Technical Appendix

Lairdmannoch Energy Park

Technical Appendix 8-5: Flood Risk and Drainage Impact Assessment

Lairdmannoch Energy Park Limited

May 2025

LAIRDMANNOCH ENERGY PARK
LAND WEST OF THE A762, LAIRDMANNOCH, CASTLE DOUGLAS,
DUMFRIES AND GALLOWAY

FLOOD RISK AND DRAINAGE IMPACT ASSESSMENT

Final Report v1.2
April 2025

Weetwood Services Ltd
info@weetwood.net
www.weetwood.net

Report Title	**Lairdmannoch Energy Park** **Land West of the A762, Lairdmannoch, Castle Douglas, Dumfries and Galloway** Flood Risk and Drainage Impact Assessment Final Report v1.2
Client	Lairdmannoch Energy Park Limited
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Prepared by	Rebecca Murphy BSc (Hons) MCIWEM *Associate Director* Dan Hodson BEng (Hons) MCIWEM *Senior Engineer*
Checked by	Tim Brook BSc (Hons) MCIWEM *Technical Director*
Approved by	Rebecca Murphy BSc (Hons) MCIWEM *Associate Director*

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List of Abbreviations

AEP	Annual Exceedance Probability	LDP	Local Development Plan
agl	Above Ground Level	LFMP	Local Flood Management Plan
AOD	Above Ordnance Datum	LiDAR	Light Detection and Ranging
ASGWF	Areas Susceptible to Groundwater Flooding	LA	Local Authority
bgl	Below Ground Level	l/s	Litres per Second
BGS	British Geological Survey	m	Metres
BRE	Building Research Establishment	m^2	Square Metres
BSI	British Standards Institute	m^3	Cubic Metres
CC	Climate Change	NFM	Natural Flood Management
CCMA	Coastal Change Management Area	NGR	National Grid Reference
CFMP	Catchment Flood Management Plan	NPF4	National Planning Framework 4
CIRIA	Construction Industry Research and Information Association	NVZ	Nitrate Vulnerable Zone
		OS	Ordnance Survey
DEFRA	Department for Environment, Food and Rural Affairs	QBAR	Mean annual maximum runoff rate
		QMED	Median annual maximum runoff rate
DGC	Dumfries and Galloway Council	RBD	River Basin District
DIA	Drainage Impact Assessment	RBMP	River Basin Management Plan
DWPA	Drinking Water Protection Area	RFI	Request for Information (to SEPA)
EA	Environment Agency	RMA	Risk Management Authority
FCERM	Flood and Coastal Erosion Risk Management	RoFSW	Risk of Flooding from Surface Water
		SEPA	Scottish Environment Protection Agency
FFL	Finished Floor Level	SFRA	Strategic Flood Risk Assessment
FMP	Flood Management Plan	SMP	Shoreline Management Plan
FRA	Flood Risk Assessment	SoP	Standard of Protection
FRDIA	Flood Risk and Drainage Impact Assessment	SPP	Scottish Planning Policy
FRMP	Flood Risk Management Plan	SSSI	Site of Special Scientific Interest
FWA	Flood Warning Area	SuDS	Sustainable Drainage System
FWEP	Flood Warning and Evacuation Plan	SW	Scottish Water
FWS	Flood Warning System	SWMP	Surface Water Management Plan
GBBs	General Binding Rules	WFD	Water Framework Directive
Ha	Hectare		
km	Kilometres		

1 INTRODUCTION

1.1 Purpose of Report

Weetwood Services Ltd ('Weetwood') has been instructed by Lairdmannoch Energy Park Limited ("the Applicant") to prepare a Flood Risk and Drainage Impact Assessment (FRDIA) report to accompany a full planning application for the development of land north-east of Gatehouse of Fleet and approximately 10 km west of Castle Douglas (the "Proposed Development Site") for use as an energy park. The Proposed Development Site lies entirely within the Dumfries and Galloway Council (DGC) planning authority area.

The Proposed Development consists of nine wind turbines each with a tip height of 180 m agl, ground mounted solar panels, a battery energy storage system (BESS) and associated infrastructure. This report relates to the solar element of the scheme only (the "Solar Development"), with flood risk and drainage for the wind element assessed and reported on in **Chapter 8: Hydrology, Geology and Hydrogeology**.

The assessment has been undertaken in accordance with the requirements of National Planning Policy Framework 4 (NPF4).

1.2 Structure of the Report

The report is structured as follows:

Section 1 Introduction and report structure
Section 2 Provides background information relating to the development site
Section 3 Presents national and local flood risk and drainage planning policy
Section 4 Assesses the potential risk of flooding to the development site
Section 5 Presents an illustrative surface water drainage scheme
Section 6 Presents a summary of key findings and the recommendations

1.3 Relevant Documents and Planning Policy

The assessment has been informed by the following documents, policy and information:

- Climate Change Allowances for Flood Risk Assessment in Land Use Planning, Version 6, Scottish Environment Protection Agency (SEPA), February 2025;
- Flood Risk Standing Advice for Planning Authorities, SEPA, July 2024;
- Flood Risk and Land Use Vulnerability Guidance, SEPA, July 2024;
- National Planning Framework 4, Scottish Government, February 2023;
- Technical Flood Risk Guidance for Stakeholders: Scottish Environment Protection Agency Requirements for Undertaking a Flood Risk Assessment, Version 13, SEPA, June 2022;
- Flood Risk Management Plan 2022 - 2028: Solway Local Plan District (LPD 14), DGC in partnership with SEPA, Scottish Water and other partners, 2022;
- Flood Risk Management Plan: Solway Local Plan District, SEPA, December 2021;
- The River Basin Management Plan for Scotland 2021 - 2027, SEPA and Scottish Government, December 2021;
- The River Basin Management Plan for the Solway Tweed River Basin District 2021 Update, SEPA and Environment Agency (EA), Undated;
- Supplementary Guidance - Flooding and Development, DGC, February 2020;
- Supplementary Guidance - Surface Water Drainage and Sustainable Drainages Systems (SuDS), DGC, February 2020;
- Local Development Plan 2, DGC, October 2019;
- Development Management Guidance: Flood Risk, SEPA, July 2018;
- BRE Digest 365 Soakaway Design, BRE, February 2016;
- The SuDS Manual (C753), CIRIA, December 2015;
- Strategic Flood Risk Assessment: Scottish Environment Protection Agency Technical Guidance to Support Development Planning, SEPA, August 2015;

- Surface Water Policy: Standard Advice Note and Process Guidance, Scottish Water, Undated, https://www.scottishwater.co.uk/Help-and-Resources/Document-Hub/Business-and-Developers/Connecting-to-Our-Network
- HR Wallingford Greenfield Runoff Tool, www.uksuds.com;
- National Soil Map of Scotland, Scottish Government, https://map.environment.gov.scot/Soil_maps/;
- National Geoscience Data Centre's Single Onshore Borehole Index, https://www.bgs.ac.uk/products/onshore/SOBI.html;
- British Geological Survey (BGS) Mapping of Surface Geology, https://www.bgs.ac.uk/map-viewers/geoindex-onshore/; and
- Scotland's Environment Map, Scottish Government, https://map.environment.gov.scot/sewebmap/.

1.4 Third Party Surveys, Drawings and Assessments

The assessment has been informed by the following third party drawing:

- Figure 1-2 Site Layout, Atmos Consulting, Ref. TL010 40418/SL/093c, March 2025 (**Appendix A**).

1.5 Explanatory Note on Flood Probability

This report refers to the likelihood of a flood event occurring in terms of an annual exceedance probability (AEP) expressed as a percentage. This terminology is consistent with the definitions utilised by SEPA (refer to **Section 4.2** of this report).

The AEP is the reciprocal of the return period which describes the rarity of an event in terms of its statistical reoccurrence interval in years. For example, a '1 in 30 year flood' has a 1/30 = 0.033 (3.3%) probability of occurring or being exceeded in any one year, whilst a '1 in 100 year flood' has a 1/100 = 0.010 (1.0%) probability of occurring or being exceeded in any one year.

AEP	AEP (expressed as a %)	Return Period (years)	Alternative Expression
1.000	100.0%	1	1 in 1
0.500	50.0%	2	1 in 2
0.435	43.5%	2.3	1 in 2.3
0.100	10.0%	10	1 in 10
0.050	5.0%	20	1 in 20
0.033	3.3%	30	1 in 30
0.020	2.0%	50	1 in 50
0.010	1.0%	100	1 in 100
0.005	0.5%	200	1 in 200
0.001	0.1%	1,000	1 in 1,000

2 SITE DETAILS AND PROPOSED DEVELOPMENT

2.1 Site Location

The approximately 612.2 hectare (ha) greenfield Proposed Development Site is located to the west of the A762 and east of Laurieston Road at Ordnance Survey National Grid Reference (OS NGR) NX 66233 62404, as shown in **Figure 1**. The Solar Development is in the east of the Proposed Development Site and comprises a parcel to the north and south of Tarff Water (refer to **Figure 2**).

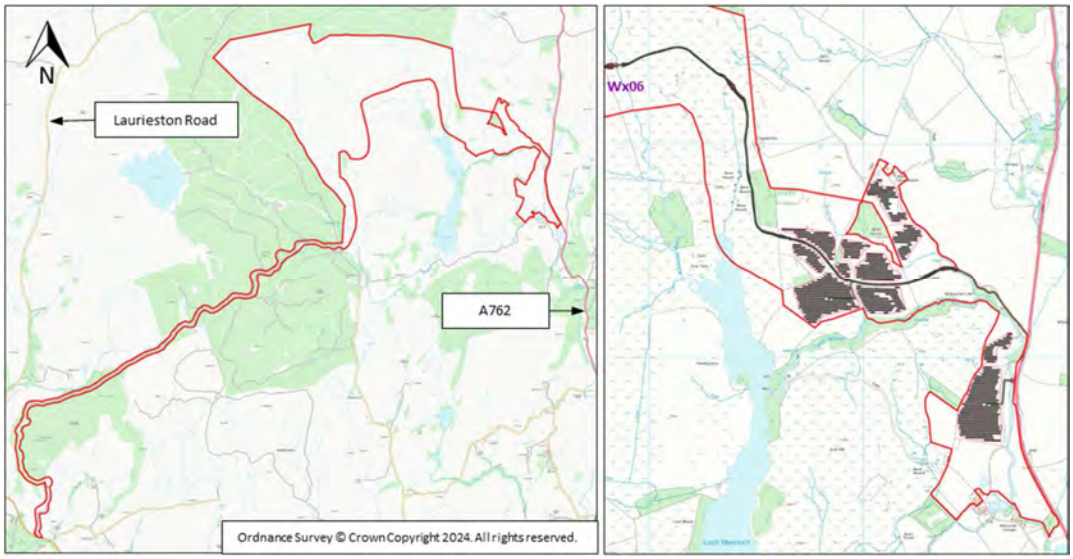


Figure 1: Site Location

2.2 Proposed Development

The Proposed Development consists of nine wind turbines each with a tip height of 180 metres above ground level (m agl), ground mounted solar panels, a BESS and associated infrastructure including:

- Access tracks;
- Turbine foundations and crane hardstandings;
- Substation;
- One borrow pit;
- Underground cabling;
- Temporary construction compound;
- Solar infrastructure including a power station and switching and breaking station; and
- Up to eight watercourse crossings.

The Solar Development consists of the following key elements: PV solar panels and associated support frames and cabling, two PV power stations (one in the north and south parcel), a switching station (in the north parcel), internal access tracks, security fencing, and landscaping.

Vehicular access to the Proposed Development Site will be provided via the existing access off the A762, which will be upgraded and extended as necessary to facilitate the Proposed Development. Access to the parcel of land to the south of Tarff Water will be provided via a new access crossing over Tarff Water circa. 230 m to the south.

The Proposed Development Site layout is provided in **Appendix A**.

The SEPA Flood Risk and Land Use Vulnerability Guidance classifies essential utility infrastructure as Essential Infrastructure.

2.3 Surface Waterbodies in the Vicinity of the Proposed Development Site

Tarff Water flows in an easterly and then southerly direction adjacent to and through the proposed Solar Development. Flows into Tarff Water are controlled via a weir and spillway on Loch Mannoch, located to the west and south of the Solar Development.

Anstool Burn flows in a southerly direction through the Proposed Development Site, to the west of the proposed Solar Development and outfalls to Loch Mannoch.

Barstobrick Burn flows in a south-westerly direction to the east of the Proposed Development Site and A762 before being culverted under the A762 and flowing in open channel along the south-eastern boundary of the Proposed Development Site, ultimately outfalling to Tarff Water.

OS mapping indicates the presence of a number of existing drainage ditches and small surface waterbodies on and within the vicinity of the Proposed Development Site as illustrated in **Figure 2**.

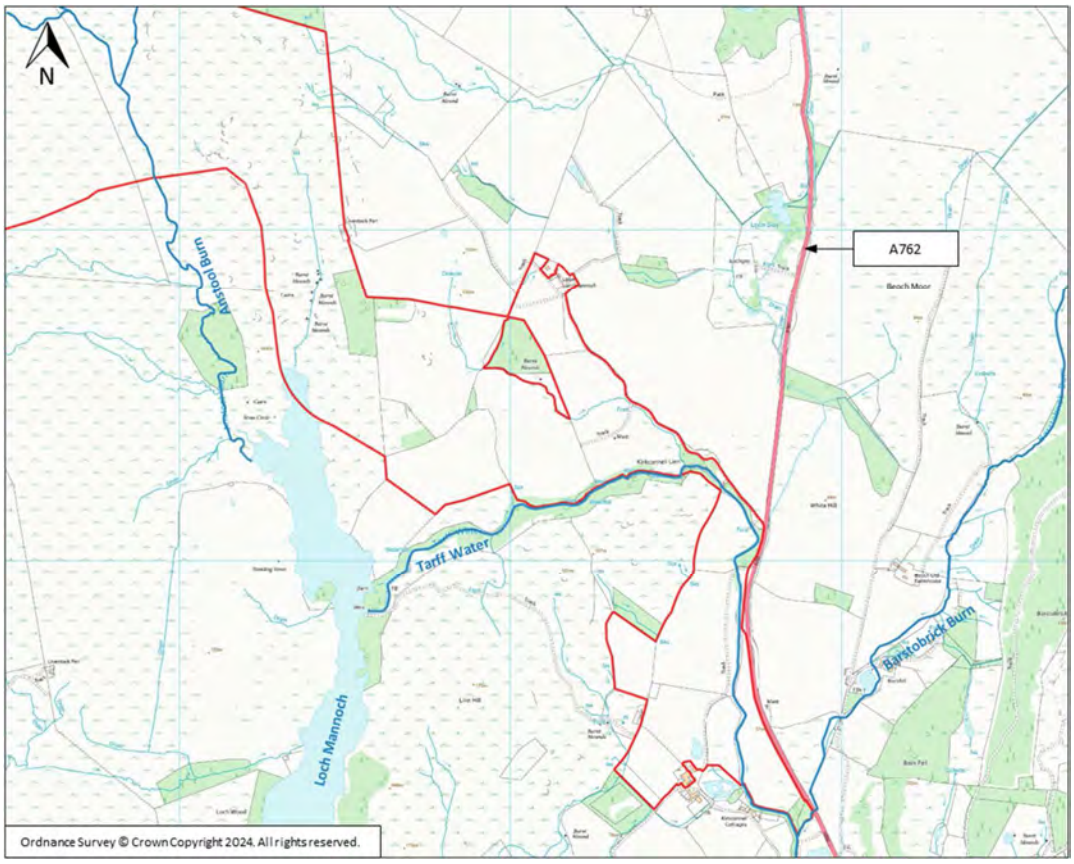


Figure 2: Location of Surface Waterbodies

2.4 Topographic Levels

LiDAR data has been used to develop a digital terrain model of the Proposed Development Site and surrounding area as illustrated in **Figure 3**. Ground levels within the proposed Solar Development are indicated as follows:

- North parcel in the region of 95.0 - 148.0 m Above Ordnance Datum (AOD) within the vicinity of the proposed solar panels, falling to the south and east. Levels rise to over 170.0 m AOD to the north-west before falling to 150.0 - 160.0 m AOD in the location of the proposed water crossing “WX06” (refer to **Figure 1**).
- South parcel in the region of 66.0 - 72.0 m AOD, falling to the south and east.

Ground levels on the A762 are indicated to be in the region of 55.5 - 72.5 m AOD adjacent to the Proposed Development Site. The existing access off the A762 is at a level of 68.1 m AOD with the track rising to 75.5 m AOD on the Proposed Development Site (to the west) within a distance of circa. 250 m (i.e. where the first bend is evident).

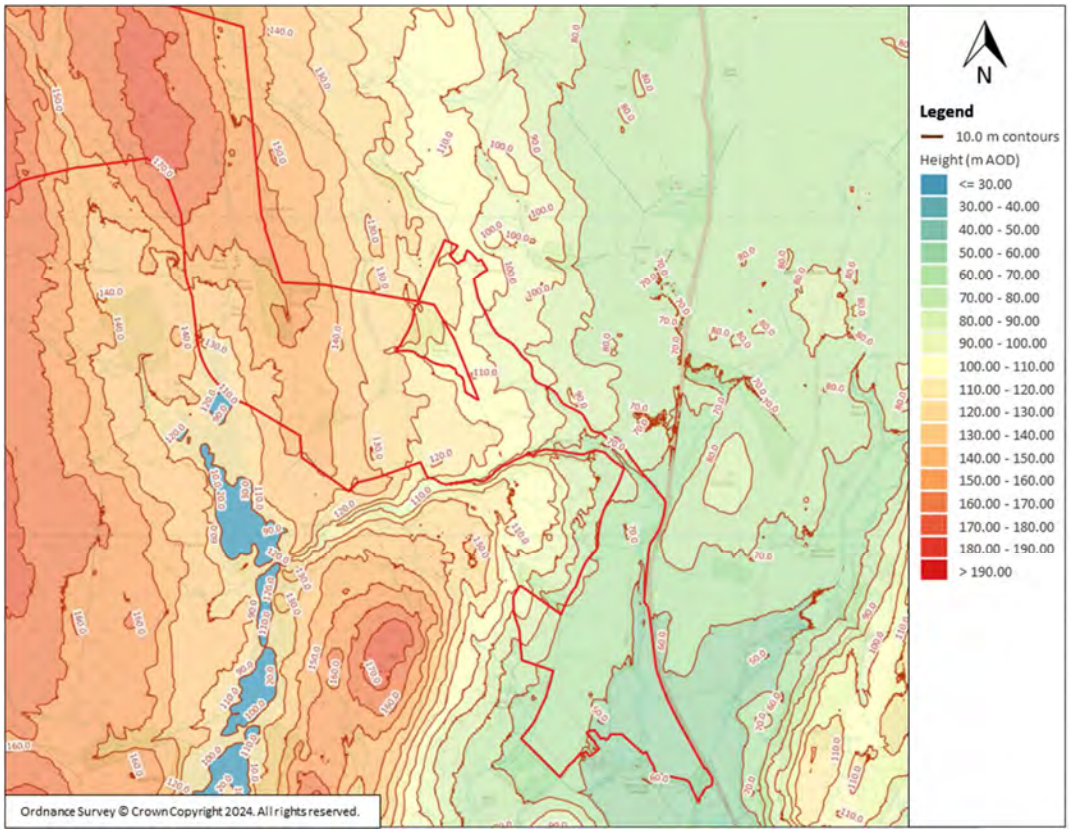


Figure 3: Digital Terrain Model from LiDAR Data

2.5 Ground Conditions

According to the National Soil Map of Scotland[1], the soil type within the proposed Solar Development comprises predominately brown soils (brown earths with rankers), which is classified as *"free or imperfectly drained soils"* including shallow soils with rock near the surface. However, there is an area of peaty podzols in the north-west towards "WX06", typically defined as "well drained" soils but with the potential for waterlogging in some areas. No data is available to define the soil runoff risk.

BGS mapping of surface geology[2] indicates the underlying bedrock formation comprises Kirkmaiden Formation - Wacke in the south and Cairnharrow Formation - Wacke in the north, overlain by Alluvium - Silt, Sand and Gravel superficial deposits in the south-east and to the north of Loch Mannoch.

According to the Scotland's Environment map the Proposed Development Site is underlain by a low productivity (Class 2C) aquifer where flow is virtually all through fractures and other discontinuities. The Proposed Development Site is located within the Tarff Water DWPA (Surface) and Castle Douglas DWPA (Ground) referred to in the Water Environment (Drinking Water Protected Areas) (Scotland) Order 2013.

1 https://map.environment.gov.scot/Soil_maps/
2 https://www.bgs.ac.uk/map-viewers/geoindex-onshore/

3 PLANNING POLICY AND GUIDANCE

3.1 National Planning Policy and Policy Guidance

The Flood Risk Management (Scotland) Act was enacted in 2009 and provides the framework for an integrated catchment-wide, sustainable and risk-based approach to flood risk management considering flooding from all sources.

The NPF4 sets out the national planning policies for development and land use in Scotland. The NPF4 requires planning authorities to ensure that flood risk is taken into account at all stages in the planning process and is appropriately addressed.

Policy 22 - Flood Risk and Water Management of the NPF4 stipulates the intent to strengthen resilience to flood risk by promoting avoidance as a first principle and reducing the vulnerability of existing and future development to flooding. The policy states:

a. *Development proposals at risk of flooding or in a flood risk area will only be supported if they are for:*

   i. *Essential infrastructure where the location is required for operational reasons;*
   ii. *Water compatible uses;*
   iii. *Redevelopment of an existing building or site for an equal or less vulnerable use; or.*
   iv. *Redevelopment of previously used sites in built up areas where the [Local Development Plan (LDP)] has identified a need to bring these into positive use and where proposals demonstrate that long term safety and resilience can be secured in accordance with relevant [SEPA] advice.*

   The protection offered by an existing formal flood protection scheme or one under construction can be taken into account when determining flood risk.

   In such cases, it will be demonstrated by the applicant that:

   - *All risks of flooding are understood and addressed;*
   - *There is no reduction in floodplain capacity, increased risk for others, or a need for future flood protection schemes;*
   - *The development remains safe and operational during floods;*
   - *Flood resistant and resilient materials and construction methods are used; and*
   - *Future adaptations can be made to accommodate the effects of climate change.*

   Additionally, for development proposals meeting criteria part iv, where flood risk is managed at the site rather than avoided these will also require:

   - *The first occupied/utilised floor, and the underside of the development if relevant, to be above the flood risk level and have an additional allowance for freeboard; and*
   - *That the proposal does not create an island of development and that safe access/egress can be achieved.*

b. *Small scale extensions and alterations to existing buildings will only be supported where they will not significantly increase flood risk.*

c. *Development proposals will:*

   i. *Not increase the risk of surface water flooding to others, or itself be at risk;*
   ii. *Manage all rain and surface water through Sustainable Drainage Systems [SuDS], which should form part of and integrate with proposed and existing blue-green infrastructure. All proposals should presume no surface water connection to the combined sewer;*
   iii. *Seek to minimise the area of impermeable surface.*

d. *Development proposals will be supported if they can be connected to the public water mains. If connection is not feasible, the applicant will need to demonstrate that water for drinking water purposes will be sourced from a sustainable water source that is resilient to periods of water scarcity.*
e. *Development proposals which create, expand or enhance opportunities for natural flood risk management, including blue and green infrastructure, will be supported.*

Policy 1 and Policy 2 of the NPF4 also identify the importance of "*development proposals [being] sited and designed to adapt to current and future risks from climate change"*.

Annex F of NPF4 states that *"for planning purposes, at risk of flooding or in a flood risk area means land or built form with an annual probability of being flooded of greater than 0.5% which must include an appropriate allowance for future climate change* [Note. The "appropriate allowance for climate change" is indicated on the SEPA Future Flood Map at a strategic level, an appropriate allowance for climate change should be taken from the latest available guidance and evidence for application in Scotland[3])…*The calculated risk of flooding can take account of any existing, formal flood protection schemes in determining the risk to the site.*

Where the risk of flooding is less than this threshold, areas will not be considered 'at risk of flooding' for planning purposes, but this does not mean there is no risk at all, just that the risk is sufficiently low to be acceptable for the purpose of planning. This includes areas where the risk of flooding is reduced below this threshold due to a formal flood protection scheme."

3.2 Local Planning Policy

The Dumfries and Galloway Local Development Plan 2 was adopted by DGC in October 2019. The following policies are relevant in respect of flood risk and drainage:

Policy IN7 - Flooding and Development

The avoidance principle is the most sustainable form of flood management, in accordance with the policy principle for managing flood risk of [Scottish Planning Policy (SPP)] and the Flood Risk Management (Scotland) Act 2009. Where proposed development could lead to an unacceptable on-site or off-site flood risk[1], as defined by the Risk Framework in SPP, then it will not be permitted. Where a proposed development could lead to an unacceptable flood risk, it may be that a [Flood Risk Assessment (FRA)] is able to clarify to the satisfaction of the Council and SEPA that the level of risk both on and off site would be acceptable. For any site a [DIA] may be required to ensure that surface water flows are properly taken into account in the development design. Consideration should be given to pluvial flows[2] especially those which exceed the capacity of the proposed drainage systems. Design of development must avoid flood risk from exceedance flows[3].

In order to satisfy the Council in respect of FRAs and [Drainage Impact Assessments {DIAs)], parties will be expected to provide independent verification of their professional competence, unless it is clear that this is not required.

Supplementary guidance provides further detail on the levels and requirements for [FRAs].

[1] Note: The meaning of 'flood risk' is from SPP. It is 'the combination of the probability of a flood and of the potential adverse consequences, associated with a flood, for human health, the environment, cultural heritage and economic activity'.

[2] Pluvial flooding is a result of rainfall runoff flowing or ponding over the ground before it enters a natural drainage system (e.g. watercourse) or an artificial one (e.g. sewer) because for example the system is already full to capacity or the drainage inlets have limited capacity.

[3] Those which exceed the capacity of any formal drainage system.

Policy IN8 – Surface Water Drainage and Sustainable Drainage Systems (SuDS)

With the exception of single houses and those with direct discharges to coastal waters, [SuDS] will be a required part of all proposed development as a means of treating the surface water and managing flow rates and must form part of any planning permission in principle proposal.

Consideration of drainage issues is a planning requirement for every planning proposal. This consideration should be initiated as part of any preliminary site assessment and should progressively inform the generation of schemes as they develop. For any site a [DIA] at the appropriate level may be required to ensure that surface water flows are properly taken into account in the development design.

[3] https://www.sepa.org.uk/media/594272/future-flood-maps-explanatory-note.pdf

Planning applications must include appropriate and proportionate details of the proposed SuDS to show how they will:

- *Ensure the system is designed to avoid flood risk from exceedance flows;*
- *Be accommodated within the proposed site[4], and understood as an essential factor in determination of the overall capacity of any site;*
- *Be based on a unified approach to cover surface water drainage from on-site roads and from the remainder of the site;*
- *Contribute positively to the biodiversity, general amenity and water quality of the area of the proposal;*
- *Include a coordinated approach between new developments that are adjacent to one another;*
- *Include the arrangements for its long term maintenance. There should be appropriate arrangements for surface water drainage during the construction phase of a development site. This could be by way of a SuDS scheme or some alternative interim solution. Supplementary guidance provides further detail on the levels and requirements for [DIAs].*

[4] It should be understood that this means the site for the overall scheme, and does not mean the sites for individual houses or components within an overall scheme.

DGC acknowledge the adoption of NPF4 in February 2023 and state[4] that where polices in the NPF4 contradict those in the Local Development Plan 2 then NPF4, as the most recent plan, will take precedence.

3.3 Drainage Technical Guidance

Surface Water Drainage and Sustainable Drainages Systems (SuDS) supplementary guidance was published by DGC in February 2020. The guidance supports the adopted 2019 Local Development Plan 2, setting out the Councils requirements and objectives for SuDS to assist developers, consultants and all stakeholders involved in the planning process.

The guidance sets out how surface water runoff generated during the present day 3.3% and 0.5% AEP rainfall events should be managed, including an allowance for climate change, how peak runoff rates should be restricted and how runoff volumes should be controlled.

3.4 Water Framework Directive

The Water Framework Directive (WFD) provides a legal framework for the protection, improvement and sustainable use of inland surface waters, groundwater, transitional waters, and coastal waters across Scotland, and seeks to:

- Prevent deterioration in the status of surface water and groundwater bodies;
- Protect, enhance and restore surface water and groundwater bodies (except artificial or heavily modified water bodies) with the aim of achieving good ecological, chemical and groundwater quantitative status by December 2021;
- Protect and enhance artificial and heavily modified water bodies with the aim of achieving good ecological potential and good chemical status by December 2021;
- Progressively reduce or phase out the release of individual pollutants or groups of pollutants that present a significant threat to the aquatic environment and progressively reduce pollution of groundwater.

The WFD applies to any development which has the potential to impact on a waterbody. Where this is the case, SEPA may require evidence demonstrating that the Proposed Development does not compromise the aims of the WFD.

3.5 Controlled Activities Regulations

Under the Water Environment (Controlled Activities) (Scotland) Regulations 2011, authorisation is required from SEPA for works in or near inland surface waters where those works pose a risk of significant adverse impact.

[4] https://www.dumfriesandgalloway.gov.uk/planning-building/planning/planning-policy/local-development-plan/local-development-plan-2-ldp2#lgd-guides__title#lgd-guides__title

In order to allow for proportionate regulation based on the risk an activity poses to the water environment, there are three types of authorisation: General Binding Rules (GBRs), registrations and licences.

4 REVIEW OF FLOOD RISK

4.1 Historical Records of Flooding

The DGC "Flood Events and SEPA Flood Maps"[5] does not contain any records of flooding at or within the immediate vicinity of the Proposed Development Site.

4.2 Flood Risk from the Sea (Tidal / Coastal) and Rivers (Fluvial)

The Flood Map - Coastal and River[6] (**Figure 4**) indicates that most of the Proposed Development Site is not at risk of flooding from the sea and rivers; however, there is an area indicated to be at a low to high likelihood of river flooding adjacent to and through the proposed Solar Development associated with Anstool Burn in the north-west, and Tarff Water and Barstobrick Burn in the south/south-east. SEPA defines flood risk in three categories as follows:

- High likelihood. Land having a 10% annual probability of coastal or river flooding
- Medium likelihood. Land having a 0.5% annual probability of coastal or river flooding
- Low likelihood. Land having a 0.1% annual probability of coastal or river flooding.

The Future Flood Map - River (**Figure 4**) takes account of the possible impacts of climate change and consequent changes in the future probability of flooding by the 2080s for the medium likelihood scenario. This indicates that the flood extents are broadly the same as the present-day medium (0.5% AEP) and low (0.1% AEP) likelihood scenarios.

The flood extents indicated on the Flood Map have been overlaid on the layout for the proposed Solar Development (refer to **Figure 4**). This indicates that all development would be located outside the 0.1% AEP event and 0.5 % AEP event including an allowance for climate change, except for the access tracks off the A762 and water crossing "WX06" in the north-west.

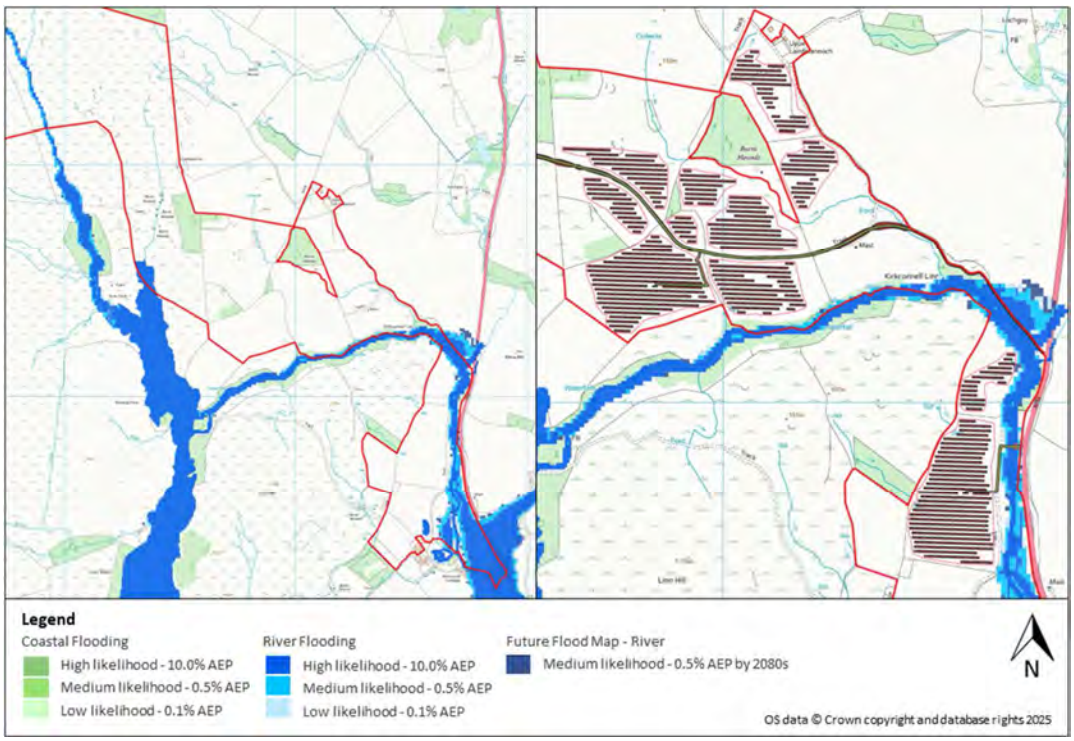


Figure 4: Flood Map - Coastal and River
Source: sepa.org.uk website; Accessed: March 2025

[5] https://storymaps.arcgis.com/stories/32929d7842ae40d9ba990425e7fca317
[6] https://map.sepa.org.uk/floodmaps

LiDAR data indicates that the bank of Tarff Water rises quickly, with the existing (northern) access track off the A762 a minimum of circa. 2.0 m above the bank level. The Flood Risk Management Map - River[7] subsequently indicates that within the area indicated to be at risk, the flood depth and velocity is typically less than 0.3 m and 1 m/s respectively during all events. Given the nature of the proposals, the risk may therefore be defined as low.

The new (southern) access crossing over Tarff Water will be designed to maintain existing conveyance capacity within the channel and floodplain as discussed further in **Section 4.6**.

4.3 Flood Risk from Small Watercourses and Surface Water (Pluvial)

As detailed in **Section 2.3**, a number of drainage ditches are located within the vicinity of the Proposed Development Site. No modelled information is available for these watercourses. The Flood Map - Surface Water and Small Watercourses (**Figure 5**) has therefore been utilised to assess the risk of flooding from these sources and pluvial surface water. This mapping indicates the presence of several overland flow routes through the proposed Solar Development. However, the areas of identified risk are relatively confined and form where the natural contours of the land forms shallow valleys where overland flow would be directed to.

The Future Flood Map - Surface Water and Small Watercourses (**Figure 5**) takes account of the possible impacts of climate change and consequent changes in the future probability of flooding by the 2070s for the medium likelihood scenario. This indicates that the flood extent is broadly the same as the low (0.1% AEP) likelihood scenario.

The flood extents indicated on the Flood Map have been overlaid on the layout for the proposed Solar Development (refer to **Figure 5**). This indicates that most of the Proposed Development is located outside the 0.1% AEP event and 0.5% AEP event including an allowance for climate change, except for a small part of the access track off the A762 and a north to south flow route through the south parcel.

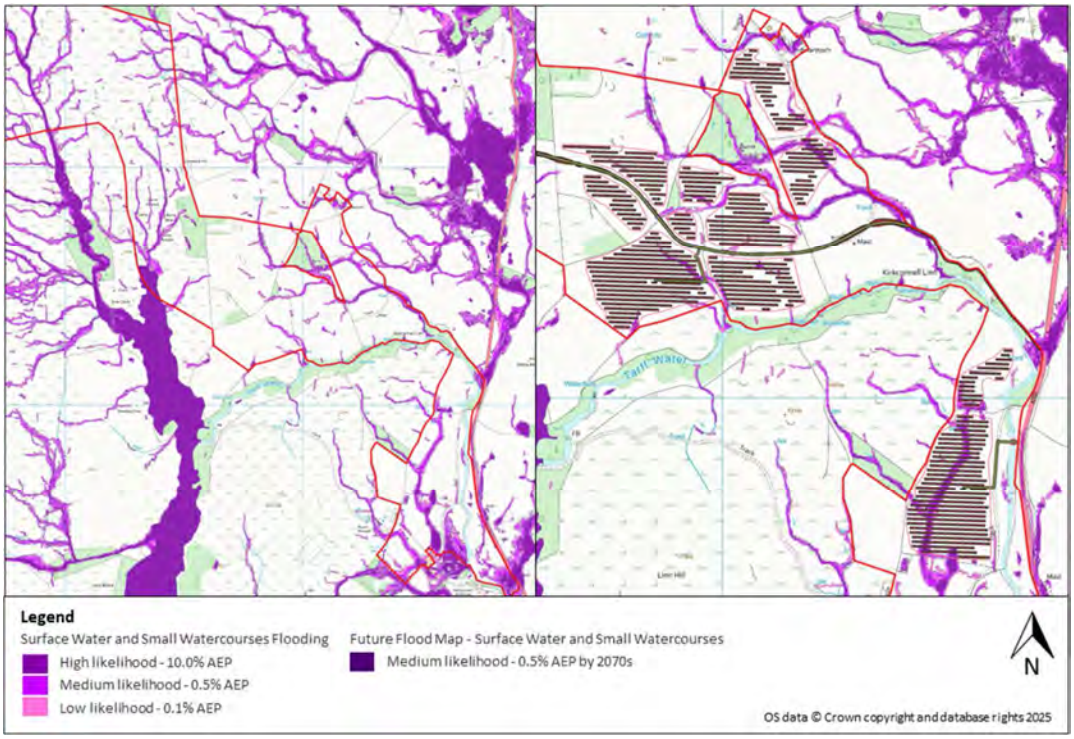


Figure 5: Flood Map - Surface Water Surface Water and Small Watercourses
Source: sepa.org.uk website; Accessed: March 2025

[7] https://map.sepa.org.uk/floodmap/map.htm

The maximum flood depth indicated is typically less than 0.3 m during all events, with some small, isolated areas of 0.3 - 1.0 m (Note. Those areas where the flood depth exceeds 0.3 m fall outside the areas where the solar panels and associated infrastructure are proposed except in the south where there is a localised depression in the topography). The maximum velocity during all events is typically indicated to be less than 1.0 m/s albeit with some areas of 1.0 - 2.0 m/s owing to the steep topography of the land.

4.4 Flood Risk from Reservoirs, Canals and Other Water Impounding Structures

The Reservoir Inundation Map[8] indicates that the Proposed Development Site is located within an area that may flood from an uncontrolled release of water from a possible dam failure at Loch Mannoch and Loch Whinyeon to the west of the proposed Solar. The anticipated flood extent is similar to that presented on the Flood Map - River (refer to **Figure 4**).

Both of the aforementioned reservoirs have a High risk designation and, as such, are subject to a greater statutory level of engineering inspection and supervision, with essential safety work carried out as required. Reservoir flooding may therefore be considered extremely unlikely to occur.

There are no canals located within the immediate vicinity of the Proposed Development Site.

The two small surface waterbodies to the south of the Proposed Development Site, within the vicinity of Kirkconnel Cottages, are a minimum of circa 1.7 m below the lowest ground level where the solar panels are proposed in the Solar Development, with ground levels falling to the south/south-east. As such, these are not considered to pose a risk of flooding to the Proposed Development. This is reiterated on the Flood Map - Surface Water and Small Watercourses (**Figure 5**), which also indicates that the proposed Solar Development is not at risk of flooding from the small surface waterbodies to the north, north-east and east of the Proposed Development Site.

4.5 Flood Risk from Groundwater

The BGS Susceptibility to Groundwater Flooding map (**Figure 6**) indicates that the part of the proposed Solar Development to the north of Tarff Water is not prone to groundwater flooding; however, the potential for groundwater flooding to occur at the surface is indicated to the south of Tarff Water, which is largely consistent with the Alluvium superficial deposits.

The Flood Risk Management Map - Groundwater[9] indicates that the Proposed Development Site is not at risk of flooding from groundwater.

[8] https://map.sepa.org.uk/reservoirsfloodmap/Map.htm
[9] https://map.sepa.org.uk/floodmap/map.htm

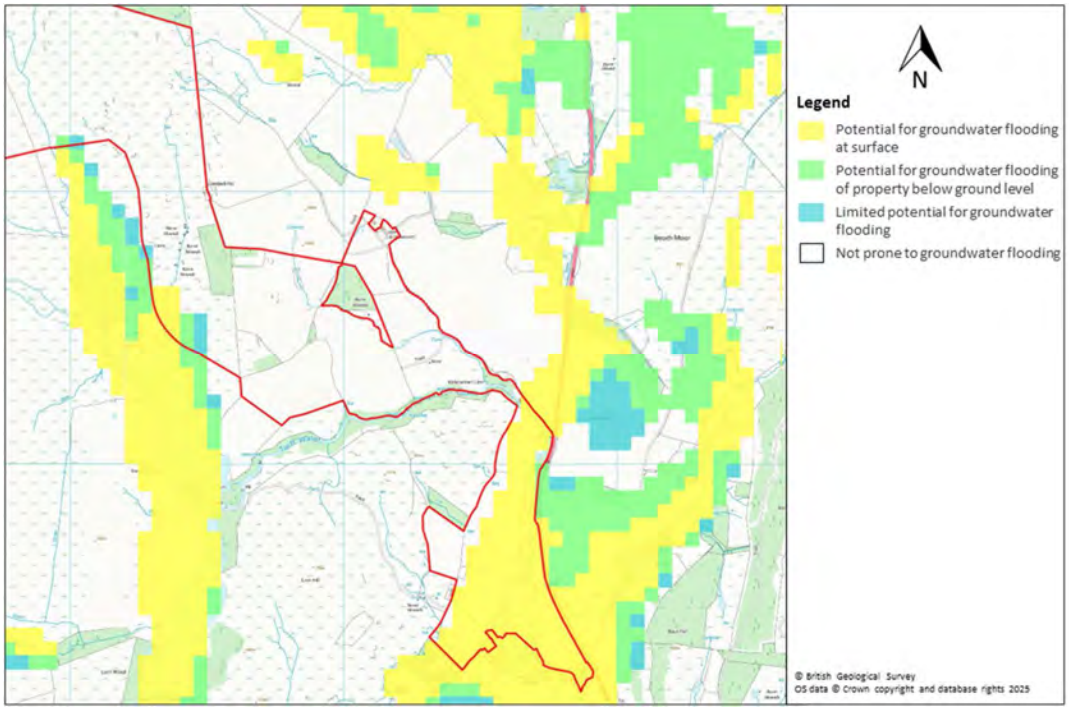


Figure 6: BGS Susceptibility to Groundwater Flooding Map
Source: Blue Sky Maps; Accessed: March 2025

4.6 Flood Risk Mitigation

The risk of flooding to the proposed Solar Development from all identified sources is assessed to be negligible/low, with the exception of Tarff Water which presents a risk to the proposed access tracks off the A762 and some small areas of low to high pluvial surface water risk due to shallow overland flow pathways.

The risk of flooding will be mitigated through the implementation of the following measures:

- Existing watercourses/drainage ditches should be retained.
- No development should occur within 8 m of existing watercourses/drainage ditches - This has been designed into the proposed site layout in **Appendix A**.
- Flood pathways associated with surface water runoff and runoff associated with existing drainage ditches should not be obstructed by the PV power stations and switching station. The lower edge of PV solar panels is typically set at a minimum of 0.8 m above ground level and, as such, should not obstruct overland flow pathways and no restrictions should be applied to the siting of the panels.
- New (southern) access crossing over Tarff Water should be designed to maintain existing conveyance capacity within the channel and on the floodplain, with no structures erected in the watercourse or the flood extent illustrated on the Flood Map (refer to **Figure 4**).
- Any other new access crossings on existing drainage ditches should be designed to maintain existing conveyance capacity.
- If flooding of the access to the Proposed Development Site occurs during construction or operation, this should not be utilised until such time as water levels have receded, unless safe to do so. This has been addressed as part of **Technical Appendix 15-1 Outline Construction Environmental Management Plan (CEMP)** and should be included in the site operation details/plans.
- The area under the solar panels should be seeded with a suitable grass mix to prevent rilling and an increase in surface water runoff rates as a result of the concentration of runoff under the drip line.

4.7 Flood Risk Elsewhere

The proposed developable area of the Solar Development is not at risk of flooding in up to a 0.5% AEP event including an allowance for climate change, except for the access tracks off the A762.

Ground levels along the proposed section of the (northern) access track to be upgraded and widened through the area of identified risk will be maintained as existing so far as is feasible. Any displaced floodwater resulting from this would be expected to be minimal and as such, would be contained on the Proposed Development Site in the locality of the works.

As detailed in **Section 4.6**, the new (southern) access crossing over Tarff Water will be designed to maintain existing conveyance capacity within the channel and on the floodplain, with no structures erected in the watercourse or the flood extent illustrated on the Flood Map (refer to **Figure 4**).

Recognising the above, the proposals would not be expected to have an adverse impact on flood risk elsewhere and no compensatory flood storage would need be provided for the proposed Solar Development.

5 SURFACE WATER MANAGEMENT

5.1 Surface Water Drainage at the Existing Site

The Proposed Development Site currently comprises greenfield land and as such no formal drainage is understood to be present. Given the topography and ground conditions, surface water runoff would be expected to slowly infiltrate where conditions allow and flow overland towards Tarff Water and the existing network of local drainage ditches.

The greenfield surface water runoff rates for the Proposed Development Site, calculated using the HR Wallingford Greenfield Runoff Tool[10] are presented in **Table 1**. Details of the input parameters and the output results are provided in **Appendix B**.

Table 1: Greenfield Runoff Rate

AEP of Rainfall Event	Greenfield Runoff Rate (l/s/ha)	Greenfield Runoff Rate for 612.2 ha Site (l/s)
100.0%	13.2	8,111.7
QBAR	15.2	9,317.7
3.3%	29.7	18,176.2
0.5%	45.5	27,867.3

5.2 Surface Water Drainage in the Solar Development

5.2.1 Disposal of Surface Water

In accordance with the Scottish Water Surface Water Policy[11], surface water runoff should be disposed of according to the following hierarchy: Rainwater collected for use; Into the ground (infiltration); To a surface water body; To a surface water sewer; To a combined sewer.

Given the nature of the proposals, the collection of water for reuse is not considered to be appropriate or necessary.

As detailed in **Section 2.5**, the proposed Solar Development is underlain by brown soils (brown earths with rankers), which is classified as *"free or imperfectly drained soils"* and potentially shallow groundwater levels in some areas. As such the disposal of surface water via infiltration is unlikely to be feasible; however, infiltration tests have not been undertaken at this stage. Such tests may be undertaken at the detailed design stage in accordance with the guidelines in BRE365[12]. It is subsequently proposed to discharge surface water runoff from the proposed Solar Development to Tarff Water either directly or via the network of existing drainage ditches.

5.2.2 Post Development Impermeable Area

'Greenfield' Areas of the Solar Development

According to published research into the impact of solar farm panels on runoff rates and volumes[13], solar panels do not have a significant impact on the hydrologic response of a site when the ground comprises well managed vegetation such as good grass cover. In such instances, the research cites that well managed vegetation beneath the solar panels results in a potential increase of up to 0.35% in runoff volume.

The Proposed Development will include managed grassland beneath the solar panels, and the impact on runoff rates and volumes from the panelled part of the Solar Development is consequently assessed to be negligible. No specific drainage for the panelled part of the Solar Development is proposed.

10 www.uksuds.com
11 Surface Water Policy: Standard Advice Note and Process Guidance, Scottish Water,
12 BRE Digest 365 Soakaway Design, Building Research Establishment, 2016
13 Hydrologic Response of Solar Farms, Cook LM and McCuen RH, American Society of Civil Engineers, 2013

Access Tracks and Other Areas of Hardstanding

For the purposes of this assessment, the proposed Solar Development has been subdivided into three drainage areas based on the Proposed Development layout, topography and the location of surface waterbodies, as illustrated in **Figure 7**.

The area of impermeable surfaces associated with the access tracks has been calculated based on the Proposed Development Site layout (**Appendix A**) and is presented in **Table 2**, along with the proposed discharge rates based on the greenfield QBAR rate within each drainage area.

Figure 7: Indicative Drainage Areas

Table 2: Summary of Proposed Impermeable Areas and Peak Discharge Rates

Drainage Area	**Impermeable Area** (ha)	**Peak Discharge Rate** (l/s)
1	0.39	5.9
2	1.00	15.2
3	0.13	1.9

5.2.3 Volume Control

As outlined within The SuDS Manual extra runoff volumes in extreme events may be managed by releasing all runoff (above the 100.0% AEP event) from the Proposed Development at a maximum rate of 2 l/s/ha or QBAR, whichever is the higher value.

It is therefore proposed to restrict peak discharge rates to the greenfield QBAR rate in up to the 0.5% AEP event, including an allowance for climate change.

5.2.4 Attenuation Storage

Attenuation storage will be provided to store surface water runoff generated across areas of hardstanding, i.e. access tracks.

The attenuation storage facility has been modelled using the Source Control module of MicroDrainage (**Appendix C**). The required storage volume has been sized to store the 0.5 % AEP rainfall event including a 53% increase in rainfall intensity to allow for climate change, in accordance with SEPA guidance[14].

The storage volumes could be accommodated within attenuation basins, as detailed in **Table 3**.

A preliminary surface water drainage layout is provided in **Appendix D**.

Table 3: Summary of Proposed Surface Water Attenuation

Drainage Area	**Contributing Area** (ha)	**Peak Discharge Rate** (l/s)	**Total Required Attenuation Volume** (m^3)	**Storage Type**	**Storage Area** (m^2)	**Storage Depth** (m)
1	0.39	5.9	370.5	Attenuation basin	735.0	1.0
2	1.00	15.2	962.0	Attenuation basin	1,719.0	1.0
3	0.13	1.9	114.9	Attenuation basin	461.0	0.7

5.2.5 Exceedance Routes

Flows resulting from rainfall in excess of the 0.5% AEP rainfall event including an allowance for climate change will be managed in exceedance routes. It is assumed that as the detailed design progresses, the design of the Proposed Development would ensure flood flows are directed away from sensitive electrical equipment.

5.2.6 Pollution Control

Table 26.2 of the CIRIA SuDS Manual identifies general access roads as having a low pollution hazard level and indicates that the pollution hazard indices associated with such uses for total suspended solids, hydrocarbons and metals are 0.50, 0.40 and 0.40 respectively.

It is proposed to discharge surface water runoff from the access tracks via filter drains which can help reduce pollutant levels in runoff by filtering out fine sediments, metals, hydrocarbons and other pollutants. They can also encourage adsorption and biodegradation processes. Table 26.3 of the CIRIA SuDS Manual indicates that the SuDS mitigation indices for filter drains for total suspended solids, hydrocarbons and metals are 0.40, 0.40 and 0.40 respectively.

Attenuation basins can provide water quality benefits via the settlement of pollutants in still or slow moving water, adsorption by the soil, and biological activity. Table 26.3 of the CIRIA SuDS Manual indicates that the SuDS mitigation indices for attenuation basins for total suspended solids, hydrocarbons and metals are 0.50, 0.50 and 0.60 respectively.

In addition, the use of catchpit within flow control manhole chambers will help prevent contaminants discharging into the downstream receptor.

5.2.7 Adoption and Maintenance of SuDS

SuDS for the Proposed Development will be maintained by the site operator or their appointed management company.

An indicative maintenance schedule is presented in **Table 4**.

14 SEPA Climate change allowances for flood risk assessment in land use planning, Version 6

Table 4: Maintenance Requirements

Schedule	Required action	Frequency
Attenuation Basin		
Regular maintenance	Remove litter and debris	Monthly
	Cut grass	Monthly during grow season Or as required)
	Manage other vegetation and remove nuisance plants	Monthly at start, then as required
	Inspect inlets, outlets and overflows for blockages, and clear if required.	Monthly
	Inspect banksides, structures, pipework etc for evidence of physical damage	Monthly
	Inspect inlets and facility surface for silt accumulation. Establish appropriate silt removal frequencies	Monthly for first year, then annually or as required
	Tidy all dead growth before start of growing season	Annually
	Remove sediment from inlets/outlets	Annually (or as required)
Occasional maintenance	Reseed areas of poor vegetation growth	As required
	Prune and trim any trees and remove cuttings	Every two years, or as required
	Remove sediments from inlets/outlets and main basin when required	
Remedial actions	Repair erosion or other damage by reseeding or re-turfing	As required
	Realignment of rip-rap	
	Repair/rehabilitation of inlets/outlets	
	Relevel uneven surface and reinstate design levels	
Filter Drain		
Regular maintenance	Remove litter including leaf litter and debris from filter drain surface, access chambers and pre-treatment devices	Monthly (or as required)
	Inspect filter drain surface, inlet/outlet pipework and control systems for blockages, clogging, standing water and structural damage	Monthly
	Inspect pre-treatment systems, inlets and perforated pipework for silt accumulation, and establish appropriate silt removal frequencies	Six monthly
	Remove sediment from pre-treatment devices	Six monthly (or as required)
Occasional maintenance	Remove or control tree roots where they are encroaching the sides of the filter drain, using recommended methods (e.g. NJUG, 2007 or BS 3998:2010)	As required
	At locations with high pollution loads, remove surface geotextile and replace, and wash or replace overlying filter medium	Five yearly (or as required)
	Clear perforated pipework of blockages	As required
Flow Control Unit		
Routine maintenance	Remove litter and debris and inspect for sediment accumulation	Six Monthly
	Remove sediment from sump	As necessary – Indicated by system inspections
Remedial actions	Replace malfunctioning parts or structures	As required
Monitoring	Inspect for evidence of poor operation	Six Monthly
	Inspect flow control unit and establish appropriate replacement frequencies	Six Monthly
	Inspect sediment accumulation rates and establish appropriate removal frequencies	Monthly during first year of operation, then every six months

6 SUMMARY AND RECOMMENDATIONS

This report has been prepared for Lairdmannoch Energy Park Limited and relates to the development of land north-east of Gatehouse of Fleet and approximately 10 km west of Castle Douglas for use as an energy park.

The Proposed Development consists of nine wind turbines each with a tip height of 180 m agl, ground mounted solar panels, a BESS and associated infrastructure. This report relates to the Solar Development only, with flood risk and drainage for the wind element assessed and reported on in **Chapter 8: Hydrology, Geology and Hydrogeology**.

The SEPA Flood Map indicates that most of the Proposed Development Site is not at risk of flooding from the sea and rivers; however, there is an area indicated to be at a low to high likelihood of river flooding adjacent to and through the proposed Solar Development associated with Anstool Burn in the north-west, and Tarff Water and Barstobrick Burn in the south/south-east.

An assessment of flood risk from all identified potential sources of flooding has been undertaken using best available information. The risk of flooding to the proposed Solar Development is assessed to be negligible/low, with the exception of Tarff Water which presents a risk to the proposed access tracks off the A762 and some small areas of low to high pluvial surface water risk due to shallow overland flow pathways.

The risk of flooding will be mitigated through the implementation of the following measures:

- Existing watercourses/drainage ditches to be retained, with no development proposed within a minimum of 8 m.
- Flood pathways associated with surface water runoff and runoff associated with existing drainage ditches not to be obstructed by the PV power stations and switching station.
- New (southern) access crossing on Tarff Water to be designed to maintain existing conveyance capacity within the channel and on the floodplain, with no structures erected in the watercourse or the flood extent illustrated on the Flood Map.
- Any other new access crossings on existing drainage ditches to be designed to maintain existing conveyance capacity.
- If flooding of the access to the Proposed Development Site occurs during construction or operation, this should not be utilised until such time as water levels have receded, unless it is safe to do so. This has been addressed as part of the **CEMP (Technical Appendix 15-1)** and should be included in the site operation details/plans.
- Ground under the PV solar panel drip line to be seeded with a suitable grass mix to prevent rilling and an increase in surface water runoff rates.

The proposals would not be expected to have an adverse impact on flood risk elsewhere.

The assessment presents a preliminary scheme for the management of surface water from the proposed Solar Development. A summary of the findings is provided below:

- The Proposed Development Site currently comprises greenfield land and as such no formal drainage is understood to be present.
- Surface water runoff from the proposed access tracks will be intercepted and conveyed by filter drains and will be discharged to Tarff Water either directly or via the existing network of drainage ditches.
- Flows will be restricted to greenfield QBAR rates with storage provided within attenuation basins.
- The use of filter drains, attenuation basins and catchpits within flow control manhole chambers will provide the necessary water quality treatment measures.
- SuDS for the Proposed Development will be maintained by the site operator or their appointed management company.

In conclusion, this report demonstrates that the proposed Solar Development may be completed in accordance with the requirements of planning policy.

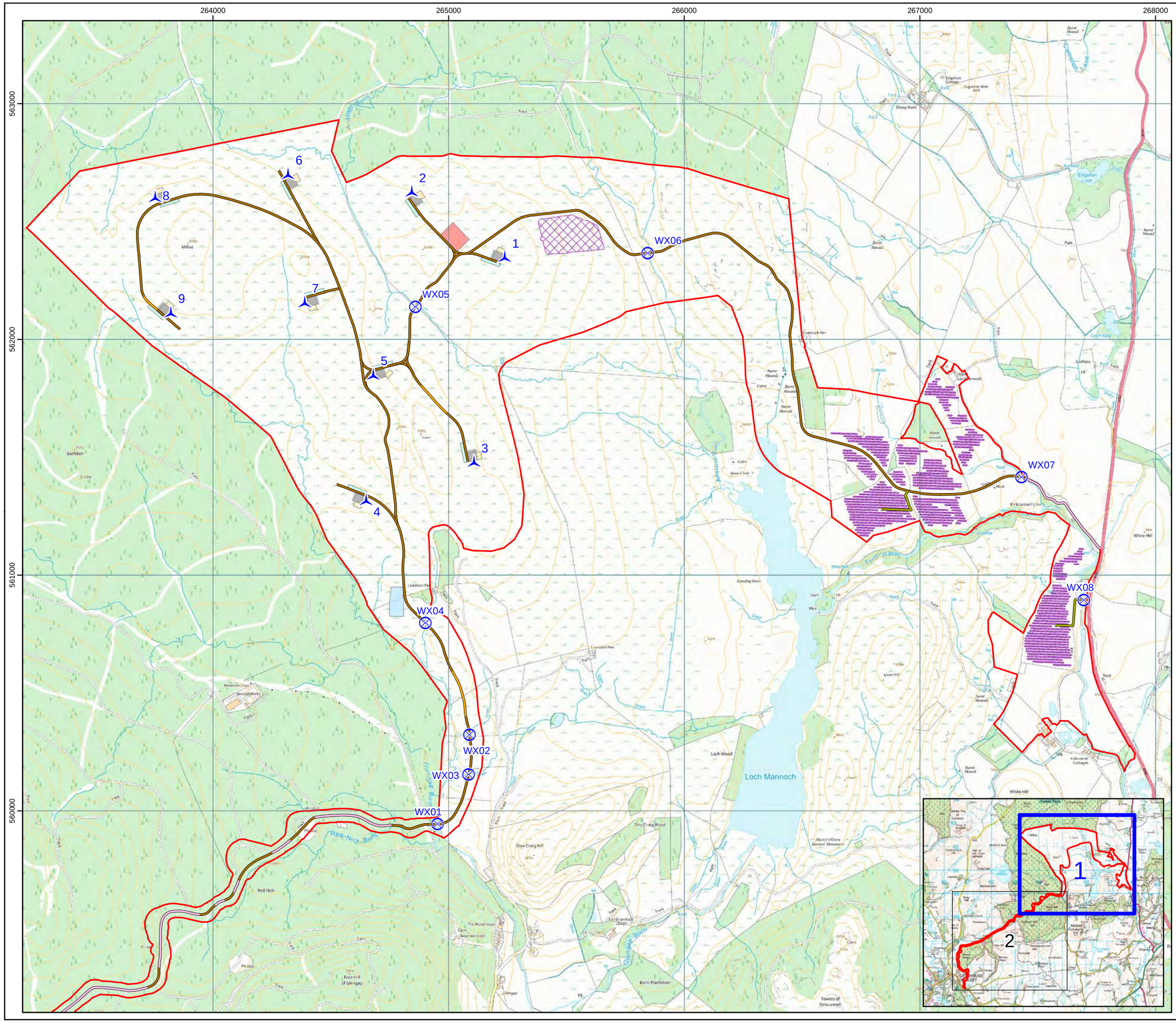
APPENDIX A

Proposed Development Site Layout

Lairdmannoch Energy Park

wind2

Figure 1-2a
Site Layout - Map 1
Development Site



Key

- Site boundary
- Turbine Location

Wind infrastructure

- Turbine foundation
- Crane hardstanding
- Auxillary crane area
- Tower storage
- Blade storage
- Substation and BESS
- Construction compound
- Borrow Pit

Track lines

- Access track - cut
- Access track - floating
- Access track - upgraded / widened
- Access track - solar
- Watercourse crossing

Solar infrastructure

- Solar panel
- Power Station
- Switching and Breaking Station

atmos CONSULTING

0 212.5 425 850

Metres

N

Scale @ A3:
1:15,000

21/03/2025 TL010 40418/SL/093c

Drawn by: TH Checked by: TH Approved by: JG

Lairdmannoch Energy Park

wind2

Figure 1-2b
Site Layout - Map 2
Access Route

Key

Site boundary

Track lines

Access track - cut

Access track - upgraded / widened

Watercourse crossing

atmos CONSULTING

0 212.5 425 850

Metres

N

Scale @ A3:
1:15,000

21/03/2025 TL010 40418/SL/093c

Drawn by: TH Checked by: TH Approved by: JG

APPENDIX B

Greenfield Runoff Calculations

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	dan hodson
Site name:	LAIRDMANNOCH
Site location:	DG7 2AG

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:	54.93572° N
Longitude:	4.0876° W
Reference:	3088697096
Date:	Mar 13 2025 15:38

Runoff estimation approach

IH124

Site characteristics

Total site area (ha): 1

Methodology

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

Soil characteristics

	Default	Edited
SOIL type:	5	5
HOST class:	N/A	N/A
SPR/SPRHOST:	0.53	0.53

Hydrological characteristics

	Default	Edited
SAAR (mm):	1495	1495
Hydrological region:	2	2
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	1.95	1.95
Growth curve factor 100 years:	2.63	2.63
Growth curve factor 200 years:	2.99	2.99

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):	15.22	15.22
1 in 1 year (l/s):	13.25	13.25
1 in 30 years (l/s):	29.69	29.69
1 in 100 year (l/s):	40.04	40.04
1 in 200 years (l/s):	45.52	45.52

This report was produced using the greenfield runoff tool developed by HR Wallingford and available at www.uksuds.com. The use of this tool is subject to the UK SuDS terms and conditions and licence agreement , which can both be found at www.uksuds.com/terms-and-conditions.htm. The outputs from this tool are estimates of greenfield runoff rates. The use of these results is the responsibility of the users of this tool. No liability will be accepted by HR Wallingford, the Environment Agency, CEH, Hydrosolutions or any other organisation for the use of this data in the design or operational characteristics of any drainage scheme.

APPENDIX C

Surface Water Attenuation - Storage Volume Calculation

Summary of Results for 200 year Return Period (+53%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	159.298	0.298	5.9	140.9	O K
30 min Summer	159.403	0.403	5.9	196.5	O K
60 min Summer	159.502	0.502	5.9	252.4	O K
120 min Summer	159.562	0.562	5.9	287.2	O K
180 min Summer	159.590	0.590	5.9	304.0	O K
240 min Summer	159.605	0.605	5.9	313.1	O K
360 min Summer	159.616	0.616	5.9	319.5	O K
480 min Summer	159.612	0.612	5.9	317.4	O K
600 min Summer	159.605	0.605	5.9	312.7	O K
720 min Summer	159.596	0.596	5.9	307.4	O K
960 min Summer	159.576	0.576	5.9	295.6	O K
1440 min Summer	159.533	0.533	5.9	270.0	O K
15 min Winter	159.331	0.331	5.9	158.2	O K
30 min Winter	159.447	0.447	5.9	221.0	O K
60 min Winter	159.557	0.557	5.9	284.3	O K
120 min Winter	159.626	0.626	5.9	325.5	O K
180 min Winter	159.660	0.660	5.9	346.6	O K
240 min Winter	159.679	0.679	5.9	358.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	199.257	0.0	141.3	22
30 min Summer	140.134	0.0	199.8	37
60 min Summer	91.685	0.0	265.9	66
120 min Summer	54.339	0.0	315.4	124
180 min Summer	39.837	0.0	347.0	184
240 min Summer	31.918	0.0	370.7	244
360 min Summer	23.328	0.0	406.4	362
480 min Summer	18.670	0.0	433.7	468
600 min Summer	15.702	0.0	455.9	514
720 min Summer	13.625	0.0	474.7	572
960 min Summer	10.882	0.0	505.3	694
1440 min Summer	7.912	0.0	550.5	956
15 min Winter	199.257	0.0	158.6	22
30 min Winter	140.134	0.0	224.0	36
60 min Winter	91.685	0.0	298.0	66
120 min Winter	54.339	0.0	353.4	124
180 min Winter	39.837	0.0	388.7	182
240 min Winter	31.918	0.0	415.3	238

Summary of Results for 200 year Return Period (+53%)

	Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
360	min Winter	159.696	0.696	5.9	369.2	O K
480	min Winter	159.698	0.698	5.9	370.5	O K
600	min Winter	159.692	0.692	5.9	366.6	O K
720	min Winter	159.681	0.681	5.9	359.6	O K
960	min Winter	159.654	0.654	5.9	342.9	O K
1440	min Winter	159.590	0.590	5.9	304.1	O K

	Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
360	min Winter	23.328	0.0	455.3	354
480	min Winter	18.670	0.0	485.8	464
600	min Winter	15.702	0.0	510.6	572
720	min Winter	13.625	0.0	531.6	676
960	min Winter	10.882	0.0	565.7	766
1440	min Winter	7.912	0.0	616.2	1054

Rainfall Details

Rainfall Model	FEH
Return Period (years)	200
FEH Rainfall Version	2013
Site Location	GB 267484 561415 NX 67484 61415
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	1440
Climate Change %	+53

Time Area Diagram

Total Area (ha) 0.390

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.200	4	8	0.190

Time Area Diagram

Total Area (ha) 0.000

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

Model Details

Storage is Online Cover Level (m) 160.000

Tank or Pond Structure

Invert Level (m) 159.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	433.0	1.000	735.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0114-5900-1000-5900
Design Head (m)	1.000
Design Flow (l/s)	5.9
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	114
Invert Level (m)	159.000
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	5.9	Kick-Flo®	0.645	4.8
Flush-Flo™	0.295	5.9	Mean Flow over Head Range	-	5.1

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	4.0	1.200	6.4	3.000	9.9	7.000	14.8
0.200	5.7	1.400	6.9	3.500	10.6	7.500	15.3
0.300	5.9	1.600	7.3	4.000	11.3	8.000	15.8
0.400	5.8	1.800	7.8	4.500	12.0	8.500	16.2
0.500	5.6	2.000	8.2	5.000	12.6	9.000	16.7
0.600	5.2	2.200	8.5	5.500	13.2	9.500	17.1
0.800	5.3	2.400	8.9	6.000	13.7		
1.000	5.9	2.600	9.2	6.500	14.3		

Summary of Results for 200 year Return Period (+53%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	89.285	0.285	15.1	362.3	O K
30 min Summer	89.390	0.390	15.2	505.4	O K
60 min Summer	89.492	0.492	15.2	649.8	O K
120 min Summer	89.554	0.554	15.2	741.2	O K
180 min Summer	89.585	0.585	15.2	786.1	O K
240 min Summer	89.601	0.601	15.2	810.6	O K
360 min Summer	89.613	0.613	15.2	829.1	O K
480 min Summer	89.612	0.612	15.2	827.1	O K
600 min Summer	89.608	0.608	15.2	820.9	O K
720 min Summer	89.602	0.602	15.2	812.1	O K
960 min Summer	89.587	0.587	15.2	789.2	O K
1440 min Summer	89.548	0.548	15.2	732.1	O K
15 min Winter	89.318	0.318	15.2	406.8	O K
30 min Winter	89.435	0.435	15.2	568.0	O K
60 min Winter	89.548	0.548	15.2	731.3	O K
120 min Winter	89.619	0.619	15.2	837.8	O K
180 min Winter	89.655	0.655	15.2	892.4	O K
240 min Winter	89.676	0.676	15.2	924.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	199.257	0.0	348.8	22
30 min Summer	140.134	0.0	497.0	37
60 min Summer	91.685	0.0	674.2	66
120 min Summer	54.339	0.0	800.6	124
180 min Summer	39.837	0.0	881.1	184
240 min Summer	31.918	0.0	941.6	242
360 min Summer	23.328	0.0	1032.6	360
480 min Summer	18.670	0.0	1102.0	442
600 min Summer	15.702	0.0	1158.3	498
720 min Summer	13.625	0.0	1205.8	558
960 min Summer	10.882	0.0	1283.2	684
1440 min Summer	7.912	0.0	1396.0	954
15 min Winter	199.257	0.0	392.7	22
30 min Winter	140.134	0.0	558.2	36
60 min Winter	91.685	0.0	756.2	66
120 min Winter	54.339	0.0	897.7	122
180 min Winter	39.837	0.0	987.7	180
240 min Winter	31.918	0.0	1055.4	238

Summary of Results for 200 year Return Period (+53%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
360 min Winter	89.696	0.696	15.2	955.4	O K
480 min Winter	89.700	0.700	15.2	962.0	O K
600 min Winter	89.695	0.695	15.2	954.0	O K
720 min Winter	89.684	0.684	15.2	936.6	O K
960 min Winter	89.660	0.660	15.2	899.8	O K
1440 min Winter	89.602	0.602	15.2	812.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
360 min Winter	23.328	0.0	1157.1	354
480 min Winter	18.670	0.0	1234.6	464
600 min Winter	15.702	0.0	1297.4	572
720 min Winter	13.625	0.0	1350.5	670
960 min Winter	10.882	0.0	1436.8	748
1440 min Winter	7.912	0.0	1562.6	1042

Rainfall Details

Rainfall Model	FEH
Return Period (years)	200
FEH Rainfall Version	2013
Site Location	GB 267484 561415 NX 67484 61415
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	1440
Climate Change %	+53

Time Area Diagram

Total Area (ha) 1.000

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.500	4	8	0.500

Model Details

Storage is Online Cover Level (m) 90.000

Tank or Pond Structure

Invert Level (m) 89.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	1202.0	1.000	1719.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0176-1520-1000-1520
Design Head (m)	1.000
Design Flow (l/s)	15.2
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	176
Invert Level (m)	89.000
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	15.2	Kick-Flo®	0.702	12.9
Flush-Flo™	0.321	15.2	Mean Flow over Head Range	-	12.9

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)
0.100	6.2	1.200	16.6	3.000	25.7	7.000	38.6
0.200	14.6	1.400	17.8	3.500	27.6	7.500	39.9
0.300	15.2	1.600	19.0	4.000	29.5	8.000	41.2
0.400	15.1	1.800	20.1	4.500	31.2	8.500	42.4
0.500	14.8	2.000	21.1	5.000	32.8	9.000	43.6
0.600	14.2	2.200	22.1	5.500	34.4	9.500	44.8
0.800	13.7	2.400	23.1	6.000	35.8		
1.000	15.2	2.600	24.0	6.500	37.2		

Summary of Results for 200 year Return Period (+53%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	59.478	0.178	1.9	46.7	O K
30 min Summer	59.540	0.240	1.9	64.8	O K
60 min Summer	59.597	0.297	1.9	82.7	O K
120 min Summer	59.628	0.328	1.9	92.8	O K
180 min Summer	59.640	0.340	1.9	97.0	O K
240 min Summer	59.644	0.344	1.9	98.5	O K
360 min Summer	59.641	0.341	1.9	97.5	O K
480 min Summer	59.632	0.332	1.9	94.3	O K
600 min Summer	59.624	0.324	1.9	91.7	O K
720 min Summer	59.617	0.317	1.9	89.4	O K
960 min Summer	59.605	0.305	1.9	85.4	O K
1440 min Summer	59.582	0.282	1.9	77.9	O K
15 min Winter	59.498	0.198	1.9	52.4	O K
30 min Winter	59.566	0.266	1.9	73.1	O K
60 min Winter	59.630	0.330	1.9	93.5	O K
120 min Winter	59.666	0.366	1.9	105.8	O K
180 min Winter	59.682	0.382	1.9	111.3	O K
240 min Winter	59.689	0.389	1.9	114.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	199.257	0.0	48.5	19
30 min Summer	140.134	0.0	68.1	33
60 min Summer	91.685	0.0	89.3	64
120 min Summer	54.339	0.0	105.9	122
180 min Summer	39.837	0.0	116.3	182
240 min Summer	31.918	0.0	124.3	242
360 min Summer	23.328	0.0	136.2	360
480 min Summer	18.670	0.0	145.4	446
600 min Summer	15.702	0.0	152.9	500
720 min Summer	13.625	0.0	159.4	564
960 min Summer	10.882	0.0	169.5	692
1440 min Summer	7.912	0.0	185.0	966
15 min Winter	199.257	0.0	54.2	19
30 min Winter	140.134	0.0	76.4	33
60 min Winter	91.685	0.0	100.1	62
120 min Winter	54.339	0.0	118.6	120
180 min Winter	39.837	0.0	130.4	178
240 min Winter	31.918	0.0	139.3	236

Summary of Results for 200 year Return Period (+53%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
360 min Winter	59.692	0.392	1.9	114.9	O K
480 min Winter	59.687	0.387	1.9	113.0	O K
600 min Winter	59.677	0.377	1.9	109.6	O K
720 min Winter	59.665	0.365	1.9	105.6	O K
960 min Winter	59.650	0.350	1.9	100.6	O K
1440 min Winter	59.618	0.318	1.9	89.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
360 min Winter	23.328	0.0	152.8	350
480 min Winter	18.670	0.0	163.0	460
600 min Winter	15.702	0.0	171.3	562
720 min Winter	13.625	0.0	178.4	600
960 min Winter	10.882	0.0	190.0	740
1440 min Winter	7.912	0.0	207.2	1050

Rainfall Details

Rainfall Model	FEH
Return Period (years)	200
FEH Rainfall Version	2013
Site Location	GB 267484 561415 NX 67484 61415
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	1440
Climate Change %	+53

Time Area Diagram

Total Area (ha) 0.130

Time (mins) From:	To:	Area (ha)
0	4	0.130

Model Details

Storage is Online Cover Level (m) 60.000

Tank or Pond Structure

Invert Level (m) 59.300

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	237.0	0.700	461.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0070-1900-0700-1900
Design Head (m)	0.700
Design Flow (l/s)	1.9
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	70
Invert Level (m)	59.000
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

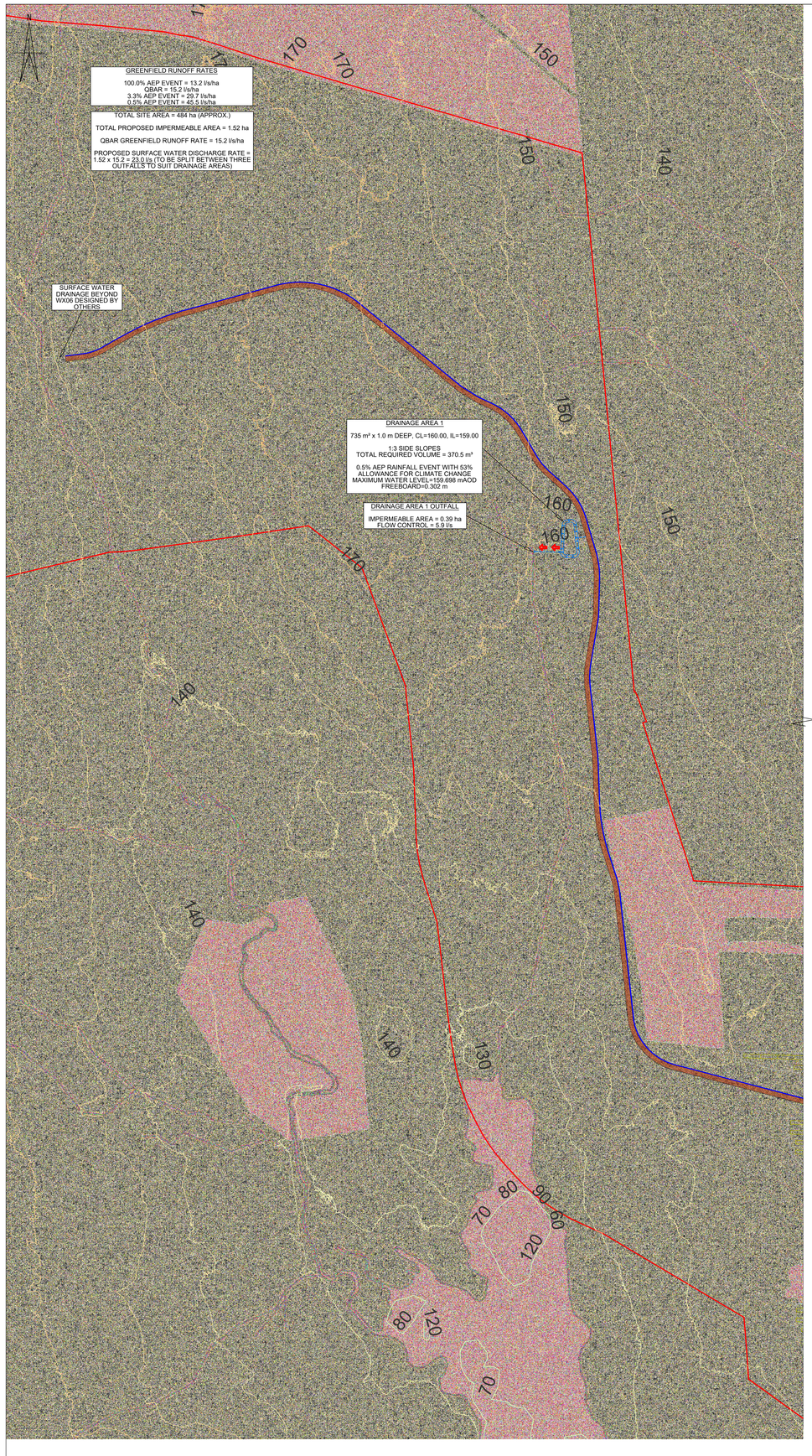
Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.700	1.9	Kick-Flo®	0.450	1.6
Flush-Flo™	0.209	1.9	Mean Flow over Head Range	-	1.7

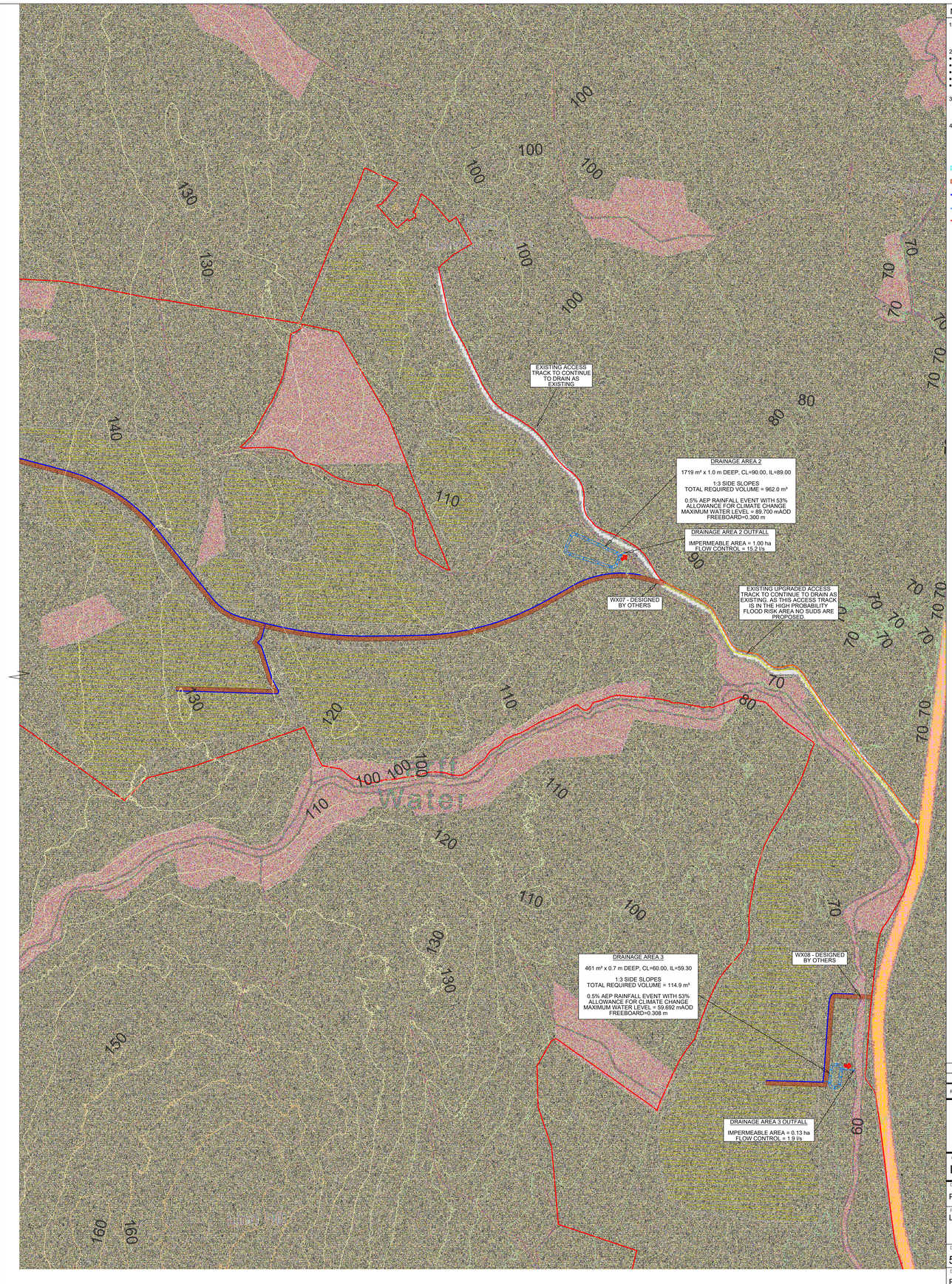
The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.7	1.200	2.4	3.000	3.7	7.000	5.5
0.200	1.9	1.400	2.6	3.500	4.0	7.500	5.7
0.300	1.9	1.600	2.8	4.000	4.2	8.000	5.9
0.400	1.7	1.800	2.9	4.500	4.5	8.500	6.1
0.500	1.6	2.000	3.1	5.000	4.7	9.000	6.2
0.600	1.8	2.200	3.2	5.500	4.9	9.500	6.4
0.800	2.0	2.400	3.3	6.000	5.1		
1.000	2.2	2.600	3.5	6.500	5.3		

APPENDIX D

Preliminary Drainage Layout





NOTES

1. THIS DRAWING TO BE READ IN CONJUNCTION WITH ALL RELEVANT WEETWOOD DRAWINGS. ANY DISCREPANCIES, ERRORS OR OMISSIONS TO BE BROUGHT TO THE ATTENTION OF WEETWOOD.
2. ANNUAL EXCEEDANCE PROBABILITY RAINFALL EVENTS:
   - 100.0% (1:1) AEP RAINFALL EVENT
   - 50.0% (2:2) AEP RAINFALL EVENT
   - 43.5% (QBAR) AEP RAINFALL EVENT
   - 3.3% (1:30) AEP RAINFALL EVENT
   - 1.0% (1:100) AEP RAINFALL EVENT
3. PROPOSED SITE LAYOUT TAKEN FROM ATMOS CONSULTING "DETAILED SITE LAYOUT" DRAWING (REF: TL010-40418/SL/079D, MAR 2025).
4. EXISTING LEVEL INFORMATION TAKEN FROM LIDAR.

DRAINAGE KEY

- EXISTING WATERCOURSE
- PROPOSED ACCESS TRACK
- PROPOSED FILTER DRAIN
- PROPOSED SURFACE WATER SEWER
- SITE BOUNDARY
- OVERLAND FLOW ROUTE

REV	DATE	DESCRIPTION	DRAWN BY	CHECK BY
P2	24.04.25	UPDATED TO CLIENT COMMENTS	DSH	TB
P1	27.03.25	INITIAL ISSUE	DSH	TB

Park House, Fforddd Byrnwr Gwair, Mold CH7 1FQ
Tel 01352 700045
info@weetwood.net
www.weetwood.net

Client: LAIRDMANNOCH ENERGY PARK LTD

Drawing Status: PLANNING
Date: MAR 2025
Scale (A2): 1:2000
Project: LAIRDMANNOCH ENERGY PARK
Drawn by: DSH
Check by: TB
Drawing Number: 5882-WTWD-00-XX-DR-D-1101
Revision: P2
Drawing Title: PRELIMINARY SURFACE WATER DRAINAGE LAYOUT

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