse will be diverted. Any proposed diversion will, as a minimum, use the same dimensions as the existing watercourse to ensure existing flow capacities are maintained. The final design of the realigned watercourse will ensure that an 8 m buffer is maintained between the banks of the watercourse and the Onshore Substation. The opportunity will be taken to improve the new channel to a more natural channel with improved channel form, substrate and sinuosity for net biodiversity benefit.

Overland Flows

1.6.10.3 Surface water run-off, from topography tending towards the proposed location of the Onshore Substation, shall be redirected by installing cut-off drains / ditches at the Onshore Substation perimeter, thus diverting overland flows around the substation and back into the unnamed watercourse further north. Cut off drains / ditches will be designed at the detailed design stage to mimic existing overland flows.

Operational Access Road

1.6.10.4 Surface water run-off from the operational access road will be collected and attenuated within roadside filter trenches and/or swales before discharging to nearby watercourses. Additional SuDS components will be incorporated as necessary and are subject to detailed design.

Operational Onshore Substation

1.6.10.5 Based on current understanding of the local ground conditions and in line with the SuDS hierarchy (subject to detailed site investigation), it is anticipated that surface water run-off from the Onshore Substation will be collected by perimeter drains and contained within an adjacent attenuation basin (site control), prior to a controlled discharge to the nearby unnamed watercourse. Additional SuDS components will be incorporated as necessary (source control) – to be reviewed at the detailed design stage. Preliminary design of the attenuation basin is outlined below.

1.6.10.6 Figure 1-3 shows the indicative Onshore Substation layout and proposed SuDs including the parameter drainage and attenuation basin. This figure is indicative only and subject to further detailed design.

Figure 1-3: Outline drainage strategy

Attenuation basin – indicative design

1.6.10.7 To comply with The Welsh Government's minimum design requirements outlined in the Statutory Standards for SuDS, and to cater for the Mona Offshore Wind Farm Projects maximum design scenario, the following design parameters have been adopted:

- Hardstanding areas: the substation footprint is assumed to be 60% hardstanding (maximum design scenario). The designed top area of the SuDS basin is also included in the design.
- Greenfield run-off rate: restricted to the 1 in 1-year rainfall event (Standard S2) up to the selected design storm event (see below). IH124, FEH and ICP SuDS methods have been calculated (using the HR Wallingford Online Tool and Micro Drainage software) and the lowest (worst case) rate selected.
- Design storm event: Designed to cater for up to the 1 in 100-year storm event (Standard S2). FEH13 rainfall figures used for design.
- Climate change allowance: Standard S2 requires that consideration be given to climate change. A 40% increase in rainfall intensity has been adopted in line with the upper estimate allowances (up to 2070-2115) from Adapting to Climate Change: Guidance for Flood and Coastal Erosion Risk Management Authorities in Wales (The Welsh Government, 2022).
- Design depth: A maximum design depth of 1 m has been adopted up to the design storm event as a worst case scenario for estimating the SuDS basin footprint. An overall construction depth of 1.5 m at the shallowest point has been adopted to incorporate a freeboard within the design, and to provide a suitable shape and profile.
- Sensitivity checks: Additional sensitivity checks have been undertaken to assess the impact of the 1 in 1000-year storm event (plus 40% climate change) and the impact of a 1 in 10 year storm event (plus 40% climate change) occurring within 24 hours of the design storm event (1 in 100-year storm event +40% climate change).

1.6.10.8 Preliminary micro drainage calculations, using the above parameters, have confirmed the total storage required for the 1 in 100-year design event (+40% climate change) - with a design depth of 1 m - is approximately 5,015 m^3.

1.6.10.9 Sensitivity checks confirm there is sufficient freeboard within the overall 1.5 m construction depth of the attenuation basin to cater for the 1 in 1000 year event (+40% climate change).

1.6.10.10 Furthermore, the sensitivity checks also confirm there is sufficient freeboard within the overall construction depth of the attenuation basin to cater for a 1 in 10-year (+40% climate change) event within 24 hours of the design event (1 in 100-year +40% climate change).

1.6.10.11 Based on the above, an attenuation basin with an overall construction depth of 1.5m and a plan area of approximately 7,665 m^2 is sufficient for the design.

1.6.10.12 Preliminary drainage calculations (including greenfield run-off estimates, Micro Drainage calculations and a SuDS Design Summary and Assumptions spreadsheet) can be viewed in Appendix B of this report.

Outline foul water drainage strategy

1.6.10.13 The exact details of any welfare areas associated with the Onshore Substation are still to be determined. The Onshore Substation will be un-manned, therefore foul water quantities will be minimal and mainly limited to planned maintenance periods. It is anticipated that any foul water flows from the site will drain to a septic tank or package treatment plant prior to discharge to ground (subject to the suitability of the ground conditions) or a nearby watercourse. Alternatively, collection in a storage tank for off site disposal may be adopted. This will be determined during the detailed design stage.

Future maintenance

1.6.10.14 The maintenance of the operational drainage will be secured through the approved final Operational Drainage and Management Strategy. The undertaker will ensure that appropriate and clear responsibilities are set out within the approved plan.

1.6.10.15 The maintenance schedule for the various surface water features will be included in the final Operational Drainage and Management Strategy once the detailed design of each element has been confirmed.

1.7 Conclusion

1.7.1.1 This report gives details of the outline operational drainage strategy for the Onshore Substation and has been prepared in accordance with national and local guidance.

1.7.1.2 Existing surface water flows can be managed appropriately on site, and the proposals incorporate the principles of SuDS to manage surface water run-off from hardstanding areas on site.

1.7.1.3 The unnamed watercourse crossing the Onshore Substation will be diverted east to mitigate the potential flood risk from this source.

1.7.1.4 Cut-off drains / ditches will be provided to re-direct overland flows away from the proposed Onshore Substation footprint – to mitigate the potential flood risk from this source.

1.7.1.5 Subject to detailed site investigation, an attenuation basin with a controlled discharge to the unnamed watercourse has been selected as the most appropriate method of surface water disposal.

1.7.1.6 Sufficient space is available for an attenuation basin catering for run-off from the Onshore Substation (60% hardstanding) up to the 1:100-year design storm (+40% climate change) when discharge is limited to the 1:1 year greenfield run-off rate.

1.7.1.7 Sufficient freeboard is allowed for in the design to cater for up to the 1:1000-year storm event (+40%CC) or a 1:10-year storm event (+40% CC) occurring within 24 hours of the design storm event (1:100-year + 40% CC).

1.7.1.8 The associated permanent access road will be drained by roadside filter trenches and/or swales before discharging to nearby watercourses.

1.7.1.9 Additional SuDS measures will be reviewed and incorporated at the detailed design stage to comply with statutory requirements and best practice guidance.

1.8 References

CIRIA (2015) The SuDS Manual. London: CIRIA

Denbighshire County Council (2011) Preliminary Flood Risk Assessment Flood Risk Regulations (2009). Available at: https://www.denbighshire.gov.uk/en/documents/your-council/strategies-plans-and-policies/strategies/community-and-living/local-flood-risk-management-strategy/preliminary-flood-risk-assessment-flood-risk-regulations-2009.pdf Accessed November 2023

MET Office (2018) UKCP Data. Available at: https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/data/index Accessed November 2023

Natural Resources Wales (2022) Flood Maps for Planning. Available at https://flood-map-for-planning.naturalresources.wales/ Access November 2023

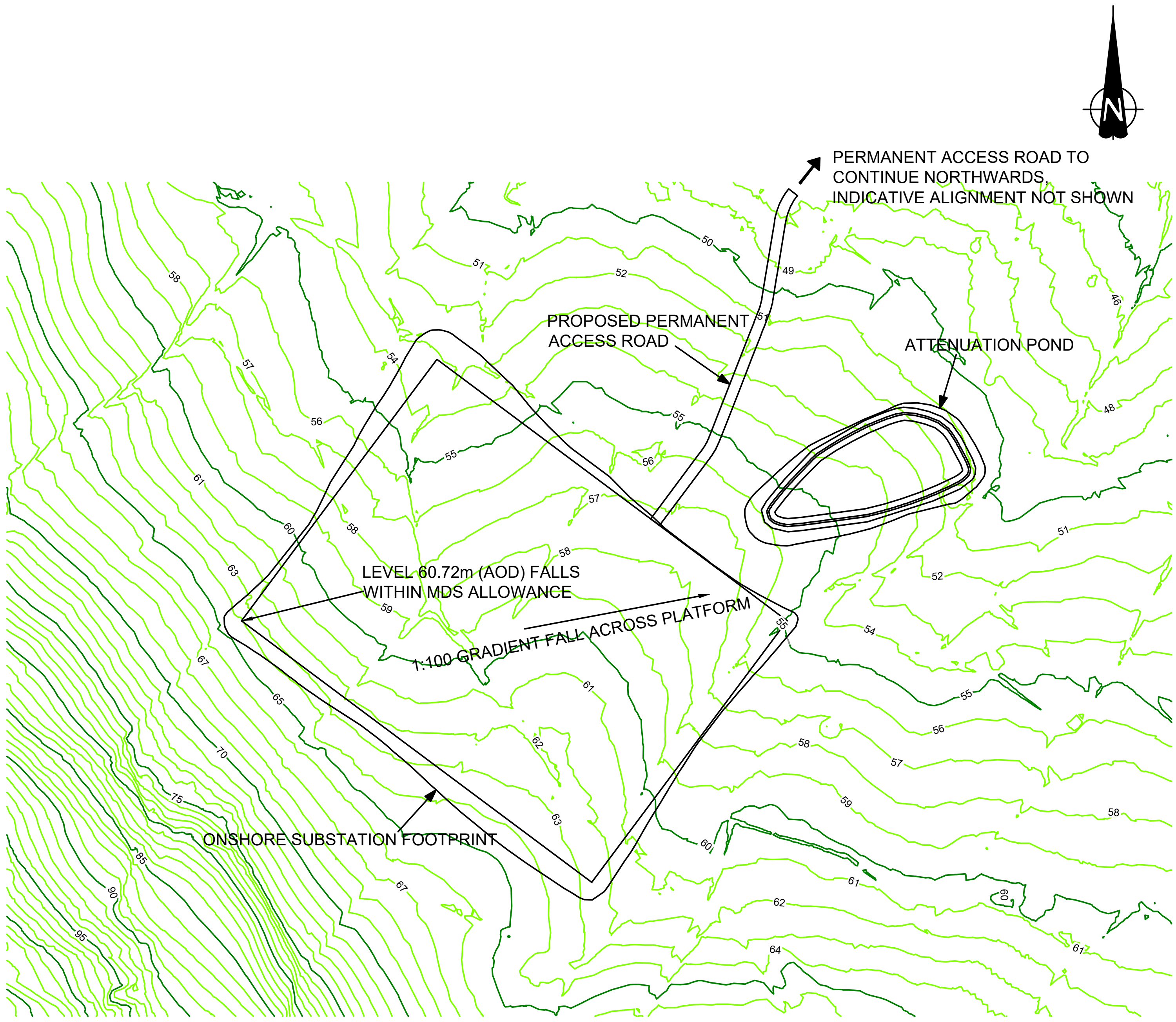
Welsh Government (2018) Statutory Standards for Sustainable Urban Drainage Systems – designing, constructing, operating, and maintaining surface water drainage systems. Available at https://www.gov.wales/national-standards-sustainable-drainage-systems-suds Access November 2023

Welsh Government (2021) Flood Consequences Assessments: Climate change allowances. Available at https://www.gov.wales/sites/default/files/publications/2021-09/climate-change-allowances-and-flood-consequence-assessments_0.pdf Access November 2023

A. Drawings

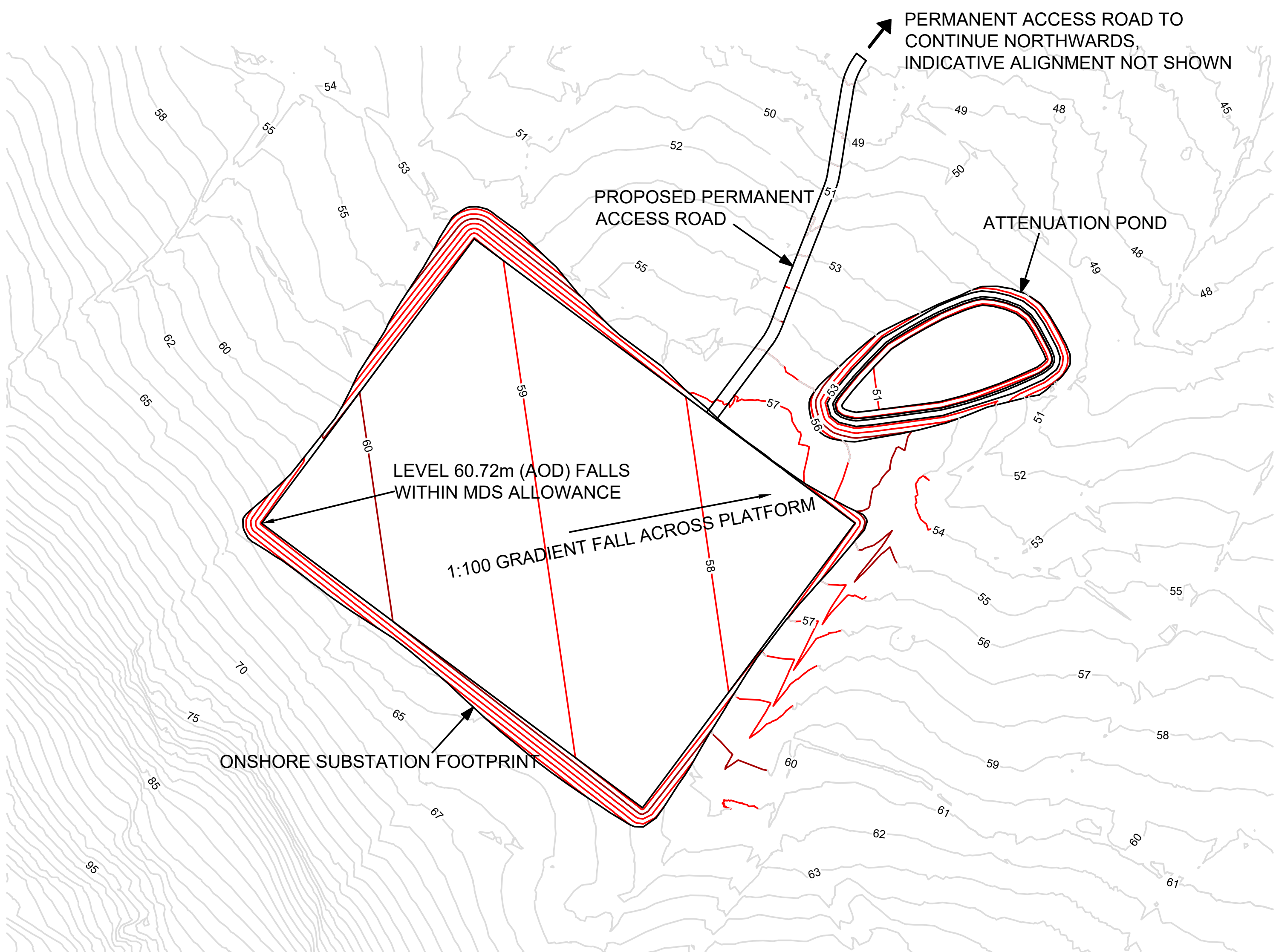
DO NOT SCALE FROM THIS DRAWING

EXISTING GROUND CONTOURS



APPROXIMATE PROPOSED CONTOURS

THE FINISHED GROUND LEVELS RELATE TO THE TOP OF THE COMPACTED EARTHWORKS (SOIL) PLATFORM AND DO NOT INCLUDE ANY SUBSEQUENT PLACEMENT OF GRANULAR FILL (E.G. 6F5, TYPE 1, TYPE 3 ETC.) AS MAY BE NECESSARY TO FORM A DEVELOPMENT PLATFORM FOR CONSTRUCTION.



KEY

- EXISTING GROUND
- PROPOSED GROUND
- UNMODIFIED PROPOSED GROUND CONTOUR

NOT FOR CONSTRUCTION PURPOSES

REVISION	DETAILS	DATE	DR'N	CHK'D	APP'D
A	FIRST ISSUE	04-02-24	AJC	MW	AH

CLIENT
MONA OFFSHORE WIND LIMITED

PROJECT
MONA OFFSHORE WIND FARM

DRAWING TITLE
ONSHORE SUBSTATION EXISTING AND PROPOSED GROUND LEVEL CONTOURS

DRG No.	REV	SUIT.
ED13798-GE-1058	A	

DRG SIZE	SCALE	DATE
A3	1:4000	14 FEB 2024

DRAWN BY	CHECKED BY	APPROVED BY
AJC	MW	AH

wardell armstrong

N:\ST\ED13798 - MONA WINDFARM (ST SHADOW)\DESIGN\ED13798-GE-1058-A ONSHORE SUBSTATION EXISTING AND PROPOSED CONTOURS.DWG

B. Preliminary drainage calculations

SUDS Design Summary - Mona - Substation Option 2 - 29.08.23

Notes:

1. SUDS design proposal to attenuate surface water flows from substation hardstanding areas associated with Mona substations (not including access roads, cable sealing compounds or any other unknown / undefined hardstanding areas).

2. Substation footprints assumed to be 60% hardstanding for design.

3. Drainage from substations to discharge to SUDS Basin then to an existing watercourse at the pre-development run-off rate. To mimic existing drainage regime and achieve no net increase in flows to receiving watercourse.

4. SUDS design undertaken in line with national and local guidance and as set out in The SUDS Manual (C753).

5. Pre Development discharge rates estimated using ICP SUDS / IH124 / FEH method - Micro Drainage design software / HR Wallingford Greenfield Runoff Rate Estimation Online Tool.

6. SUDS sizing estimated using FEH13 Rainfall and Micro Drainage design software.

7. Additional SUDS to be provided as source control / treatment during detailed design.

Design Parameters / Assumptions	Mona	Notes
Hardstanding (all footprints assumed 100% impermeable)		
Substation operational footprint (m2)	39,029	
SUDS Basin Footprint (including perimeter access track) (m2)	7,664	Substation operational footprint = 220.5m x 295m = 65047.5m^2. 60% hardstanding = 39,028.5m^2.
Total (m2)	**46,693**	
Pre-Development Run-Off Rates (calculated from HR Wallingford Greenfield Runoff Rate Estimation Online Tool) (l/s)		
2 l/s/ha (l/s)	**7.81**	
	ICP SUDS Method	
1 Year Return (l/s)	**6.8**	
2 Year Return (Q_{BAR}) **(l/s)**	7.2	
30 Year Return (l/s)	13.6	
100 Year Return (l/s)	16.8	
200 Year Return (l/s)	-	
	IH124 Method	
1 Year Return (l/s)	**21.61**	
2 Year Return (Q_{BAR}) (l/s)	24.56	
30 Year Return (l/s)	43.72	
100 Year Return (l/s)	53.54	
200 Year Return (l/s)	60.42	
	FEH Method	
1 Year Return (l/s)	**22.28**	
2 Year Return (Q_{BAR}) (l/s)	25.31	
30 Year Return (l/s)	45.06	
100 Year Return (l/s)	55.18	
200 Year Return (l/s)	62.27	
Attenuated Post Development Run-Off Rates	**Limited to pre-development 1-year ICP SUDS run-off rate as worst case. Provides betterment over 1-year IH124 rate, 1-year FEH rate and 2 l/s/ha rate.**	
Design Storm Event	**1 in 100 year + 40% climate change as per national and local guidance.**	Welsh guidance suggests a 40% allowance for climate change (upper end estimate for 2070 to 2115) should be used for permanent works.
Attenuation Storage Required (calculated from FEH13 Rainfall using Micro Drainage design software) (m3)		
All Hardstanding Areas (m3)	5,014.5	
Total storage required (m3)	**5014.5**	

Design Check - Attenuation Dimensions (m)		
Design Top area (m2)	5,935	
Freeboard Top area (m2)	6,389	
Perimeter access track top area (m2)	7,626	
Basin Top area (m2)	7,664	
Base area (m2)	4,604	
Design storage depth (m)	1.0	
Design freeboard (design depth + 0.3m) (m)	1.3	
Overall depth (design depth + 0.5m) (m)	1.5	
Side slopes (m)	1 in 4	
Design Check - Attenuation Storage Provided		
Detention Basins		
Basin Design	5,270	
Freeboard	1,849	
Perimeter access track	701	
Additional storage between track and basin top	765	
Total (design)	**5,270**	
Total (inc. freeboard, access track etc)	8,584	
Design storage required < attenuation storage provided?	**YES = OK**	
Discharge Location	**Existing watercourse (TBC).**	**Design flows up to 1:100 year + 40% CC are attenuated within the basin design depth.** **Additional 300mm freeboard provided provided over and above design capacity with another 200mm to the top of the basin from the bottom edge of the access track (total 1.5m depth).**
Sensitivity Check - Attenuation Storage Provided		
Storage Requirements		
1 in 200 year + 40% climate change	**5,663.4**	
1 in 1000 year + 40% climate change	**7,238.7**	
Storage Available		
Total (inc. freeboard, access track etc)	**8,584**	
Sensitivity check storage required < attenuation storage provided?	**YES = OK**	
Sensitivity Check - Half Drain Down Time		
Half Drain Down Time = < 24 hours?	**NO**	
Surplus Storage Available (Over and Above Design Storm)		
Total (design)	5,270	
Total (inc. freeboard, access track etc)	8,584	
Surplus (freeboard minus design)	**3,314**	
1 in 10 year + 40% climate change	**2994.9**	
Subsequent storm surplus storage can cater for	**Up to 1 in 10 year**	
Sensitivity check storage required < attenuation storage provided?	**YES = OK**	

hr wallingford

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Sean Taylor
Site name:	ED13798 - Mona
Site location:	Substation Option 2

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site Details

Latitude:	53.25152° N
Longitude:	3.4841° W
Reference:	1229501475
Date:	Sep 04 2023 14:51

Runoff estimation approach

FEH Statistical

Site characteristics

Total site area (ha):	4.7

Methodology

Q_{MED} estimation method:	Calculate from BFI and SAAR
BFI and SPR method:	Specify BFI manually
HOST class:	N/A
BFI / BFIHOST:	0.365
Q_{MED} (l/s):	
Q_{BAR} / Q_{MED} factor:	1.08

Hydrological characteristics

	Default	Edited
SAAR (mm):	749	749
Hydrological region:	9	9
Growth curve factor 1 year:	0.88	0.88
Growth curve factor 30 years:	1.78	1.78
Growth curve factor 100 years:	2.18	2.18
Growth curve factor 200 years:	2.46	2.46

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Q_{BAR} (l/s):		25.31
1 in 1 year (l/s):		22.28
1 in 30 years (l/s):		45.06
1 in 100 year (l/s):		55.18
1 in 200 years (l/s):		62.27

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Sean Taylor
Site name:	ED13798 - Mona
Site location:	Substation Option 2

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site Details

Latitude:	53.25193° N
Longitude:	3.4826° W
Reference:	532008224
Date:	Sep 04 2023 14:48

Runoff estimation approach

IH124

Site characteristics

Total site area (ha): 4.7

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	4	4
HOST class:	N/A	N/A
SPR/SPRHOST:	0.47	0.47

Hydrological characteristics

	Default	Edited
SAAR (mm):	749	749
Hydrological region:	9	9
Growth curve factor 1 year:	0.88	0.88
Growth curve factor 30 years:	1.78	1.78
Growth curve factor 100 years:	2.18	2.18
Growth curve factor 200 years:	2.46	2.46

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Q_{BAR} (l/s):	24.56	24.56
1 in 1 year (l/s):	21.61	21.61
1 in 30 years (l/s):	43.72	43.72
1 in 100 year (l/s):	53.54	53.54
1 in 200 years (l/s):	60.42	60.42

ICP SUDS Mean Annual Flood

Input

Return Period (years)	2	SAAR (mm)	749	Urban	0.000
Area (ha)	3.903	Soil	0.300	Region Number	Region 9

Results	**l/s**
QBAR Rural	7.7
QBAR Urban	7.7
Q2 years	7.2
Q1 year	6.8
Q30 years	13.6
Q100 years	16.8

Summary of Results for 10 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.151	0.151	6.3	708.3	O K
30 min Summer	0.196	0.196	6.6	925.3	O K
60 min Summer	0.244	0.244	6.7	1161.4	O K
120 min Summer	0.303	0.303	6.8	1454.6	O K
180 min Summer	0.341	0.341	6.8	1642.4	O K
240 min Summer	0.368	0.368	6.8	1780.1	O K
360 min Summer	0.406	0.406	6.8	1974.0	O K
480 min Summer	0.432	0.432	6.8	2109.7	O K
600 min Summer	0.452	0.452	6.8	2211.3	O K
720 min Summer	0.467	0.467	6.8	2290.3	O K
960 min Summer	0.489	0.489	6.8	2403.5	O K
1440 min Summer	0.512	0.512	6.8	2526.2	O K
2160 min Summer	0.524	0.524	6.8	2588.0	O K
2880 min Summer	0.524	0.524	6.8	2587.0	O K
4320 min Summer	0.516	0.516	6.8	2545.1	O K
5760 min Summer	0.510	0.510	6.8	2511.9	O K
7200 min Summer	0.507	0.507	6.8	2499.4	O K
8640 min Summer	0.507	0.507	6.8	2496.5	O K
10080 min Summer	0.508	0.508	6.8	2503.2	O K
15 min Winter	0.168	0.168	6.4	793.5	O K
30 min Winter	0.219	0.219	6.7	1036.8	O K
60 min Winter	0.273	0.273	6.8	1301.7	O K
120 min Winter	0.339	0.339	6.8	1631.5	O K
180 min Winter	0.380	0.380	6.8	1843.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	81.308	0.0	383.4	19
30 min Summer	53.254	0.0	492.4	34
60 min Summer	33.582	0.0	881.6	64
120 min Summer	21.201	0.0	1053.5	124
180 min Summer	16.075	0.0	1109.7	184
240 min Summer	13.156	0.0	1118.8	244
360 min Summer	9.851	0.0	1112.1	364
480 min Summer	7.992	0.0	1097.3	482
600 min Summer	6.779	0.0	1080.5	602
720 min Summer	5.918	0.0	1063.4	722
960 min Summer	4.761	0.0	1029.9	962
1440 min Summer	3.482	0.0	968.2	1442
2160 min Summer	2.533	0.0	2045.1	2160
2880 min Summer	2.021	0.0	1959.0	2852
4320 min Summer	1.473	0.0	1793.7	3496
5760 min Summer	1.185	0.0	3690.1	4216
7200 min Summer	1.013	0.0	3746.6	5048
8640 min Summer	0.897	0.0	3628.0	5880
10080 min Summer	0.815	0.0	3465.0	6760
15 min Winter	81.308	0.0	431.4	19
30 min Winter	53.254	0.0	529.3	34
60 min Winter	33.582	0.0	972.2	64
120 min Winter	21.201	0.0	1112.4	122
180 min Winter	16.075	0.0	1131.3	182

Summary of Results for 10 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
240 min Winter	0.411	0.411	6.8	1998.9	O K
360 min Winter	0.454	0.454	6.8	2219.1	O K
480 min Winter	0.483	0.483	6.8	2374.4	O K
600 min Winter	0.506	0.506	6.8	2491.5	O K
720 min Winter	0.523	0.523	6.8	2583.4	O K
960 min Winter	0.549	0.549	6.8	2717.7	O K
1440 min Winter	0.577	0.577	6.8	2871.6	O K
2160 min Winter	0.595	0.595	6.8	2967.6	O K
2880 min Winter	0.600	0.600	6.8	2994.9	O K
4320 min Winter	0.592	0.592	6.8	2949.2	O K
5760 min Winter	0.579	0.579	6.8	2880.0	O K
7200 min Winter	0.573	0.573	6.8	2850.6	O K
8640 min Winter	0.569	0.569	6.8	2829.2	O K
10080 min Winter	0.567	0.567	6.8	2817.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
240 min Winter	13.156	0.0	1129.9	240
360 min Winter	9.851	0.0	1114.9	360
480 min Winter	7.992	0.0	1096.1	478
600 min Winter	6.779	0.0	1077.3	596
720 min Winter	5.918	0.0	1059.1	714
960 min Winter	4.761	0.0	1025.0	950
1440 min Winter	3.482	0.0	964.2	1414
2160 min Winter	2.533	0.0	2030.5	2100
2880 min Winter	2.021	0.0	1945.7	2772
4320 min Winter	1.473	0.0	1800.4	4064
5760 min Winter	1.185	0.0	3935.4	4616
7200 min Winter	1.013	0.0	3832.6	5544
8640 min Winter	0.897	0.0	3691.5	6480
10080 min Winter	0.815	0.0	3546.4	7368

Rainfall Details

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	10	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 302049 373327 SJ 02049 73327	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 4.669

Time (mins) From:	To:	Area (ha)
0	4	4.669

Model Details

Storage is Online Cover Level (m) 1.500

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	4604.4	1.000	5934.9	1.300	6389.0	1.400	7626.0	1.500	7664.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0122-6800-1000-6800
Design Head (m)	1.000
Design Flow (l/s)	6.8
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	122
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	6.8	Kick-Flo®	0.653	5.6
Flush-Flo™	0.299	6.8	Mean Flow over Head Range	-	5.9

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)	Depth (m)	Flow (l/s)
0.100	4.3	0.800	6.1	2.000	9.4	4.000	13.1	7.000	17.1
0.200	6.6	1.000	6.8	2.200	9.8	4.500	13.8	7.500	17.6
0.300	6.8	1.200	7.4	2.400	10.3	5.000	14.5	8.000	18.2
0.400	6.7	1.400	8.0	2.600	10.6	5.500	15.2	8.500	18.7
0.500	6.5	1.600	8.5	3.000	11.4	6.000	15.9	9.000	19.3
0.600	6.1	1.800	9.0	3.500	12.3	6.500	16.5	9.500	19.8

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.285	0.285	6.8	1363.8	O K
30 min Summer	0.376	0.376	6.8	1822.0	O K
60 min Summer	0.474	0.474	6.8	2327.4	O K
120 min Summer	0.569	0.569	6.8	2825.1	O K
180 min Summer	0.624	0.624	6.8	3125.0	O K
240 min Summer	0.663	0.663	6.8	3335.2	O K
360 min Summer	0.714	0.714	6.8	3614.1	O K
480 min Summer	0.748	0.748	6.8	3803.7	O K
600 min Summer	0.773	0.773	6.8	3942.1	O K
720 min Summer	0.791	0.791	6.8	4047.5	O K
960 min Summer	0.817	0.817	6.8	4194.7	O K
1440 min Summer	0.845	0.845	6.8	4352.2	O K
2160 min Summer	0.857	0.857	6.8	4421.7	O K
2880 min Summer	0.855	0.855	6.8	4409.8	O K
4320 min Summer	0.830	0.830	6.8	4268.4	O K
5760 min Summer	0.802	0.802	6.8	4107.1	O K
7200 min Summer	0.786	0.786	6.8	4017.9	O K
8640 min Summer	0.777	0.777	6.8	3969.0	O K
10080 min Summer	0.775	0.775	6.8	3954.5	O K
15 min Winter	0.318	0.318	6.8	1527.8	O K
30 min Winter	0.419	0.419	6.8	2041.3	O K
60 min Winter	0.528	0.528	6.8	2608.1	O K
120 min Winter	0.632	0.632	6.8	3167.7	O K
180 min Winter	0.694	0.694	6.8	3505.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	156.300	0.0	572.2	19
30 min Summer	104.552	0.0	579.0	34
60 min Summer	66.950	0.0	1150.5	64
120 min Summer	40.825	0.0	1116.2	124
180 min Summer	30.230	0.0	1077.8	184
240 min Summer	24.289	0.0	1037.3	244
360 min Summer	17.681	0.0	989.2	364
480 min Summer	14.062	0.0	968.6	484
600 min Summer	11.747	0.0	962.0	604
720 min Summer	10.126	0.0	963.3	724
960 min Summer	7.987	0.0	966.1	964
1440 min Summer	5.686	0.0	954.4	1442
2160 min Summer	4.020	0.0	1926.2	2160
2880 min Summer	3.138	0.0	1897.5	2880
4320 min Summer	2.204	0.0	1812.7	4320
5760 min Summer	1.725	0.0	3816.4	5248
7200 min Summer	1.443	0.0	3668.4	5912
8640 min Summer	1.257	0.0	3530.3	6664
10080 min Summer	1.128	0.0	3418.0	7464
15 min Winter	156.300	0.0	578.6	19
30 min Winter	104.552	0.0	576.7	34
60 min Winter	66.950	0.0	1138.9	64
120 min Winter	40.825	0.0	1079.6	124
180 min Winter	30.230	0.0	1020.3	182

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
240 min Winter	0.737	0.737	6.8	3742.1	O K
360 min Winter	0.793	0.793	6.8	4056.1	O K
480 min Winter	0.831	0.831	6.8	4270.9	O K
600 min Winter	0.858	0.858	6.8	4428.7	O K
720 min Winter	0.879	0.879	6.8	4549.8	O K
960 min Winter	0.909	0.909	6.8	4720.9	O K
1440 min Winter	0.941	0.941	6.8	4909.8	O K
2160 min Winter	0.958	0.958	6.8	5007.9	O K
2880 min Winter	0.959	0.959	6.8	5014.5	O K
4320 min Winter	0.939	0.939	6.8	4897.1	O K
5760 min Winter	0.913	0.913	6.8	4745.9	O K
7200 min Winter	0.893	0.893	6.8	4629.0	O K
8640 min Winter	0.880	0.880	6.8	4553.4	O K
10080 min Winter	0.876	0.876	6.8	4531.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
240 min Winter	24.289	0.0	993.2	242
360 min Winter	17.681	0.0	984.2	360
480 min Winter	14.062	0.0	998.4	480
600 min Winter	11.747	0.0	1008.3	598
720 min Winter	10.126	0.0	1013.7	716
960 min Winter	7.987	0.0	1016.1	952
1440 min Winter	5.686	0.0	1002.6	1426
2160 min Winter	4.020	0.0	2026.4	2120
2880 min Winter	3.138	0.0	1999.8	2820
4320 min Winter	2.204	0.0	1910.4	4152
5760 min Winter	1.725	0.0	3887.0	5472
7200 min Winter	1.443	0.0	3783.6	6696
8640 min Winter	1.257	0.0	3711.9	7000
10080 min Winter	1.128	0.0	3642.2	7864

Rainfall Details

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 302049 373327 SJ 02049 73327	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 4.669

Time (mins) From:	To:	Area (ha)
0	4	4.669

Model Details

Storage is Online Cover Level (m) 1.500

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	4604.4	1.000	5934.9	1.300	6389.0	1.400	7626.0	1.500	7664.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0122-6800-1000-6800
Design Head (m)	1.000
Design Flow (l/s)	6.8
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	122
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	6.8	Kick-Flo®	0.653	5.6
Flush-Flo™	0.299	6.8	Mean Flow over Head Range	-	5.9

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)	Depth (m)	Flow (l/s)
0.100	4.3	0.800	6.1	2.000	9.4	4.000	13.1	7.000	17.1
0.200	6.6	1.000	6.8	2.200	9.8	4.500	13.8	7.500	17.6
0.300	6.8	1.200	7.4	2.400	10.3	5.000	14.5	8.000	18.2
0.400	6.7	1.400	8.0	2.600	10.6	5.500	15.2	8.500	18.7
0.500	6.5	1.600	8.5	3.000	11.4	6.000	15.9	9.000	19.3
0.600	6.1	1.800	9.0	3.500	12.3	6.500	16.5	9.500	19.8

Summary of Results for 200 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.339	0.339	6.8	1633.3	O K
30 min Summer	0.450	0.450	6.8	2201.1	O K
60 min Summer	0.567	0.567	6.8	2815.8	O K
120 min Summer	0.668	0.668	6.8	3363.8	O K
180 min Summer	0.726	0.726	6.8	3682.2	O K
240 min Summer	0.766	0.766	6.8	3903.2	O K
360 min Summer	0.818	0.818	6.8	4201.4	O K
480 min Summer	0.853	0.853	6.8	4397.2	O K
600 min Summer	0.877	0.877	6.8	4537.5	O K
720 min Summer	0.896	0.896	6.8	4643.2	O K
960 min Summer	0.921	0.921	6.8	4790.3	O K
1440 min Summer	0.946	0.946	6.8	4939.4	O K
2160 min Summer	0.957	0.957	6.8	5002.1	O K
2880 min Summer	0.953	0.953	6.8	4980.5	O K
4320 min Summer	0.924	0.924	6.8	4807.6	O K
5760 min Summer	0.890	0.890	6.8	4609.4	O K
7200 min Summer	0.869	0.869	6.8	4488.5	O K
8640 min Summer	0.856	0.856	6.8	4417.5	O K
10080 min Summer	0.851	0.851	6.8	4387.3	O K
15 min Winter	0.378	0.378	6.8	1829.7	O K
30 min Winter	0.501	0.501	6.8	2465.9	O K
60 min Winter	0.630	0.630	6.8	3155.5	O K
120 min Winter	0.742	0.742	6.8	3770.5	O K
180 min Winter	0.806	0.806	6.8	4128.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	187.106	0.0	580.6	19
30 min Summer	126.219	0.0	573.4	34
60 min Summer	80.908	0.0	1124.6	64
120 min Summer	48.513	0.0	1046.6	124
180 min Summer	35.535	0.0	1001.9	184
240 min Summer	28.356	0.0	987.3	244
360 min Summer	20.498	0.0	995.7	364
480 min Summer	16.205	0.0	1010.2	484
600 min Summer	13.473	0.0	1018.0	604
720 min Summer	11.569	0.0	1021.8	724
960 min Summer	9.076	0.0	1021.9	964
1440 min Summer	6.410	0.0	1005.3	1442
2160 min Summer	4.505	0.0	2027.2	2164
2880 min Summer	3.501	0.0	1996.8	2880
4320 min Summer	2.441	0.0	1899.2	4320
5760 min Summer	1.899	0.0	3867.2	5472
7200 min Summer	1.579	0.0	3744.5	6056
8640 min Summer	1.370	0.0	3645.2	6824
10080 min Summer	1.225	0.0	3562.2	7568
15 min Winter	187.106	0.0	581.3	19
30 min Winter	126.219	0.0	566.4	34
60 min Winter	80.908	0.0	1088.3	64
120 min Winter	48.513	0.0	1002.5	124
180 min Winter	35.535	0.0	998.7	182

Summary of Results for 200 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
240 min Winter	0.849	0.849	6.8	4377.0	O K
360 min Winter	0.908	0.908	6.8	4713.8	O K
480 min Winter	0.946	0.946	6.8	4936.3	O K
600 min Winter	0.973	0.973	6.8	5096.9	O K
720 min Winter	0.994	0.994	6.8	5218.6	O K
960 min Winter	1.023	1.023	6.9	5390.4	O K
1440 min Winter	1.053	1.053	7.0	5571.4	O K
2160 min Winter	1.068	1.068	7.0	5663.4	O K
2880 min Winter	1.068	1.068	7.0	5661.2	O K
4320 min Winter	1.043	1.043	6.9	5511.4	O K
5760 min Winter	1.012	1.012	6.8	5329.0	O K
7200 min Winter	0.988	0.988	6.8	5186.1	O K
8640 min Winter	0.970	0.970	6.8	5077.5	O K
10080 min Winter	0.964	0.964	6.8	5040.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
240 min Winter	28.356	0.0	1019.9	242
360 min Winter	20.498	0.0	1047.9	362
480 min Winter	16.205	0.0	1062.5	480
600 min Winter	13.473	0.0	1070.2	598
720 min Winter	11.569	0.0	1073.7	716
960 min Winter	9.076	0.0	1072.8	952
1440 min Winter	6.410	0.0	1053.6	1426
2160 min Winter	4.505	0.0	2133.4	2120
2880 min Winter	3.501	0.0	2099.1	2824
4320 min Winter	2.441	0.0	1994.6	4188
5760 min Winter	1.899	0.0	4000.8	5480
7200 min Winter	1.579	0.0	3938.2	6704
8640 min Winter	1.370	0.0	3866.8	7176
10080 min Winter	1.225	0.0	3782.9	7968

Rainfall Details

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	200	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 302049 373327 SJ 02049 73327	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 4.669

Time (mins) From:	To:	Area (ha)
0	4	4.669

Model Details

Storage is Online Cover Level (m) 1.500

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	4604.4	1.000	5934.9	1.300	6389.0	1.400	7626.0	1.500	7664.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0122-6800-1000-6800
Design Head (m)	1.000
Design Flow (l/s)	6.8
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	122
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	6.8	Kick-Flo®	0.653	5.6
Flush-Flo™	0.299	6.8	Mean Flow over Head Range	-	5.9

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)	Depth (m)	Flow (l/s)
0.100	4.3	0.800	6.1	2.000	9.4	4.000	13.1	7.000	17.1
0.200	6.6	1.000	6.8	2.200	9.8	4.500	13.8	7.500	17.6
0.300	6.8	1.200	7.4	2.400	10.3	5.000	14.5	8.000	18.2
0.400	6.7	1.400	8.0	2.600	10.6	5.500	15.2	8.500	18.7
0.500	6.5	1.600	8.5	3.000	11.4	6.000	15.9	9.000	19.3
0.600	6.1	1.800	9.0	3.500	12.3	6.500	16.5	9.500	19.8

Summary of Results for 1000 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.478	0.478	6.8	2345.1	O K
30 min Summer	0.638	0.638	6.8	3198.0	O K
60 min Summer	0.807	0.807	6.8	4137.3	O K
120 min Summer	0.911	0.911	6.8	4731.0	O K
180 min Summer	0.969	0.969	6.8	5070.3	O K
240 min Summer	1.008	1.008	6.8	5303.3	O K
360 min Summer	1.060	1.060	7.0	5614.1	O K
480 min Summer	1.093	1.093	7.1	5816.4	O K
600 min Summer	1.117	1.117	7.2	5959.8	O K
720 min Summer	1.134	1.134	7.2	6066.5	O K
960 min Summer	1.158	1.158	7.3	6211.6	O K
1440 min Summer	1.181	1.181	7.3	6351.3	O K
2160 min Summer	1.188	1.188	7.4	6398.3	O K
2880 min Summer	1.181	1.181	7.3	6354.4	O K
4320 min Summer	1.144	1.144	7.2	6123.8	O K
5760 min Summer	1.101	1.101	7.1	5862.5	O K
7200 min Summer	1.067	1.067	7.0	5655.0	O K
8640 min Summer	1.044	1.044	6.9	5517.5	O K
10080 min Summer	1.030	1.030	6.9	5433.6	O K
15 min Winter	0.531	0.531	6.8	2627.0	O K
30 min Winter	0.708	0.708	6.8	3582.8	O K
60 min Winter	0.894	0.894	6.8	4635.1	O K
120 min Winter	1.008	1.008	6.8	5301.6	O K
180 min Winter	1.071	1.071	7.0	5683.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	268.448	0.0	571.8	19
30 min Summer	183.172	0.0	522.8	34
60 min Summer	118.666	0.0	1005.9	64
120 min Summer	68.083	0.0	1061.4	124
180 min Summer	48.805	0.0	1091.5	184
240 min Summer	38.411	0.0	1110.0	244
360 min Summer	27.281	0.0	1130.8	364
480 min Summer	21.330	0.0	1140.7	484
600 min Summer	17.592	0.0	1144.8	604
720 min Summer	15.013	0.0	1145.3	724
960 min Summer	11.668	0.0	1139.7	964
1440 min Summer	8.145	0.0	1113.9	1442
2160 min Summer	5.666	0.0	2252.6	2164
2880 min Summer	4.371	0.0	2209.1	2880
4320 min Summer	3.015	0.0	2088.6	4320
5760 min Summer	2.323	0.0	4185.1	5760
7200 min Summer	1.913	0.0	4098.3	6408
8640 min Summer	1.643	0.0	3998.8	7088
10080 min Summer	1.455	0.0	3887.7	7864
15 min Winter	268.448	0.0	562.5	19
30 min Winter	183.172	0.0	490.9	34
60 min Winter	118.666	0.0	1054.6	64
120 min Winter	68.083	0.0	1116.4	124
180 min Winter	48.805	0.0	1147.4	182

Summary of Results for 1000 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
240 min Winter	1.115	1.115	7.1	5946.4	O K
360 min Winter	1.172	1.172	7.3	6298.3	O K
480 min Winter	1.209	1.209	7.4	6528.7	Flood Risk
600 min Winter	1.235	1.235	7.5	6693.3	Flood Risk
720 min Winter	1.255	1.255	7.6	6816.8	Flood Risk
960 min Winter	1.282	1.282	7.6	6987.8	Flood Risk
1440 min Winter	1.309	1.309	7.7	7161.0	Flood Risk
2160 min Winter	1.321	1.321	7.7	7238.7	Flood Risk
2880 min Winter	1.317	1.317	7.7	7215.6	Flood Risk
4320 min Winter	1.285	1.285	7.6	7008.4	Flood Risk
5760 min Winter	1.247	1.247	7.5	6767.6	Flood Risk
7200 min Winter	1.214	1.214	7.4	6560.4	Flood Risk
8640 min Winter	1.186	1.186	7.4	6385.3	O K
10080 min Winter	1.167	1.167	7.3	6266.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
240 min Winter	38.411	0.0	1166.2	242
360 min Winter	27.281	0.0	1187.0	362
480 min Winter	21.330	0.0	1196.5	480
600 min Winter	17.592	0.0	1199.8	598
720 min Winter	15.013	0.0	1199.5	716
960 min Winter	11.668	0.0	1192.0	954
1440 min Winter	8.145	0.0	1161.9	1428
2160 min Winter	5.666	0.0	2360.9	2136
2880 min Winter	4.371	0.0	2311.1	2824
4320 min Winter	3.015	0.0	2178.8	4192
5760 min Winter	2.323	0.0	4413.6	5536
7200 min Winter	1.913	0.0	4318.4	6840
8640 min Winter	1.643	0.0	4212.2	8032
10080 min Winter	1.455	0.0	4096.1	8176

Rainfall Details

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	1000	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 302049 373327 SJ 02049 73327	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 4.669

Time (mins) From:	To:	Area (ha)
0	4	4.669

Model Details

Storage is Online Cover Level (m) 1.500

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	4604.4	1.000	5934.9	1.300	6389.0	1.400	7626.0	1.500	7664.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0122-6800-1000-6800
Design Head (m)	1.000
Design Flow (l/s)	6.8
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	122
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	6.8	Kick-Flo®	0.653	5.6
Flush-Flo™	0.299	6.8	Mean Flow over Head Range	-	5.9

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)	Depth (m)	Flow (l/s)
0.100	4.3	0.800	6.1	2.000	9.4	4.000	13.1	7.000	17.1
0.200	6.6	1.000	6.8	2.200	9.8	4.500	13.8	7.500	17.6
0.300	6.8	1.200	7.4	2.400	10.3	5.000	14.5	8.000	18.2
0.400	6.7	1.400	8.0	2.600	10.6	5.500	15.2	8.500	18.7
0.500	6.5	1.600	8.5	3.000	11.4	6.000	15.9	9.000	19.3
0.600	6.1	1.800	9.0	3.500	12.3	6.500	16.5	9.500	19.8