Cossans Solar and BESS

Technical Appendix 7.1: Flood Risk & Drainage Assessment Report

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1. Introduction

1.1 Preamble

Gondolin Land and Water Ltd (Gondolin) has been appointed by SLR Consulting Limited on behalf of Trio Power Ltd (The Client) to carry out a Flood Risk and Drainage Assessment (FRDA) to provide support and input to the Environmental Impact Assessment Report (EIAR) submission to support a planning application for a proposed solar farm and battery storage development at land 1.5km west of the A90 Forfar Bypass, Cossans, Angus DD8 1QY. This Flood Risk and Drainage Assessment (FRDA) report has been prepared as a report for planning and Technical Appendix 1 to Chapter 7: Hydrology and Flood Risk within the EIAR.

This report addresses any potential flood risk to the proposed developments from all possible sources in accordance with best practice and Scotland's fourth National Planning Framework (NPF4).

This report provides the relevant technical assessment for the site taking due cognisance of local / national drainage design guidance (CIRIA Report C753), Angus Council specific guidance and Scottish Water Sewers for Scotland 4th Edition.

The Site was visited in September 2024 by an experienced Hydrologist and Civil Engineer to inform this assessment.

1.2 Site Context

The site covers an area of approximately 87ha approximately 1.6km east of the town of Forfar, some 5km southeast of Kirriemuir and 200m north of the Dean Water at the approximate National Grid Reference (NGR): NO 41320 49695. The site is located in the Angus Council Local Authority. The Proposed Development is for a Solar Farm and BESS with associated access, landscaping, drainage and ancillary works.

The site is currently agricultural land and 'greenfield', as there has been no development since the mid-19th century. The residential properties of Haughs of Cossans House and Cottage are located just south of the site.

The site is bounded to the east by an unnamed minor road.

A site location plan is included as Drawing FRDA-001.

1.3 Development Details

The proposed development is for a 65.05MW PV Solar Farm with the following related equipment:

- Substation
- Battery storage facility
- Underground cabling
- Invertor stations
- Transformers
- Maintenance building
- Access and site tracks

Proposed development plans are included in Appendix A.

1.4 Topography

Detailed Scottish LiDAR Phase 1 1m DTM data available from the Scottish Remote Sensing Portal was used to inform this assessment. Review of the site DTM data indicates that the site has a varied topography. The west and east have higher elevations that slope down to the centre of the site which features small mounds of higher ground amongst the lower elevation. Natural ground levels range from 61mAOD in the east (along the northern boundary) to 52.5mAOD in the centre of the site. Land falls toward the Dean Water across the southern boundary of the site and beyond.

1.5 Geology and Hydrogeology

1.5.1 Geology

1.5.1.1 Superficial

Review of the British Geological Survey (BGS) online geology maps[1] indicates that the site is underlain by a mixture of glaciofluvial deposits comprised of gravel, sand and silt and Lacustrine deposits comprised of silt and sand. There is also a small pocket of peat deposit in the northeast of the site.

1.5.1.2 Bedrock

Review of the BGS online 1:50,000 bedrock map indicates that the underlying bedrock geology of the entire site and surrounding area is made up of the Dundee Flagstone Formation comprised of sandstone, siltstone and mudstone.

Review of the BGS online linear features map indicates that there are no linear features onsite, but there is an inferred displacement fault is mapped approximately 1.4km to the east of the site.

1.5.2 Hydrogeology

Review of the BGS online hydrogeology maps indicates that the underlying bedrock geology is characterised by a moderately productive aquifer, summarised as 'sandstones, in places flaggy, with siltstones, mudstones and conglomerates and interbedded lavas, locally yield moderate amounts of groundwater'.

1.6 Local Hydrology

Review of the Flood Estimation Handbook (FEH) Web Service[2] and other available mapping indicates that the main watercourse associated with the site is the Dean Water which runs east to west 200-400m south of the site. It is sourced from the Loch of Forfar 1.5km upstream of the site. There are two other main watercourses in locality to the site which discharge into the Dean Water (Ballindarg Burn and Kerbet Water). The Ballindarg Burn runs north to south through the centre of the site between areas of development before discharging into the Dean Water. The Kerbet Water flows south to north before discharging into the Dean Water south of the site. There are also a variety of minor watercourses/ field drains running through the site between development areas.

The Ballindarg Burn and the Kerbet Water each have their own natural surface water catchment (33.35km^2 and 65.53km^2), however the entirety of the site is also within the natural surface water catchment of the Dean Water (119.06km^2, taken downstream of the site). The site naturally drains to the Dean Water directly or via the Ballindarg Burn or other small watercourses / drains.

A hydrological summary and catchment characteristics of the Dean Water upstream of the site (US), the Ballindarg Burn, Kerbet Water and the Dean Water downstream of the site (DS) are shown in Table 1 below. The data shown is taken from the FEH Web Service and the catchment has been delineated from the NGR: NO 39650 48800, a point just downstream of the site along the Dean Water.

[1] British Geological Survey (2025) Natural Environment Research Council – online Geology of Britain Viewer, available at: https://mapapps.bgs.ac.uk/geologyofbritain/home.html (accessed on 25th March 2025)
[2] UK Centre for Ecology and Hydrology (2025) Flood Estimation handbook Web Service, available at: https://fehweb.ceh.ac.uk/ (accessed on 25th March 2025)

Table 1 Hydrological Summary

Waterbody Catchment	Area (km²)	SAAR[1] (mm)	URBEXT[2] (%)	PROPWET[3]	SPRHOST[4] (%)	ALTBAR[5] (m)
Dean Water (DS)	119.06	830	0.0209	0.37	39.25	124
Ballindarg Burn	33.35	832	0.0134	0.42	37.48	106
Kerbet Water	146	838	0.0007	0.36	41.38	146
Dean Water (US)	17.7	802	0.0787	0.36	36.3	83

[1]*SAAR = Standard Annual Average Rainfall*
[2]*URBEXT = Extent of Urban and Suburban Land Cover*
[3]*PROPWET = Proportion of Time the Soil Moisture Deficit (SMD) was equal to, or below, 6mm during 1961-1990*
[4]*SPRHOST = Standard Percentage Runoff using UK Hydrology of Soil Types (HOST) Classification*
[3]*ALTBAR = Mean Catchment Altitude*

The FEH data indicates that all catchments in Table 1 experience a low to moderate SAAR value for a Scottish catchment and that the catchments are mainly rural with some urbanisation, with the PROPWET values showing that the soils are wet less than half of the time. A SPRHOST value of 36.3-41.38% indicates moderate to high runoff potential.

Drawing FRDA-002 provides hydrological overview for the site and immediate surroundings.

2. Planning & Policy Context

2.1 Overview

This assessment has been completed in accordance with guidance presented within National Planning Framework for Scotland 4 (NPF4) and taking cognisance of the Flood Risk Management (Scotland) Act 2009.

The assessment also references and takes due consideration of the following principal guidance and policy documents:

- British Standards Institution (2017) Assessing and Managing Flood Risk in Development – Code of Practice, Report BS-8533:2017;
- British Water – Code of Practice, Flows and Loads 4, 2013
- CIRIA (2015) The SuDS Manual, Report C753
- Angus Council (2023) Flood Risk and Surface Water Drainage Requirements;
- CIRIA (2006) Report C635 – Designing for Exceedance in Urban Drainage, Good Practice
- Angus Council (2016) Local Development Plan;
- Angus Council (2015) Strategic Flood Risk Assessment;
- Scottish Environment Protection Agency (2018) Technical Flood Risk Guidance for Stakeholders (Reference: SS-NFR-P-002) July 2018;
- Scottish Environment Protection Agency (2024) Flood Risk and Land Use Vulnerability Guidance (Reference: LUPS-GU24), July 2024;
- Scottish Environment Protection Agency (2018) SEPA Development Plan Guidance Note 2a: Development Management Guidance: Flood Risk (Reference: LUPS-DM-GU2a), July 2018;
- Scottish Environment Protection Agency (2024) Climate Change Allowances for Flood Risk Assessment in Land Use Planning (Reference: LUPS-CC1) August 2024.

- Scottish Environment Protection Agency (2014) WAT-RM-08 – Sustainable Urban Drainage Systems (SuDS)
- Scottish Water (2018) – Sewers for Scotland v4

2.2 National Planning Policy Framework 4

This report has been prepared in accordance with NPF4 Policy 22 relating to Flood Risk and Water Management, which states:

2.2.1.1 "Policy 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.

2.2.1.2 Policy Outcomes:

- "Places are resilient to current and future flood risk.
- Water resources are used efficiently and sustainably.
- Wider use of natural flood risk management benefits people and nature."

Furthermore, NPF4 states that development proposals at risk of flooding or in a flood risk area will only be supported if they are for:

- "Essential infrastructure where the location is required for operational reasons;
- Water compatible uses;
- Redevelopment of an existing building or site for an equal or less vulnerable use; or.
- Redevelopment of previously used sites in built up areas where the 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".

2.3 SEPA Flood Risk and Land Use Vulnerability Guidance

2.3.1 Context

This guidance outlines how SEPA assess the vulnerability to flooding of different land use with the following categories:

- Most Vulnerable Uses;
- Highly Vulnerable Uses;
- Least Vulnerable Uses;
- Essential Infrastructure; and
- Water Compatible uses.

The following excerpt from the guidance is provided for context:

"This guidance supports Policy 22 of the National Planning Framework 4 (NPF4) by explaining vulnerability in a flooding context, and the relative vulnerability of different land uses to flooding. Policy 22 sets out exceptions where development can be permitted in a flood risk area. This guidance aims to support application of the first three of those exceptions, specifically the emboldened terms:

*i. **Essential infrastructure** where the location is required for operational reasons.*

*ii. **Water compatible uses**; and*

*iii. Redevelopment of an existing building or site for **an equal or less vulnerable use**."*

2.3.2 Proposed Development Suitability

With reference to the above guidance the proposed developed is considered **Essential Infrastructure** category. In accordance with NPF4 Policy 22, the proposed development would therefore be suitable within an area identified to be at risk of flooding provided the following criteria is demonstrated:

- 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.

3. Flood Risk Assessment

3.1 Screening Assessment of Potential Source of Flood Risk

3.1.1 Overview

There are a number of potential sources of flooding which should be evaluated in accordance with best practice and NPF4 such as:

- Flooding from rivers or fluvial flooding;
- Flooding from the sea or tidal / coastal flooding;
- Flooding from land;
- Flooding from groundwater;
- Flooding from sewers; and
- Flooding from reservoirs, canals, and other artificial sources.

The flood risk from each of these potential sources is discussed in the following sections and a 'screening assessment' is presented in Section 3.1.8 which confirms any potential flood risk sources requiring a more detailed analysis and specification of bespoke mitigation measures.

Flood 'risk' definitions within the screening exercise are based on a qualitative technical assessment taking into account the information reviewed, risk to site users and the Proposed Development itself.

3.1.2 Fluvial Flooding

Review of SEPA's Fluvial Flood Map for the site indicates that the lower elevation central area of the site and areas along the southern site boundary are at low to high risk (0.1-10% per year) of flooding from fluvial sources. The eastern and western extents of the site are out with the mapped fluvial flooding extent.

It is noted that SEPA flood maps are only indicative and are modelled on a regional scale, this reduces their accuracy when defining flood extents at a local level. Therefore, a site-specific flood model is required to assess the flood extent for the proposed development.

Therefore, there is a '**Low** to **High Risk'** of fluvial flooding (0.1-10% AEP) from river sources and therefore fluvial flooding will be considered further in Section 4 of this report.

3.1.3 Tidal/Coastal Flooding

The site is located sufficiently inland from tidally influenced waters and the coast, thus is not subject to tidal or coastal flood risk and designated as **'No Risk'** to the site.

Flooding from this source is therefore not considered further in the assessment.

3.1.4 Flooding from Land (Pluvial or Surface Water Flooding)

Review of SEPA's Surface Water Flood Map shows that there are pockets of low to high risk of surface water flooding across the site predominantly associated with the minor drains in the local area. The most prolific of these areas is along the northern site boundary in a topographic depression at the foot of the western slope. This area is also noted in the fluvial flood extents. Other small pockets of surface water flooding exist across the site however these are in small topographic depressions and are highly localised.

It is to be noted that the majority of surface water flooding is interlinked with fluvial flooding therefore any risk of flooding from land sources is encompassed within the fluvial assessment.

Taking the above into account it is considered that there is **'Low Risk'** of flooding to the site from land (that is not associated and encapsulated within the fluvial flooding assessment) and therefore this source will not be considered further in the assessment.

3.1.5 Groundwater Flooding

Review of SEPA's Groundwater Flood Map shows that the some of the site and surrounding area are located in an area identified to be at low risk of groundwater flooding. Despite Angus Council Strategic Flood Risk Assessment describing groundwater as a significant part of flooding issues in the council area, the historic floods in Forfar have been accounted to surface water, and Forfar has not been flagged as an area at particular risk from groundwater flooding.

Taking the above into account it is considered that the development site is at **'Low Risk'** of groundwater flooding and therefore this source is not considered further in the assessment.

3.1.6 Flooding from Sewers / Drainage Systems

Given the rural nature of the development and review of the Scottish Water Extranet indicates that there are no public sewers located within the immediate vicinity.

Taking the above into account it is considered that there is **'No Risk'** of flooding to the site from sewers and drainage systems and therefore this source is not considered further in the assessment.

3.1.7 Flooding from Infrastructure Failure / Blockage

Review of SEPA's Reservoir Flood Mapping indicates that there are no significant impoundments of water immediately upgradient and in hydraulic continuity with the site which would pose a flood risk to the site in the event of failure. The Loch of Forfar is located upgradient of the site and in hydraulic continuity but is not included within SEPA's Reservoir Flood Mapping. It is noted that in the event of failure of this loch, flood waters would be routed downstream along the Dean Water. The Dean Water passes beneath A90 immediately downgradient of the loch. This structure would act as a throttle to any rapid inundation due to the loch failure which would limit any flooding extents further downstream close to the site. Furthermore, the loch is a natural body of water and thus the potential for failure is negligible.

There are no other known water infrastructure features at / in proximity to the site which would pose a material flood risk in the event of failure.

As such it is considered that the development site is at **'No Risk'** of flooding from this source and therefore is not considered further in the assessment.

3.1.8 Flood Risk Screening Assessment Review

A summary of the potential flood risk to the site from the sources reviewed is presented in Table 2 below.

This 'Screening Assessment' is used to identify if any sources of flood risk are required to be investigated in more detail i.e., a 'Technical' more detailed assessment which would include consideration / specification of bespoke flood mitigation measures for the site development.

Table 2 Flood Risk Screening Assessment

Potential Flood Source	Screening Assessment of Flood Risk at Site[1]	Requiring Further Consideration i.e. Technical Assessment?
Fluvial flooding	Low to High Risk	Yes
Tidal flooding	No Risk	No
Flooding from land	Low	No
Groundwater flooding	Low Risk	No
Flooding from sewers / artificial drains	No Risk	No
Flooding due to infrastructure failure / blockage	No Risk	No

Notes: [1]only Flood Risks designated as being 'Medium' or 'High' warrant further investigation

The Screening Assessment above indicates that with the exception of fluvial flooding, all screened sources of flooding have been identified as low risk or lower and therefore will not be considered further in this assessment. A technical assessment of fluvial flooding has been undertaken in Section 4.

3.2 Climate Change

3.2.1 Context

The most recent Climate Change (CC) projections published by The UK Climate Impacts Programme are presented in report 'UKCP18'. Central estimates published in UKCP18 indicate marked increases in winter rainfall and decreases in summer rainfall but with more intense storms under all CO2 emissions scenarios across the majority of the country.

SEPA's most recent climate change allowances were published in August 2024[3] and are based on UKCP18 findings in conjunction with The Centre for Ecology and Hydrology's (CEH) 2020 study[4].

A climate change allowance in drainage and flood risk assessment terms is a prediction of anticipated change in peak river flow, peak rainfall intensity and sea level rise caused by future climate change.

The allowances applied for sea level rise, peak river flow and peak rainfall intensity are determined by river basin regions across Scotland. SEPA have developed a web map[5] to allow any location in Scotland to be identified for its applicable river basin region and respective climate change uplift allowances.

3.2.2 Peak River flow

With reference to SEPA's online map service, the site is located within the Tay River Basin Region. The peak river flow allowance until 2100 for this region is a 53% uplift.

This increase in peak river flows has been applied to the technical fluvial assessment to appropriately consider climate change impacts on the Dean Water, Ballindarg Burn and Kerbet Water.

3.2.3 Peak rainfall intensity

Using SEPA's online map service, the site is located within the Tay River Basin Region. The peak rainfall intensity allowance until 2100 for this region is a 39% uplift.

This increased rainfall intensity is appropriately factored into the proposed SuDS strategy / drainage design.

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[3] Scottish Environment Protection Agency (2024) Climate change allowances for flood risk assessment in land use planning
[4] Centre for Ecology & Hydrology (2021) Climate change impacts on peak river flows: Combining national-scale hydrological modelling and probabilistic projections
[5] SEPA Climate Change Allowances for Flood Risk Assessment in Land Use Planning: https://scottishepa.maps.arcgis.com/apps/webappviewer/index.html?id=2ddf84e295334f6b93bd0dbbb9ad7417 (accessed on 25th March 2025)

3.2.4 Sea Level Rise

Using SEPA's online map service, the site is located within the Tay River Basin Region. The cumulative sea level rise allowance until 2100 for this region is a 0.85m uplift.

This increase in predicted Sea Level rise will not increase the coastal flood risk to the site due to the distance from the site to the closest tidally influenced waters.

4. Technical Flood Risk Assessment – Fluvial

4.1 Introduction

4.1.1 Context

The screening assessment outlined above concludes a potential **'Low** to **High Risk'** of fluvial flooding from the Dean Water, Ballindarg Burn and Kerbet Water. As such, a detailed technical assessment of fluvial flooding at the site has been undertaken in the form of a detailed site-specific Hydraulic Flood Modelling Study.

4.1.2 Fluvial Flood Risk Overview

The local hydrology described in Section 1.6 of this report highlighted the locality of the Dean Water, Ballindarg Burn and Kerbet Water to the site. Given the proximity of the watercourses to the site there is a potential risk of high flows inundating parts of the site as outlined in Section 3.1.2 previously.

SEPAs flood maps are not produced at a suitably accurate local scale to be relied upon for site specific assessments (as noted by SEPA themselves) and thus a bespoke hydraulic flood model has been constructed to determine the site-specific risk.

4.1.3 Model Selection

To accurately assess the potential flood risk to the site, Gondolin have developed a 2D hydraulic flood model using the Hydrologic Engineering Centre's River Analysis System (HEC-RAS). Additionally, the hydraulic flood model will assess the modes of flooding (i.e., onset of flooding, preferential flow routes etc.) and the maximum flood extents.

A 2D model approach has been chosen for the assessment given the objective of the model is to assess floodplain flow within the site at larger flood events. The model selection has been informed by relevant SEPA guidance[6].

HEC-RAS has been successfully applied across the UK and is a recognised modelling package endorsed by SEPA and Local Authorities.

4.1.4 Model Extents

The 2D domain has been constructed to include a sufficient length of the Dean Water, Ballindarg Burn and Kerbet Water both upstream and downstream of the proposed development. The total reach length of the Dean Water in the model is approximately 7250m with the site being located at the approximate middle point of the reach. Three upstream extents of the model have been selected for each of the three watercourses. They have been selected at the outflow of culverts that pass beneath the A90 (Dean Water) and farm track upstream of the site (Ballindarg Burn) as well as a point in the Kerbet Water upstream of the discharge point into the Dean Water (within an area where the channel is incised and contained). The inflow locations have been selected at existing flow constraint points to enable an accurate representation of flooding within the area of interest.

No structures have been considered as being hydraulically significant within locality to the site. Therefore, none have been included within the 2D model – with the exception of applying inflows near to culvert / structure outflow location however these have not been explicitly modelled. There are numerous small crossings within the minor watercourses and the Ballindarg Burn which have been removed from the terrain. Given the anticipated wide extents of flooding, these structures are not

[6] SEPA, Flood Modelling Guidance for Responsible Authorities, Version 1.1

considered to have a significant impact on flood flows during extreme events as they would quickly become overwhelmed within the wide floodplain extents.

The 2D domain also incorporates the local area adjacent to the left and right overbanks of the Dean Water, Ballindarg Burn and Kerbet Water and is extended sufficiently outward from the three watercourses to ensure all potential floodplain inundation extents are included within the model.

An overview of the hydraulic flood model is shown on Drawing FRDA-003.

4.2 Data Collection

4.2.1 Model Requirements

The construction of the 2D hydraulic flood model requires a number of data sets and parameters which can be summarised under the following headings:

- Terrain data
- Hydrological inputs
- Hydraulic boundaries
- Roughness (Manning's n)

4.2.2 Terrain Data

Terrain data must be applied to the 2D model to accurately represent the local topography and assess flows / flooding extents. LiDAR data obtained from the Scottish Remote Sensing Portal[7] has been used to represent the local terrain within the model.

4.2.3 Hydrological Inputs

The hydrological inputs used in the model are detailed within Section 4.3 of the report.

4.2.4 Hydraulic Boundaries

Three inflows and a single outflow hydraulic boundary (boundary condition) were applied within the hydraulic flood model. The applied boundary conditions are summarised as follows:

- 2D Inflow Boundary: Flow hydrograph to represent the inflow into the model. Locations as follows:
    1. Downstream of the culvert channelling the Dean Water underneath the A90 to represent the inflow of the Dean Water.
    2. Downstream of the culvert channelling the Ballindarg Burn under a farm track north of the site to represent the inflow of the Ballindarg Burn.
    3. A point in the Kerbet Water upstream of the discharge point into the Dean Water to represent the inflow of the Kerbet Water. Located within incised section of the watercourse to ensure all receiving flows are represented appropriately.
- 2D Outflow Boundary: Normal Depth boundary to represent the outflow from the model at the downstream extent of the Dean Water after the Ballindarg Burn and Kerbet Water have discharged into the Dean Water past the western extent of the site. Outflow location has been located sufficiently downstream of the site to ensure flood extents within the site and local area are accurately captured.

4.2.5 Roughness (Manning's n)

Channel and floodplain roughness were represented within the model by values of Manning's n. All values were chosen from standard values published in texts such as Chow[8], in comparison with photographs collected during site visits / provided by the survey team, satellite imagery and from professional experience / judgement.

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[7] https://remotesensingdata.gov.scot/data#/map
[8] Chow, V.T., Open Channel Hydraulics, 1959

4.3 Hydrological Analysis

4.3.1 Overview

The FEH offers two principal methods of flood flow estimation; the Rainfall-Runoff Method and the Statistical Method. The Statistical Method estimates peak flow for a catchment for a given annual exceedence probaility (AEP) event using a combination of historic gauging station data and catchment descriptors. The Rainfall-Runoff Method estimates the response of a catchment to a rainfall event of a given AEP and generates a peak flow based entirely on catchment descriptors.

The FEH is supported by WINFAP-FEH (WINFAP) and the Revitalised Flood Hydrograph V.2 (ReFH2) software applications published by Wallingford Hydrosolutions[9] which are used in combination with the FEH Web Service.

The WINFAP software supports the statistical procedures for flood frequency estimation, using historic annual maxima data alongside catchment descriptors. The latest version of WINFAP, version 5.0, has been used in this study in conjunction with the latest version of WINFAP data files.

Catchment charateristics of the Dean Water upstream (US) and downstream (DS), Ballindarg Burn and Kerbet Water are outlined in Table 1 obtained from the FEH Web Service have been used within the hydrolgoical analysis.

4.3.2 Revitalised Flood Hydrograph V.2 (ReFH2)

The catchment associated with the reach of the Dean Water upstream of the site (US Dean), Ballindarg Burn and Kerbet Water have been applied to the ReFH2 software to estimate peak flows for a range of AEP events and their respective hydrographs.

The catchment associated with the Dean Water downstream of the site (DS Dean) has also been applied to the ReFH2 software to estimate the peak flow of a range of AEP events and their respective hydrographs. This is the main catchment for the site which encompasses the other sub-catchments (US Dean, Ballindarg and Kerbet). Therefore, the peak flow of this catchment should be equal to the peak flows of the sub-catchments combined.

The hydrographs produced from the analysis are used as the basis of the upstream boundary conditions the hydraulic flood model.

Table 3 below provides the peak flow estimate for a range of typical return periods. The peak flows shown are for a critical storm duration of 11 hours as this is the consistent critical storm duration that can be used for all catchments to produce the most conservative estimate of peak flow.

Table 3 ReFH2 Peak Flow Estimation Summary of the Dean Water, Ballindarg Burn, Kerbet Water and US Dean Water

		Peak Flow (m^3/s)			
Return Period (years)	**AEP (%)**	**DS Dean Water**	**Ballidarg Burn**	**Kerbet Water**	**US Dean Water**
2	50	16.17	4.124	11.38	2.377
10	10	23.98	6.257	16.70	3.545
50	5	33.77	9.082	23.24	5.026
100	1	39.83	10.81	27.25	5.950
200	0.5	47.10	12.84	32.10	7.092
200 +53% CC	0.5	72.06	19.65	49.11	10.85
1,000	0.1	66.78	18.23	45.26	10.16

[9] https://www.hydrosolutions.co.uk/software/

In accordance with SEPA climate change guidance, peak river flow uplift has been applied to the analysis given the catchment size of the Dean Water. The results shown that peak river flow uplift represents the worst case and thus this climate change allowance has been used within the assessment.

4.3.3 Statistical Method

4.3.3.1 Overview

The Statistical Method is broadly a two-part process; the estimation of the median annual flood (QMED) and the derivation of a growth curve. The growth curve relates the increase in peak flow as a multiple of QMED against the rarity of the AEP event.

QMED can be generated from either annual maxima flow data or catchment descriptors, whereas the growth curve is generated solely from annual maxima data. The value of QMED used within the analysis is derived from catchment descriptors with donor transfer.

The annual maxima data required to generate the growth curve can either be from a single gauged site, or from a pooled group of hydrologically similar gauged sites. There is a Dean Water gauging station downstream of the site which is deemed suitable for pooling, however the data spans 53 years and we are predicting a 200yr storm event upstream of the station in various catchments. Therefore, it is more reliable to generate a growth curve from a pooling group including the downstream gauging station on the Dean Water.

WINFAP analysis has been undertaken on the catchment associated with the DS Dean Water. A QMED value and growth curve was generated and peak flow calculated for the DS Dean Water catchment (main catchment) for the ability to compare the peak flow in the 200yr event to the peak flow generated using ReFH2. By comparing the main catchment, which encompasses all the sub-catchments in the model, the sub-catchments could be scaled accordingly to the worst-case scenario.

4.3.3.2 Pooled Group Selection

Gauging stations within a pooling group do not need to be close to one another in geographical space but rather have similar hydrological characteristics for parameters such as AREA, SAAR and BFIHOST. The hydrological characteristics of the pooling group are centred on those of the subject site. WINFAP has been used to automatically generate a pooling group from the latest version WINFAP-FEH data files. This NRFA dataset contains Annual Maximum Flow (AMAX) and Peaks Over Threshold (POT) data for approximately 1,000 gauging stations in the UK. Only those catchments that are marked as 'suitable for pooling' have been considered for inclusion in the pooling group.

The minimum recommended pooling group size has a total record length of at least 500 years of Annual Maxima (AM) data.

4.3.3.3 Reviewing the Pooling Group

Once the pooling group has been generated, it must be reviewed to ensure that the most appropriate catchments are selected to predict the flood growth curve for the target site. The following factors were examined for each gauging station included in the initial pooling group:

- Station location and period of record;
- Similarity of flood seasonality;
- Similarity of further catchment descriptors;
- Comments and other information on the gauging station that may deem it unsuitable for inclusion in the pooling group; and
- Discordant sites and heterogeneity.

For each pooling group analysis, WINFAP provides a value of heterogeneity. Heterogeneity is a comparison of the L-moment ratios from site to site within the pooling group.

Calculating for the main catchment initially, the original pooling group first had a heterogeneity value of approximately 6.9 which was very heterogeneous and therefore unacceptable to use for modelling of the desired catchment. After review and refinement of the pooling group the heterogeneity value had decreased to approximately 1.45 which is deemed acceptable and therefore no further refinement of the pooling group was undertaken.

4.3.3.4 Deriving the Pooled Growth Curve

A set of flood growth curves have been generated for the pooling group in WINFAP. Growth curves are based on statistical distributions of which there are multiple methods within WINFAP. Goodness of fit analysis within the software enables the user to identify which distributions are suitable for use with the pooled analysis undertaken. Table 4 below provides a summary of the goodness of fit analysis undertaken.

Table 4 Pooling Group Goodness of Fit Test

Distribution	Goodness of Fit
General Logistic	-0.37*
General Extreme Value	-1.56*
Pearson Type III	-3.27
Kappa 3	-0.77*

*Distribution gives an acceptable fit (absolute value < 1.645)

The analysis shows that the General Logistic (GL), General Extreme Value (GEV) and Kappa 3 are statistically acceptable fits. The GL method is more commonly used in UK flood frequency analysis and yielded a more conservative peak flow estimate and therefore has been used for growth curve estimation.

The WINFAP analysis yields a 200 year peak flow estimate within the DS Dean Water catchment of 61.8m^3/s. This yields a higher estimate than the ReFH2 analysis.

Table 5 shows the WINFAP peak flow estimates after the ReFH2 peak flow estimates have been uplifted by the multiplier 1.188 to scale them to the more conservative WINFAP estimates.

Table 5 Peak Flows scaled from ReFH2 to WINFAP for DS Dean Water, Ballindarg Burn, Kerbet Water, US Dean Water

		Peak Flow (m^3/s)			
Return Period (years)	AEP (%)	DS Dean Water	Ballidarg Burn	Kerbet Water	US Dean Water
2	50	19.21	4.90	13.52	2.824
10	10	28.49	7.43	19.84	4.211
50	5	40.12	10.79	27.61	5.971
100	1	47.32	12.84	32.37	7.069
200	0.5	55.96	15.25	38.13	8.425
200 +53% CC	0.5	85.61	23.34	58.35	12.89
1,000	0.1	79.34	21.66	53.77	12.07

The scaling factor has been applied to the individual sub catchment which results in a total peak flow marginally higher than the DS Dean Water estimates, this ensures a conservative approach.

4.3.4 Adopted Peak Flows and Model Hydrographs

WINFAP has been selected as the preferred method for peak flow estimations to be used within the hydraulic flood model. WINFAP only yields peak flow estimates and does not provide a flow-time hydrograph. As such, the hydrographs obtained from the ReFH2 analysis have been utilised within the hydraulic flood model but scaled accordingly to the WINFAP peak flow estimates.

Final adopted hydrographs for the reported design events modelled (200-year and 200-year plus climate change) are presented in Appendix B. It is noted that the 1,000-year event has not been modelled as the 200-year plus climate change results in the worst-case event.

4.4 Model Implementation

4.4.1 2D Model Build

The 2D extents of the hydraulic flood model include the channel, overbanks and potential floodplain extents of the Dean Water. The 2D domain consists of 1no. 2D flow area accounting for all areas of the model.

4.5 Model Results

Model runs have been undertaken for the stated peak flow events in Table 5 above. Review of the model results are described below and represented in the following drawings:

- FRDA-004: 200 Year Flood Depths
- FRDA-005: 200 Year Plus Climate Change Flood Depths

Section 4.3 indicates that the 200-year plus climate change event yields the highest peak flow estimate (greater than the 1,000-year event) and thus this event was assessed in further detail.

The hydraulic flood model results show that the site is at risk of flooding during these events. Out of bank flows are expected to occur to varying levels of severity for the 200yr and 200yr plus climate change event. The predominant reason for out of bank flows is the conveyance capacity of the Dean Water, Ballindarg Burna and Kerbet Water in these large storm events. The majority of the flooding is seen at points of confluence of the watercourses where accumulative discharge overtops the banks.

During the 200-year event, depths vary within the site vary between approximately 0m – 1m. Flooding is worst at the centre of the site associated with the Ballindarg Burn and spreads along the northern boundary most of the flooding varying from 0.2-0.6m of flood depth. There are some deeper pockets reaching up to 1.0m of flood depth. The flooding in the southwest of the site from the Kerbet and Dean Water is limited to the site boundary edge. Flood depths range along the southern boundary mostly from 0.1-0.6m, depths reach a maximum of 1.0m in the far corner of the flood extent.

During the 200-year plus climate change event, flooding increases. Depths within the site vary between approximately 0m – 1.3m across the site. Flooding is worst at the centre of the site associated with the Ballindarg Burn and spreads along the northern boundary most of the flooding varying from 0.2-0.8m of flood depth. There are some deeper pockets reaching up to 1.2m of flood depth. There is also flooding on the east bank of the Ballindarg Burn in this event, depths ranging from 0.2-0.8m. The flooding in the southwest of the site from the Kerbet and Dean Water also increases in depth in this scenario. Flood depths range along the southern boundary mostly from 0.2-0.7m, depths reach a maximum of 1.3m in the far corner of the flood extent.

Notwithstanding the flood risk outlined above, as noted in previous sections, the proposed development is an 'essential infrastructure' development. In accordance with SEPA and relevant technical flood risk guidance – 'Flood Management' measures are outlined in Section 4.8.

4.6 Sensitivity Analysis

4.6.1 Overview

SEPA Flood Modelling Guidance recommends that key parameters in any hydraulic flood model should be varied to ensure model performance, given the inherent uncertainty in the modelling process.

The following parameters and variable have therefore been varied with the impact to the model performance assessed for the 200-year plus Climate Change event:

- Channel and floodplain roughness
- Downstream boundary conditions

Sensitivity analysis on the model inflows has already been assessed in that a range of model inflows for a variety of return periods were ran to ensure model stability.

4.6.2 Channel and Floodplain Roughness

Manning's values within the hydraulic flood model have been varied by ± 20% as part of the sensitivity analysis. A sample of 2D cell flood elevations were assessed within the site boundary using a HEC-RAS profile line. The change in water level was within ±0.10m and the difference between baseline flood extents and sensitivity analysis flood extents is insignificant. The analysis demonstrates that the model is insensitive to changes in Manning's n values with respect to the 2D domain.

4.6.3 Downstream Boundary Conditions

The normal depth downstream boundary conditions within the hydraulic flood model have been varied by ± 20% as part of the sensitivity analysis. A sample of 2D cell flood elevations were assessed within the site boundary using a HEC-RAS profile line. No changes in water levels within the site were observed. The analysis demonstrates that the model is insensitive to changes in normal depth values at the downstream boundary condition with respect to the 2D domain.

4.7 Mass Balance

It is noted that all hydraulic flood modelling of this nature carries inherent uncertainty, thus SEPA's flood modelling guidance recommends that mass balance errors should be less than 1%. This check ensures the model is not gaining or losing inappropriate amounts of water volume. Mass errors were reviewed for the design events modelled.

All modelled scenarios exhibited mass balance errors of approximately 0.001% or less.

As such, there is very high confidence in the developed 2D hydraulic flood model results used to inform the flood risk to the site.

4.8 Flood Mitigation Measures

A summary of proposed Flood Management Measures for the development are outlined in the following sections.

4.8.1 Site Layout Considerations

From review of the proposed site layout and modelling outputs, the vast majority of the proposed infrastructure will be at located outwith the modelled flood extents. All ground based development (e.g., BESS units, power stations etc.) are to be located in areas not at risk of flooding.

With respect to the solar panels, these can be appropriately designed to prevent risk of flooding. It is proposed that all solar panels are to be raised by 1.2m above the ground (measured from their lowest point). It is proposed therefore that panels can be sited within areas of flood depths up to and including 0.9m. This shall ensure a freeboard of 300mm is maintained from the design flood elevation to the base on the panels.

Any areas of flooding in excess of 0.9m are to be avoided as identified in Drawing FRDA-005,

4.8.2 Floodplain Loss

As discussed above, all ground based equipment shall be located in areas outside the predicted flood extents. All solar panels are to be raised 1.2m above respective ground levels to ensure no material loss of flood storage as a result of the development for any storm event. Negligible losses of flood storage would be associated with the mounting poles for the panels but the total area of these is considered to be insignificant.

4.9 Flood Action Plan

In order to ensure that those responsible for operations onsite are better prepared to respond in an emergency and to reduce the impact of a flood event, a well-defined Flood Action Plan (FAP) should be prepared for the site.

A FAP would detail actions to be undertaken before a flood, actions to be taken in the event of a flood and actions to be taken following a flood event to ensure the safety of personnel.

It is expected that a detailed FAP would be developed at the post planning stages and an outline FAP is provided below.

4.9.1 Flood Forecast and Warning Services

Flood Forecasts and warning systems are controlled by SEPA and the Met Office in Scotland and can be viewed on the SEPA Floodline website[10]. SEPA Floodline also offers a subscription service whereby individuals/organisations can sign up for free notifications of flood warnings and forecasts in their area via phone, text or email. It is advised that any individuals with free access to the site register to receive Floodline alerts.

No flood defences are present adjacent to or upstream of the proposed development. This removes the possibility of 'no notice' flooding via flood defence failure and increases the reliability of flood forecasts.

During construction it will be necessary to consistently monitor available resources when planning and managing works. Following the construction phase, it is envisioned that activity onsite will be limited to occasional maintenance and inspection works. No site visits or works should go ahead without taking due consideration of flood alerts, current river levels and weather warnings. Those responsible for monitoring flood risk information should be clearly identified within the works risk assessment, be aware of their responsibilities to inform others and be trained in the deployment of the Food Action Plan.

4.9.2 Access and Egress

Access and egress refer to the means of entry and exit to the site. Routes that provide access and egress should be safe, suitably constructed, regularly maintained, and kept free of obstructions.

The site will be accessed from the east via a single track lane which is free of flooding with the exception of areas near its crossing over the Balindarg Burn.

It is noted that in accordance with the FAP, no personnel should be on site during a flood alert scenario and the requirement for personnel to be on site at any time is highly limited.

The site will not include any indoor buildings to be regularly accessed by personnel and no confined spaces.

4.9.3 Flood Emergency and Response Plan

A detailed flood emergency / response plan will be prepared by the applicant in consultation with a flood expert. These internal procedures should be integrated into the site operating plan and included within the staff training packs.

External contractors visiting / working on site should also be made aware of the potential flood risks as part of their induction pack.

As part of the development flood emergency / response plan, a responsible person for the Applicant will sign up to the SEPA Flood line and Met Office weather warning service and disseminate information to staff and users of the site ahead of potential extreme flood events.

4.10 Summary of Technical Flood Risk Assessment

The Flood Risk Screening Assessment undertaken in Section 3.1 identified that further assessment was required to determine the flood risk to the site in respect to the fluvial flooding from the Dean Water, Ballindarg Burn and Kerbet Water.

As such, a bespoke 2D hydraulic flood model was developed for the site. This bespoke model has been developed in accordance with SEPA's Technical Flood risk guidance and has been constructed using present day detailed terrain and river survey information. The hydrological inputs to the model

[10] https://www.sepa.org.uk/environment/water/flooding/floodline/ (accessed on 21st February 2025)

have been based on recognised flood estimation methods and two methods have been undertaken for comparison purposes and the most appropriate method has been adopted for the assessment.

A range of return periods have been assessed within the hydraulic flood model, however only two have been reported on given they are the most extreme events that were modelled, the 200-year event and the 200-year plus 53% climate change event.

The hydraulic flood model results show that the site is at risk of flooding during these events, the flood extents do not reach the eastern or western segments of the site.

During the 200-year event, depths vary within the site vary between approximately 0m – 1m. Flooding is worst at the centre of the site associated with the Ballindarg Burn and spreads along the northern boundary most of the flooding varying from 0.2-0.6m of flood depth. There are some deeper pockets reaching up to 1.0m of flood depth. The flooding in the southwest of the site from the Kerbet and Dean Water is limited to the site boundary edge. Flood depths range along the southern boundary mostly from 0.1-0.6m, depths reach a maximum of 1.0m in the far corner of the flood extent.

During the 200-year plus climate change event, flooding increases. Depths within the site vary between approximately 0m – 1.3m across the site. Flooding is worst at the centre of the site associated with the Ballindarg Burn and spreads along the northern boundary most of the flooding varying from 0.2-0.8m of flood depth. There are some deeper pockets reaching up to 1.2m of flood depth. There is also flooding on the east bank of the Ballindarg Burn in this event, depths ranging from 0.2-0.8m. The flooding in the southwest of the site from the Kerbet and Dean Water also increases in depth in this scenario. Flood depths range along the southern boundary mostly from 0.2-0.7m, depths reach a maximum of 1.3m in the far corner of the flood extent.

From review of the proposed site layout and modelling outputs, the vast majority of the proposed infrastructure will be at located outwith the modelled flood extents. All ground based development (e.g., BESS units, power stations etc.) are to be located in areas not at risk of flooding.

With respect to the solar panels, these can be appropriately designed to prevent risk of flooding. It is proposed that all solar panels are to be raised by 1.2m above the ground (measured from their lowest point). It is proposed therefore that panels can be sited within areas of flood depths up to and including 0.9m. This shall ensure a freeboard of 300mm is maintained from the design flood elevation to the base on the panels.

Taking all the above into account, it is considered that the proposed development is suitable, safe and sustainable in flood risk planning terms.

SEPA Flood Risk Assessment Checklist is included as Appendix C of this report.

5. Proposed Surface Water Drainage Design

5.1 Sustainable Drainage Systems (SuDS)

To satisfy the requirements of current best national / local flood risk and surface water management guidance, SuDS are required to be incorporated into the design proposals to manage, attenuate, and treat surface water runoff before discharging from the site.

Current best practice guidance relating to sustainable surface water management is outlined in the SuDS Manual (CIRIA Report C753) which provides details on the use of SuDS for managing surface water runoff.

The SuDS Manual identifies a hierarchy of SuDS for managing runoff, which is commonly referred to as a 'management train' as outlined below:

- Prevention – the use of good site design and housekeeping measures on individual sites to prevent runoff and pollution (e.g. minimise areas of hard standing).
- Source Control – control of runoff at or very near its source (such as the use of rainwater harvesting, permeable paving and green roofs).
- Site Control – management of water from several sub-catchments (including routing water from roofs and car parks to one / several soakaways or attenuation ponds for the whole site).

- Regional Control – management of runoff from several sites, typically in a retention pond or wetland.

It is generally accepted that the implementation of SuDS as opposed to conventional drainage systems, provides several benefits by:

- reducing peak flows to watercourses or sewers and potentially reducing the risk of flooding downstream;
- reducing the volumes and frequency of water flowing directly to watercourses or sewers from developed sites;
- improving water quality over conventional surface water sewers by removing pollutants from diffuse pollutant sources;
- reducing potable water demand through rainwater harvesting;
- improving amenity through the provision of public open spaces and providing biodiversity and wildlife habitat enhancements; and
- replicating natural drainage patterns, including the recharge of groundwater so that base flows are maintained.

5.2 Overview

The management of surface water drainage from the development will aim to mimic existing runoff patterns while providing betterment in terms of runoff attenuation and soil erosion.

This methodology has been developed based on guidance from the Angus Council Supplementary Guidance for Renewables and Low Carbon Energy Development, which states:

"Applicants should demonstrate that any development will protect and/or enhance the water environment."

Generally, new developments need to minimise the potential flood risk and surface water run-off through:

- *minimising the area of impermeable surfaces*
- *reinstating vegetation where possible*
- *providing storage and attenuation ponds in line with sustainable drainage techniques (SuDS)*
- *using appropriate mechanisms to maintain existing hydrological regimes."*

The proposed drainage for the solar farm area shall include the implementation of erosion protection measures and runoff reduction / dispersion measures. Gravel ditches at the downslope face of smaller areas of hardstanding to attenuate and dissipate runoff from transformers and inverter stations shall be implemented. Permeable access tracks will be installed across the site allowing surface water to be disposed through infiltrate to ground, in order to mimic as much as possible, the existing runoff conditions. The proposed drainage measures for the solar farm area are described in section 5.3.

The proposed drainage strategy for the battery storage / substation facility will comprise formal attenuation within a SuDS basin (aided by a herringbone drainage system) with a restricted discharge to the Dean Water to the south. The proposed drainage measures for the battery storage / substation infrastructure are described in Section 5.4.

5.3 Solar Farm Drainage Measures

5.3.1 Overview

The existing land use at the site predominately comprises arable fields which are routinely furrowed and ploughed for crop production. The proposed development will result in the cessation of commercial farming at the site and allow for the widespread re-vegetation of the land.

Change in land use / land management practices is a recognised form of Natural Flood Management (NFM):

"The land's ability to slow down and store runoff is influenced substantially by how agricultural land is managed. Activities which result in a higher risk of soil erosion and soil compaction and leave less vegetative cover over the winter can reduce the potential for infiltration of surface runoff and associated pollutants

Certain land management practices such as high stocking densities, the use of heavy machinery and leaving soils un-vegetated over the winter can present particular risks."[11]

Intensive crop production will cease at the site and wild flower meadow will be seeded and allowed to establish / grow with minimal intervention / cutting.

This will provide significant betterment to the site hydrological runoff patterns / regime by:

- Increasing evapotranspiration rates
- Reduced widespread soil erosion and uncontrolled silt laden runoff discharging to surrounding field drains and watercourses
- Reducing runoff rates and flood risk from the site

Example photographs of established wildflower meadows at constructed Solar Farm sites are provided below.

[11] Scottish Environment Protection Agency (2015) Natural Flood Management Handbook

Figure 1 – Examples of wildflower meadows alongside solar arrays

As can be seen from the examples above, vegetation is able to establish beneath and all around the Solar PV arrays. Therefore, the change in land use at the site will provide significant betterment to the current hydrology at the site.

5.3.2 Permeable Access Tracks

Access tracks with a total area of 1.76 ha are to be required across the site. Permeable mediums will be used to create areas of new access tracks allowing surface water to be disposed through infiltration to the ground, in order to mimic as much as possible, the existing runoff conditions.

5.3.3 Transformers and Inverter Stations

4no. transformer/ inverter stations and are expected to be installed as part of the Proposed Development, which would cover an area of approximately 328m^2. These structures are estimated to be 90% impervious.

A brief assessment has been undertaken to identify runoff from the transformers compared to the baseline scenario. The assessment outcomes are presented in Table 6 and use the following equation as per CIRIA Report C753 (Equation 24.5):

"Rainfall Depth (1 in 200-year 360 minute storm) x area of transformers x Soil Index /time (seconds)"

Rainfall depth has been calculated using the FEH online service and outputs are presented in Appendix D.

Table 6 Runoff accounting for post-development site

Rainfall Depth (m)	Area m²	Soil Index	Volume (m³)	Volume (l)	Time (s)	Runoff (l/s)
Pre-development						
0.0703	863,321	0.35	21,242.013	21,242,013	21,600	983.43
Post development						
0.0703	862,993	0.35	21,233.943	21,233,943	21,600	983.31
0.0703	328	0.9	20.753	20,753	21,600	0.95
					Total:	**984.26**

$$984.26 - 983.43 = 0.83\ l/s$$

The above calculation demonstrates an overall increase of runoff across the entire 86.3ha site of 0.83l/s for the post development site compared with the baseline. It should be noted that this excludes the BESS area which will be formally drained and will not contribute to runoff from the proposed development area.

To reduce / remove the negligible impact this will have on existing surface water runoff patterns, it is recommended that gravel filled trenches are installed at the perimeter of each of the transformers, inverter stations and concrete based infrastructure.

5.3.4 PV Panel Runoff

PV solar arrays create an impermeable surface, however as the arrays are set above ground, they do not prevent the ground beneath from absorbing rainfall. Runoff from the site is therefore not considered to be increased as a result of the PV panels.

The PV arrays will be orientated east to west such that their panels will face in a southerly direction. It is acknowledged that runoff will be concentrated along the drip line which has potential to increase soil erosion.

It is therefore recommended that gravel strips are installed along the southern edge of the panels to prevent any increased soil erosion. The gravel strips will dissipate the runoff along the dripline and allow water to runoff or infiltrate, mimicking the pre-development scenario. As previously mentioned, the introduction of wildflower meadows will also significantly improve the overall site hydrology, reduce runoff rates and soil erosion.

5.4 Battery Storage Drainage Measures

5.4.1 Overview

The proposed drainage / SuDS scheme will comprise the management of surface water runoff from the proposed BESS development area. The development area will be drained via a herringbone drainage system and a perimeter filter drain around the development extents.

The development area will be constructed with semi-permeable materials to allow rainwater to infiltrate into the underlying makeup where it will be intercepted by perforated pipework (herringbone drainage system) and conveyed to a SuDS Basin at the eastern extents of the BESS area via conventional drainage measures. The SuDS basin will provide suitable treatment and attenuation prior to discharge to the Dean Water to the south of the site.

5.4.2 Drainage Discharge Locations

The hierarchy for favoured disposal options of surface water runoff from development sites is as follows:

1. Infiltration to Ground;
2. Discharge to Surface Waters; or
3. Discharge to Sewer.

Table 7 below discusses the disposal method suitability in the context of the site and proposed development.

Table 7 Suitability of Surface Water Disposal Methods

Surface Water Disposal Method	Suitability Description	Method Suitable? (Y/N)
Infiltration to Ground	Due to the mixed use of the proposed SuDS basin as surface water attenuation and fire water storage it is considered that a discharge to ground strategy is not applicable for the site. Adopting a discharge to ground strategy would see that in the event of a fire at the BESS area, contaminated runoff captured by the surface water drainage system would infiltrate via superficial deposits to groundwater receptors and the further water environment.	N
Surface Water Discharge	The site is located adjacent the Dean Water and provides the opportunity for a gravity connection to be made.	Y
Sewer Discharge	Given the rural nature of the site, no public sewers are located within the local area to facilitate a connection.	N

Taking the above into account, it is proposed that surface water runoff from the development is discharged to the nearby watercourse, as per the existing site (natural) hydrological regime.

5.4.3 Water Quantity Review

Greenfield runoff rates have been estimated through application of methodology outlined in IH R124[12] as set out within the Interim Code of Practice for SuDS (ICP).

The IH R124 method can be used to estimate Greenfield runoff release rates for a range of AEP events, or return periods, by applying regional growth curve factors to the mean annual peak runoff (i.e. QBAR).

The UK hydrological region for the Newton area is Region 1, therefore the appropriate growth curve factors for this region have been incorporated into the analysis undertaken in the MicroDrainage (2020) software suite[13].

The hydrological characteristics incorporated into the runoff modelling are shown below and results are presented in Table 8 for a range of AEP storm events.

- Average Annual Rainfall (SAAR): 900mm/year
- Soil Index: 0.300
- UK Hydrological Region: 1
- Drained Area: 0.5ha

Table 8 Estimation of the Greenfield (Pre-Development) Rate of Runoff

AEP (%)	Return Period	Runoff Rate (l/s)

[12] Institute of Hydrology Report No. 124 (1994) (IH R124), Flood estimation for small catchments, June 1994
[13] MicroDrainage (2020). WinDes Drainage Design and Modelling Software (Version 2020.1.3)

	(1 in X Years)	
100	1	2.1
QBAR		2.4
3.3	30	4.6
1	100	6.1
0.5	200	6.9

In accordance with CIRIA Report C753 (the SuDS Manual) it is proposed to limit surface water discharge from the proposed development to QBAR greenfield rates for all design events up to and including the 0.5% AEP plus 39% climate change uplift.

The total impermeable area for the proposed BESS development area is **0.5 ha**. Accordingly, a **1.2 l/s** discharge rate has been applied to the proposed discharge strategy.

This is based on a runoff coefficient (CV) of 1 being applied.

5.4.4 Water Quality Review

In accordance with CIRIA Report C753 it is necessary to undertake a 'Water Quality Risk Management' assessment to determine the suitability of SuDS methods from a water quality perspective. The approach outlined below is based on the 'Simple Index Approach' for discharge to surface waters as detailed in the SuDS Manual (Section 26.7, Tables 26.2 and 26.3).

Table 9 below compares the SuDS Mitigation Indices against the Pollution Hazard Indices for the proposed development. This is based on the application of a SuDS basin.

Table 9 SuDS Water Quality Design Criteria: Index Approach Review

Land Use	Pollution Hazard and SuDS Mitigation Indices Comparison					
	Total Suspended Solids (TSS)		*Metals*		*Hydro-Carbons*	
	Pollution Index	Mitigation Index	Pollution Index	Mitigation Index	Pollution Index	Mitigation Index
Other Roofs (industrial / commercial)	0.3	0.5	0.2	0.5	0.05	0.6

The *SuDS Mitigation Index* offered by the proposed SuDS is ≥ *Pollution Hazard Index for each Land Use type and* therefore the water quality assessment criteria is satisfied.

5.4.5 SuDS Basin Design

The proposed SuDS basin has been designed as such that it can accommodate a 200 year return period event with an additional 39% to account for climate change.

The key outline design parameters for the SuDS system are outlined in Table 10 as follows:

Table 10 SuDS System Summary Design Details

Parameter	Unit	Value	Notes
Total Depth	m	2.0	*As measured from AutoCAD design*
Storage Area	m^2	912.6	*As measured from AutoCAD design*
Total Storage Volume	m^3	1,136	*As measured from MicroDrainage SourceControl*
Limiting Discharge Rate	l/s	1.2	*To be provided by Hydrobrake Optimum (or similar)*
Side Slopes	1 in X	3	*Typical basin side slope*

Using the above design details the SuDS system has been modelled using the MicroDrainage software suite and the results are presented in Table 11 below and full modelling extracts are included as Appendix E.

Table 11 Hydraulic Modelling Performance of SuDS System

AEP (%)	Max. Water Depth (m)	Freeboard Allowance (mm)	Max Outflow Rate (l/s)	Storage Volume (m^3)	Critical Storm Duration (hours)
50	0.409	1,591	0.7	136.1	36
10	0.554	1,446	0.7	194.4	48
3.3	0.670	1,330	0.7	245.4	48
1	0.816	1,184	0.8	314.5	48
0.5	0.908	1,092	0.8	361.7	48
0.5 + 39% CC	1.222	778	1.0	542.4	72

The results above confirm that the increased runoff from the development can be adequately contained within the SuDS system and limits the discharge to the equivalent QBAR (1.2 l/s) for all modelled events. As additional contingency and in accordance with CIRIA Report C753, a suitable freeboard depth from the maximum water level to the storage design level has been factored into the design.

An overview of the proposed strategy and SuDS details, as well as typical drainage details is provided in Drawings FRDA-006 and FRDA-007.

5.4.6 Exceedance Flow Considerations

The SuDS system has been designed with a consideration of exceedance flow routes for storm events larger than the design event and available freeboard. In such a scenario additional flow would follow the natural topography to the south before being intercepted by the Dean Water and carried away from the site area.

5.5 Outline Maintenance Strategy

5.5.1 Overview

To ensure efficient operation of the proposed surface water management / SuDS scheme, drainage components should be inspected and maintained throughout the life of the development. Regular inspection / maintenance will ensure efficient operation and prevent potential failure / blockage of drainage components.

The following provisional maintenance plan has been developed from best practice guidance, professional experience and information provided in CIRIA Report C753 (The SuDS Manual).

All drainage components will be retained under private ownership, with the Applicant remaining responsible for ongoing maintenance. This maintenance schedule will be integrated into the overall site operating and maintenance strategy and tailored / refined over time as required.

The following sections provide maintenance actions for specific drainage elements.

5.5.2 SuDS Basin

Table 12 below provides the inspection and maintenance recommendations set out in Table 22.1 of CIRIA Report C753.

Table 12 SuDS Basin Maintenance Requirements

Maintenance Schedule	Required Action	Typical Frequency

Regular maintenance	Remove litter and debris	Monthly
	Cut grass - for spillways and access routes	Monthly (during growing season), or as required
	Cut grass - meadow grass in and around basin	Half yearly (spring - before nesting season, and autumn)
	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
	Check any penstocks and other mechanical devices	Annually
	Tidy all dead growth before start of growing season	Annually
	Manage wetland plants in outlet pool - where provided	Annually (as set out in Chapter 23)
Occasional maintenance	Reseed areas of poor vegetation growth	As required
	Prune and trim any trees and remove cuttings	Every 2 years, or as required
	Remove sediment from inlets, outlets, forebay and main basin where required	Every 5 years, or as required (likely to be minimal requirements where effective upstream source control is provided)
Remedial actions	Repair erosion or other damage by reseeding or re-turfing	As required
	Repair/rehabilitation of inlets, outlets and overflows	As required
	Relevel uneven surfaces and reinstate design levels	As required

5.5.3 Cut-Off/ Filter Drains

Table 13 below provides the inspection and maintenance recommendations set out in Table 16.1 of CIRIA Report C753.

Table 13 Filter Drain Maintenance Requirements

Maintenance Schedule	Required Action	Typical Frequency
Regular Maintenance	Remove litter and debris	Monthly (or as required)

Maintenance Schedule	Required Action	Typical Frequency
	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
Occasional Maintenance	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

5.5.4 Inspection Chambers and Manholes

It is recommended that inspection chamber and manhole covers are lifted at least yearly to check for debris / silt accumulations and check the drainage runs are flowing freely.

Any silt / debris accumulations should be manually removed, and jet washed where required.

5.6 Construction Drainage Strategy

5.6.1 Overview

Outlined below are recommendations for mitigation measures to be implemented during construction to control water quality impacts. These mitigation measures take due cognisance of the Water Resources Act 1991 and CIRIA Report C532 (Control of Water Pollution from Construction Sites). Good practice measures set out in the relevant Pollution Prevention Guidance (PPGs) or the updated versions (where available) and Guidance for Pollution Prevention (GPPs) have been followed. The relevant guidance includes:

- GPP 5: Works and maintenance in or near water
- PPG 6: Working at construction and demolition sites
- PPG 7: The safe operation of refuelling facilities
- GPP 13: Vehicle washing and cleaning
- GPP 21: Pollution incident response planning
- GPP 22: Dealing with spills

5.6.2 Sediment Management

Proposed mitigation for sediment management:

- Control and divert surface water entering site from surrounding land (via cut-off drains) to reduce potential impacted water volumes;
- Minimise use of stockpiles and/or cover and contain stockpiles and provide sediment interception measures at their bases, e.g. silt fencing or cut-off drains and check dams;
- If topsoil is to be stored, avoid constructing stockpiles more than 2m high. This will ensure anaerobic conditions do not occur and that the soil will remain fertile and capable of being re-seeded. It will also be less susceptible to erosion;
- Temporary drainage measures to be installed which provide filtration (filter drains or filter strips) and settlement (ponds/basins) to collect sediments prior to offsite discharge;
- Avoid mass overburden stripping on the site – expose parts of the site only when essential for operation;

- Temporary drainage measures and silt fencing to be installed around large areas of exposed soils;
- Ensure a robust site traffic management plan is in place to reduce sediment runoff risks. Good practices include minimising turning of tracked vehicles where possible and managing dedicated turning areas appropriately (hard surfacing, silt fencing etc.), avoiding unnecessary turning of large site plant and minimising overall routes on site to better manage sediment runoff;
- Prevent/reduce offsite sediment impacts to public roads. Good practices include wheel wash facilities, site-road sweeping, a formally surfaced site car park and separate access points for cars and plant/deliveries (where possible);
- Bowsers to be used to keep exposed earth and soils damp preventing dust generation reaching nearby watercourses (sediment build-up can be managed on-site); and
- Dedicated plant washing areas to control sediment runoff.

5.6.3 Excavation Management

Proposed mitigation for excavations:

- Relevant precautions to be taken to ensure no services are struck during excavations. Relevant emergency response and contacts in place in the event services are struck which could impact the water environment, e.g. oil line, water main, sewer;
- Excavation areas to be scanned for potential unrecorded culverts/field drains. De-watering measures to be present in the event of a leak;
- Existing culverts/field drains to be protected to prevent potentially polluted site runoff discharging to them prior to treatment;
- Prevent site runoff entering excavations and regularly de-water to prevent infiltration to groundwater; and
- Any deep excavations (e.g. boreholes, piled foundations) should be protected to prevent infiltration of site runoff and a direct pathway to groundwater.

5.6.4 Concrete Works Management

Proposed mitigation for concrete works:

- If concrete is brought to site – provide dedicated concrete washout skip/basin to prevent any uncontrolled spilling of material on site or nearby public roads;
- Concrete washout facilities to be regularly maintained and solids to be disposed of safely;
- If on-site concrete batching – ensure necessary containment measures are in place and suitable disposal and cleaning methods;
- Robust emergency response in place for any concrete spillage on site;
- Correct disposal of any waste or surplus concrete in agreed suitable locations both onsite and offsite;
- Where applicable, shuttered pours should be used to prevent any concrete losses to ground;
- Ensure excavations are sufficiently dewatered before concreting begins and that dewatering continues while concrete sets; and
- Covering of freshly poured concrete surfaces to prevent any polluted runoff attributed with wet weather.

5.6.5 Chemical, Oils and Fuels Management

Proposed mitigation for chemicals, oils and fuels:

- Assign designated refuelling areas where appropriate and site them as far as practicably possible from adjacent field drains and public sewers;

- Dedicated site operatives responsible for checking and maintaining temporary drainage measures;
- All site operatives to be made aware of preventative measures in place e.g. traffic systems, refuelling areas, maintenance rotas, concrete washout areas; and

All pollution prevention consumables and plant to be made readily available at all times.

6. Closure

Gondolin Land and Water Ltd (Gondolin) has been appointed by SLR Consulting Limited on behalf of Trio Power Ltd (The Client) to carry out a Flood Risk and Drainage Assessment (FRDA) to provide support and input to the Environmental Impact Assessment Report (EIAR) submission to support a planning application for a proposed solar farm and battery storage development at land 1.5km west of the A90 Forfar Bypass, Cossans, Angus DD8 1QY. This Flood Risk and Drainage Assessment (FRDA) report has been prepared as a report for planning and Technical Appendix 1 to Chapter 7: Hydrology and Flood Risk within the EIAR.

The Flood Risk Screening Assessment undertaken identified that further assessment was required to more accurately quantify the potential fluvial flood risk to the site from the Dean Water, Ballindarg Burn and Kerbet Water. No other flood risk sources required further assessment / consideration.

As such, a bespoke 2D hydraulic flood model was developed for the site. This bespoke model has been developed in accordance with SEPA's Technical Flood risk guidance and has been constructed using present day detailed terrain and river survey information. The hydrological inputs to the model have been based on recognised flood estimation methods and two methods have been undertaken for comparison purposes and the most appropriate method has been adopted for the assessment.

A range of return periods have been assessed within the hydraulic flood model, however only two have been reported on given they are the most extreme events that were modelled, the 200-year event and the 200-year plus 53% climate change event.

The hydraulic flood model results show that the site is at risk of flooding during these events, the flood extents do not reach the eastern or western segments of the site.

During the 200-year event, depths vary within the site vary between approximately 0m – 1m. Flooding is worst at the centre of the site associated with the Ballindarg Burn and spreads along the northern boundary most of the flooding varying from 0.2-0.6m of flood depth. There are some deeper pockets reaching up to 1.0m of flood depth. The flooding in the southwest of the site from the Kerbet and Dean Water is limited to the site boundary edge. Flood depths range along the southern boundary mostly from 0.1-0.6m, depths reach a maximum of 1.0m in the far corner of the flood extent.

During the 200-year plus climate change event, flooding increases. Depths within the site vary between approximately 0m – 1.3m across the site. Flooding is worst at the centre of the site associated with the Ballindarg Burn and spreads along the northern boundary most of the flooding varying from 0.2-0.8m of flood depth. There are some deeper pockets reaching up to 1.2m of flood depth. There is also flooding on the east bank of the Ballindarg Burn in this event, depths ranging from 0.2-0.8m. The flooding in the southwest of the site from the Kerbet and Dean Water also increases in depth in this scenario. Flood depths range along the southern boundary mostly from 0.2-0.7m, depths reach a maximum of 1.3m in the far corner of the flood extent.

From review of the proposed site layout and modelling outputs, the vast majority of the proposed infrastructure will be at located outwith the modelled flood extents. All ground based development (e.g., BESS units, power stations etc.) are to be located in areas not at risk of flooding.

With respect to the solar panels, these can be appropriately designed to prevent risk of flooding. It is proposed that all solar panels are to be raised by 1.2m above the ground (measured from their lowest point). It is proposed therefore that panels can be sited within areas of flood depths up to and including 0.9m. This shall ensure a freeboard of 300mm is maintained from the design flood elevation to the base on the panels.

This report assesses the potential increase in surface water runoff attributed to the proposed development and proposes a surface water management strategy to manage this. The strategy is in accordance with sustainable drainage principles and allows the site to remain free of flooding during design storm events, whilst ensuring no increase of flood risk to offsite receptors and ensures no deterioration of the water environment.

Taking all of the above into account it is considered there is no impediment to the development proposals being granted planning permission on the grounds of flood risk and drainage provision.

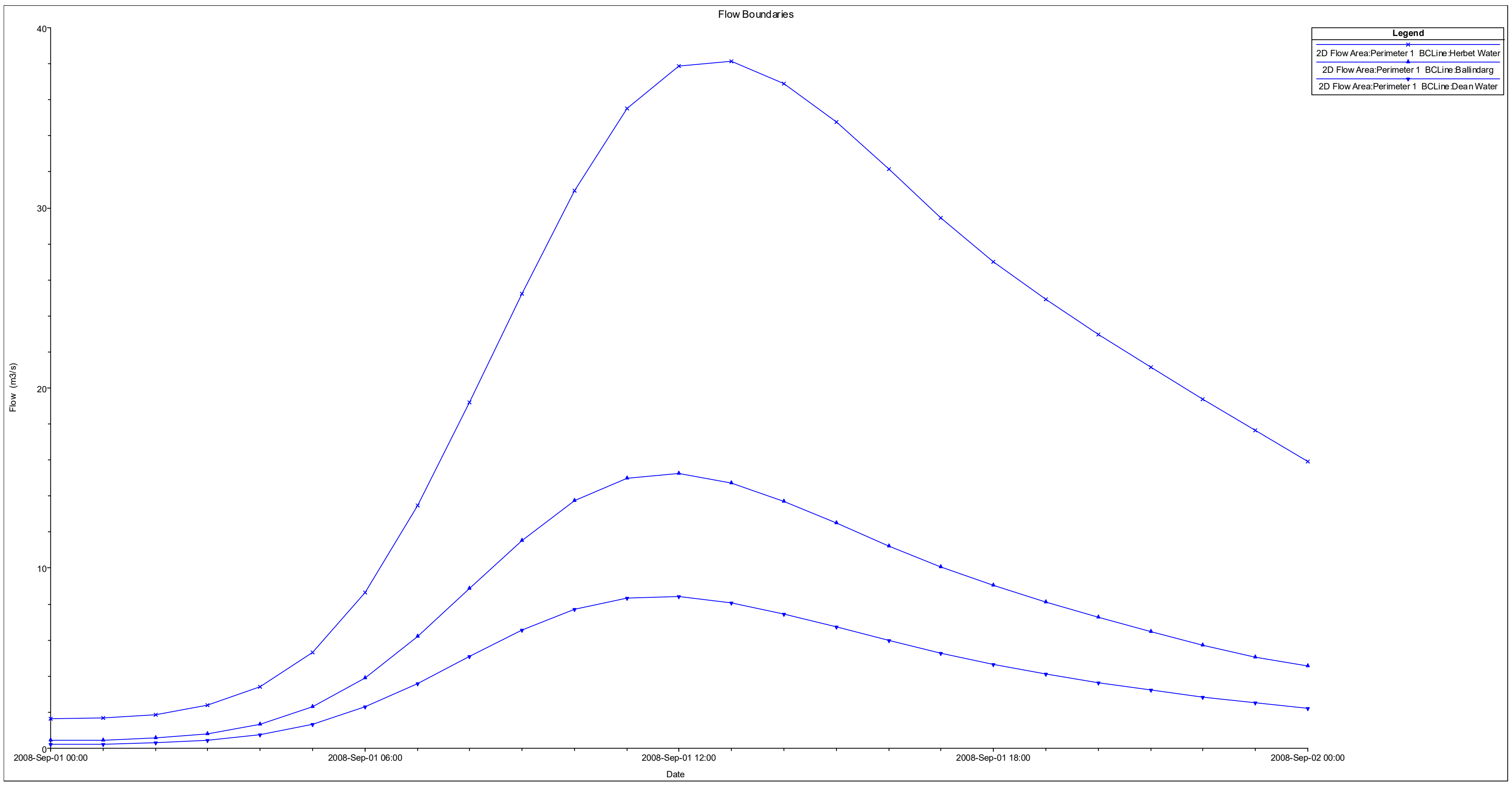
Appendix A

Proposed Development Plans

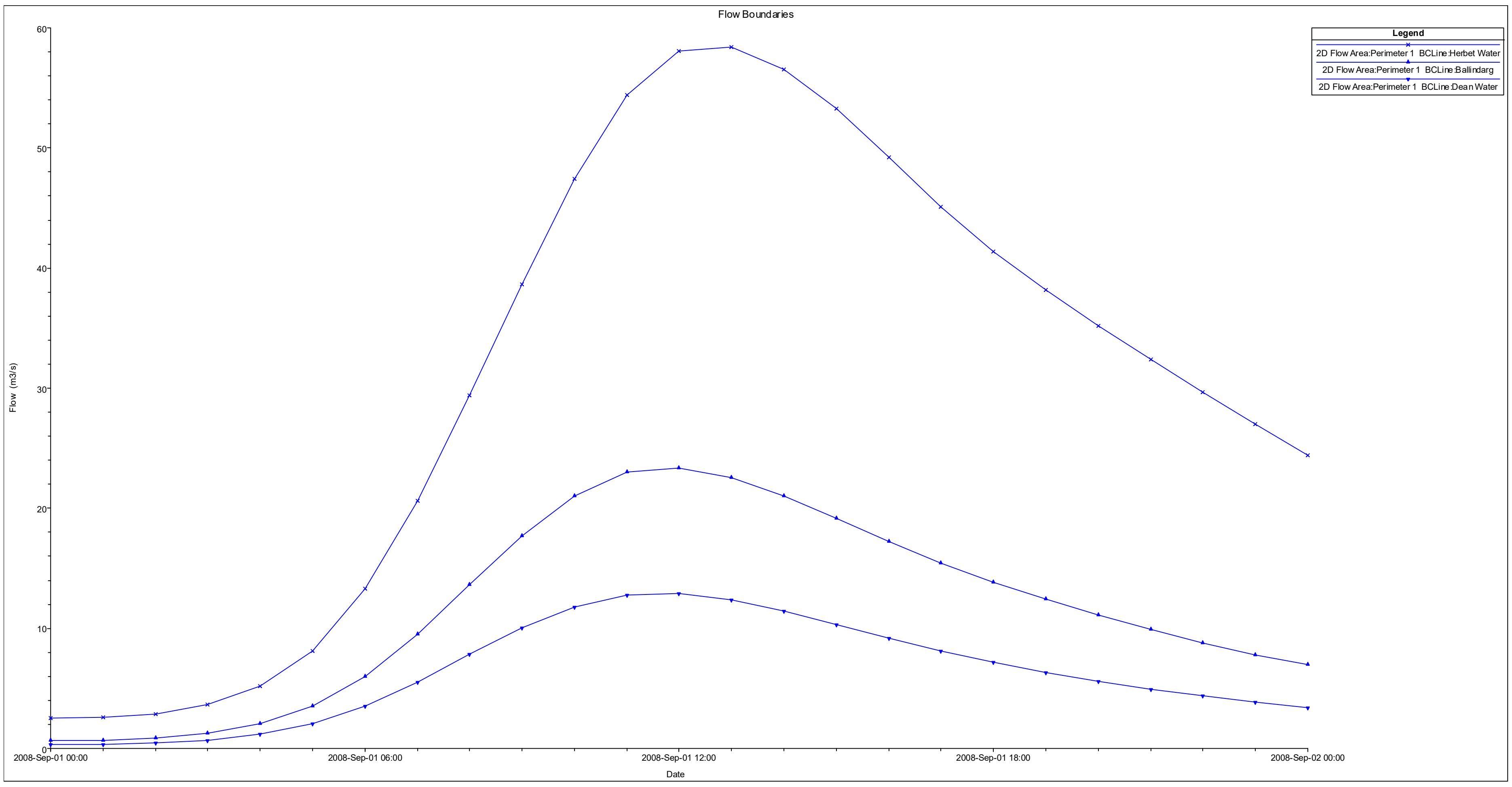
Appendix B

Design Hydrographs

200 Year Inflow Hydrographs



200 Year Plus Climate Change Inflow Hydrographs



Appendix C

SEPA FRA Checklist

Flood Risk Assessment (FRA) Checklist

(SS-NFR-F-001 - Version 16 - Last updated 27/08/2019)

This document must be attached within the front cover of any Flood Risk Assessments issued to Local Planning Authorities (LPA) in support of a development proposal which may be at risk of flooding. The document will take only a few minutes to complete and will assist SEPA in reviewing FRAs, when consulted by LPAs. This document should not be a substitute for a FRA.

Development Proposal Summary					
Site Name:		Cossans Solar and BESS			
Grid Reference:	Easting:	341320	Northing:	749695	
Local Authority:		Angus Council			
Planning Reference number (if known):					
Nature of the development:		Utility Infrastructure	If residential, state type:		
Size of the development site:		86.3	Ha		
Identified Flood Risk:	Source:	Fluvial	Source name:	Glendronach Burn	
Land Use Planning					
Is any of the site within the functional floodplain? (refer to SPP para 255)		Yes	If yes, what is the net loss of storage?	n/a	m^3
Is the site identified within the local development plan?		No	Local Development Plan Name:		Year of Publication:
			Allocation Number / Reference:		
If yes, what is the proposed use for the site as identified in the local plan?		Select from List	If Other please specify:		
Does the local development plan and/or any pre-application advice, identify any flood risk issues with or requirements for the site.		No	If so, please specify:		
What is the proposed land use vulnerability?		Essential Infrastructure	Do the proposals represent an increase in land use vulnerability?	No	
Supporting Information					
Have clear maps / plans been provided within the FRA (including topographic and flood inundation plans)?		Yes			
Has sufficient supporting information, in line with our Technical Guidance, been provided? For example: site plans, photos, topographic information, structure information and other site specific information.		Yes			
Has a historic flood search been undertaken?		Yes	If flood records in vicinity of the site please provide details:		
Is a formal flood prevention scheme present?		No	If known, state the standard of protection offered:		
Current / historical site use:		Greenfield			
Is the site considered vacant or derelict?		Yes			
Development Requirements					
Freeboard on design water level:		0.3	m		
Is safe / dry access and egress available?		Vehicular and Pedestrian	Min access/egress level:	varies	m AOD
Design levels:	Ground level:	varies	m AOD	Min FFL:	mAOD
Mitigation					
Can development be designed to avoid all areas at risk of flooding?		Yes			
Is mitigation proposed?		Yes			
If yes, is compenstory storage necessary?		No			
Demonstration of compensatory storage on a "like for like" basis?		No			
Should water resistant materials and forms of construction be used?		No			

Flood Risk Assessment (FRA) Checklist

(SS-NFR-F-001 - Version 16 - Last updated 27/08/2019)

Hydrology

Is there a requirement to consider fluvial flooding?	Yes		
Area of catchment:	1199.06 km^2	Is a map of catchment area included in FRA?	Yes
Estimation method(s) used (please select all that apply):	Pooled Analysis ☑	If Pooled analysis have group details been included?	Yes
	Single Site Analysis ☐		
	Enhanced Single Site ☐		
	ReFH2 ☑		
	FEH RRM ☐		
	Other ☐	If other (please specify methodology used):	
Estimate of 200 year design flood flow:	55.96 m^3/s		
Qmed estimate:	19.552 m^3/s	Method:	Donor Transfer
Statistical Distribution Selected:	Generalised Logistic	Reasons for selection:	WINFAP worst case

Hydraulics

Hydraulic modelling method:	2D	Software used:	HEC-RAS
		If other please specify:	
Number of cross sections:	n/a		
Source of data (i.e. topographic survey, LiDAR etc):	LiDAR	Date obtained / surveyed:	Jul-05
Modelled reach length:	7250 m		
Any changes to default simulation parameters?	No	If yes please provide details:	
Model timestep:	30sec		
Model grid size:	varies		
Any structures within the modelled length?	Select from List	Specify, if combination:	
Maximum observed velocity:	6.17 m/s		
Brief summary of sensitivity tests, and range:			
variation on flow (%)	varies %	Please specify climate change scenario considered:	53% peak river flow uplift
variation on channel roughness (%)	20 %		
blockage of structure (range of % blocked)	n/a %		
boundary conditions:	**Upstream**		**Downstream**
(1) type	Flow		Normal depth
Specify if other		Specify if other:	
(2) does it influence water levels at the site?	No		No
Has model been calibrated (gauge data / flood records)?	No		
Is the hydraulic model available to SEPA?	Yes		
Design flood levels:	varies m AOD	200 year plus climate change	varies m AOD
Cross section results provided?	No		
Long section results provided?	No		
Cross section ratings provided?	No		
Tabular output provided (i.e. levels, velocities)?	No		
Mass balance error:	0.003 %		

Coastal

Is there a requirement to consider coastal / tidal flooding?	No		
Estimate of 200 year design flood level:	m AOD		
Estimation method(s) used:	Select from List	If other please specify methodology used:	
Allowance for climate change (m):	m		
Allowance for wave action etc (m):	m		
Overall design flood level:	m AOD		

Comments

Any additional comments:	

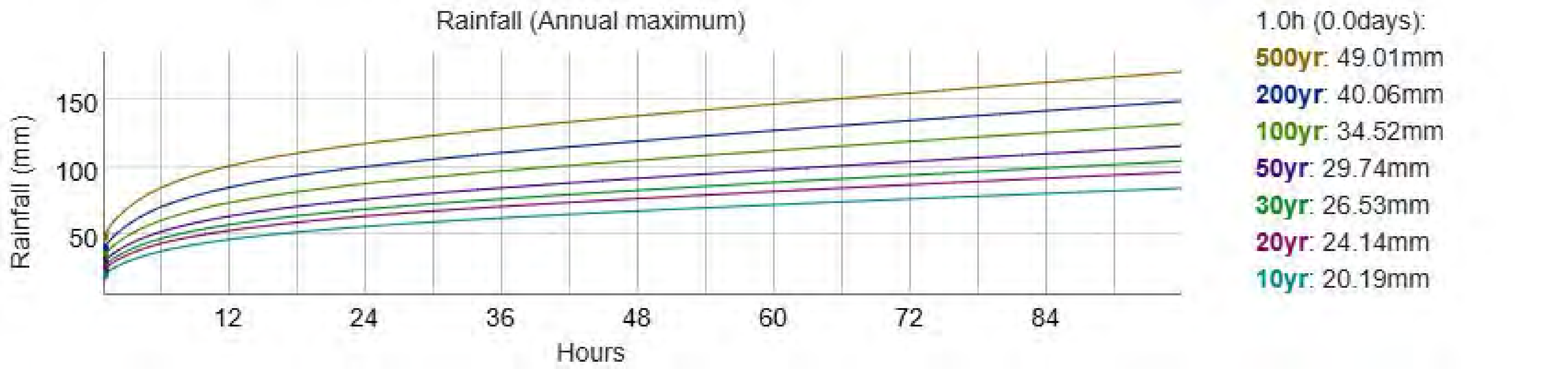
Approved by: **Stephen Donnan**
Organisation: **Gondolin Land & Water Ltd**

Date:	**16/04/2025**

Note: Further details and guidance is provided in 'Technical Flood Risk Guidance for Stakeholders' which can be accesssed here:- CLICK HERE

Appendix D

FEH Rainfall Depth Calculations


Rainfall (Annual maximum)
Rainfall (mm)
150
100
50
12
24
36
48
60
72
84
Hours
1.0h (0.0days):
500yr: 49.01mm
200yr: 40.06mm
100yr: 34.52mm
50yr: 29.74mm
30yr: 26.53mm
20yr: 24.14mm
10yr: 20.19mm

Appendix E

MicroDrainage Modelling Extracts

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	Scotland and Ireland	Cv (Winter)	0.840
M5-60 (mm)	17.000	Shortest Storm (mins)	15
Ratio R	0.300	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.500

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

Model Details

Storage is Online Cover Level (m) 2.000

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	284.0	2.000	912.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0044-1200-2000-1200
Design Head (m)	2.000
Design Flow (l/s)	1.2
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	44
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	2.000	1.2
Flush-Flo™	0.194	0.7
Kick-Flo®	0.391	0.6
Mean Flow over Head Range	-	0.9

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	0.7	1.200	1.0	3.000	1.4	7.000	2.1
0.200	0.7	1.400	1.0	3.500	1.5	7.500	2.2
0.300	0.7	1.600	1.1	4.000	1.6	8.000	2.3
0.400	0.6	1.800	1.1	4.500	1.7	8.500	2.3
0.500	0.6	2.000	1.2	5.000	1.8	9.000	2.4
0.600	0.7	2.200	1.3	5.500	1.9	9.500	2.5
0.800	0.8	2.400	1.3	6.000	2.0		
1.000	0.9	2.600	1.4	6.500	2.1		

Summary of Results for 2 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.100	0.100	0.7	29.6	O K
30 min Summer	0.133	0.133	0.7	39.8	O K
60 min Summer	0.170	0.170	0.7	51.5	O K
120 min Summer	0.210	0.210	0.7	64.6	O K
180 min Summer	0.234	0.234	0.7	72.6	O K
240 min Summer	0.252	0.252	0.7	78.9	O K
360 min Summer	0.278	0.278	0.7	88.1	O K
480 min Summer	0.296	0.296	0.7	94.2	O K
600 min Summer	0.309	0.309	0.7	98.9	O K
720 min Summer	0.319	0.319	0.7	102.4	O K
960 min Summer	0.333	0.333	0.7	107.5	O K
1440 min Summer	0.347	0.347	0.7	112.7	O K
2160 min Summer	0.355	0.355	0.7	115.8	O K
2880 min Summer	0.357	0.357	0.7	116.4	O K
4320 min Summer	0.352	0.352	0.7	114.6	O K
5760 min Summer	0.342	0.342	0.7	110.9	O K
7200 min Summer	0.328	0.328	0.7	105.9	O K
8640 min Summer	0.313	0.313	0.7	100.5	O K
10080 min Summer	0.298	0.298	0.7	95.0	O K
15 min Winter	0.112	0.112	0.7	33.2	O K
30 min Winter	0.148	0.148	0.7	44.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	32.034	0.0	26.5	19
30 min Summer	21.664	0.0	36.0	34
60 min Summer	14.178	0.0	51.2	64
120 min Summer	9.077	0.0	65.7	124
180 min Summer	6.926	0.0	75.0	182
240 min Summer	5.738	0.0	82.7	242
360 min Summer	4.397	0.0	94.1	362
480 min Summer	3.630	0.0	102.0	482
600 min Summer	3.128	0.0	107.0	602
720 min Summer	2.770	0.0	109.2	722
960 min Summer	2.286	0.0	108.7	960
1440 min Summer	1.745	0.0	103.7	1342
2160 min Summer	1.328	0.0	176.3	1712
2880 min Summer	1.094	0.0	191.2	2132
4320 min Summer	0.832	0.0	192.3	2940
5760 min Summer	0.685	0.0	245.8	3752
7200 min Summer	0.588	0.0	263.6	4608
8640 min Summer	0.519	0.0	278.9	5368
10080 min Summer	0.467	0.0	292.2	6160
15 min Winter	32.034	0.0	29.8	19
30 min Winter	21.664	0.0	40.2	33

Summary of Results for 2 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m^3)	Status
60 min Winter	0.189	0.189	0.7	57.8	O K
120 min Winter	0.234	0.234	0.7	72.7	O K
180 min Winter	0.261	0.261	0.7	81.9	O K
240 min Winter	0.281	0.281	0.7	89.1	O K
360 min Winter	0.311	0.311	0.7	99.8	O K
480 min Winter	0.332	0.332	0.7	107.2	O K
600 min Winter	0.347	0.347	0.7	112.9	O K
720 min Winter	0.360	0.360	0.7	117.4	O K
960 min Winter	0.378	0.378	0.7	124.3	O K
1440 min Winter	0.400	0.400	0.7	132.5	O K
2160 min Winter	0.409	0.409	0.7	136.1	O K
2880 min Winter	0.408	0.408	0.7	135.7	O K
4320 min Winter	0.399	0.399	0.7	132.3	O K
5760 min Winter	0.380	0.380	0.7	124.9	O K
7200 min Winter	0.354	0.354	0.7	115.4	O K
8640 min Winter	0.328	0.328	0.7	105.6	O K
10080 min Winter	0.301	0.301	0.7	96.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m^3)	Discharge Volume (m^3)	Time-Peak (mins)
60 min Winter	14.178	0.0	57.4	62
120 min Winter	9.077	0.0	73.5	122
180 min Winter	6.926	0.0	83.8	180
240 min Winter	5.738	0.0	92.1	240
360 min Winter	4.397	0.0	103.8	356
480 min Winter	3.630	0.0	109.8	474
600 min Winter	3.128	0.0	111.4	590
720 min Winter	2.770	0.0	110.8	706
960 min Winter	2.286	0.0	107.8	934
1440 min Winter	1.745	0.0	100.8	1386
2160 min Winter	1.328	0.0	195.3	2032
2880 min Winter	1.094	0.0	203.3	2336
4320 min Winter	0.832	0.0	190.6	3244
5760 min Winter	0.685	0.0	275.3	4160
7200 min Winter	0.588	0.0	295.2	5040
8640 min Winter	0.519	0.0	312.3	5872
10080 min Winter	0.467	0.0	327.0	6656

Summary of Results for 10 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.144	0.144	0.7	43.1	O K
30 min Summer	0.189	0.189	0.7	57.8	O K
60 min Summer	0.238	0.238	0.7	74.0	O K
120 min Summer	0.290	0.290	0.7	92.2	O K
180 min Summer	0.323	0.323	0.7	103.8	O K
240 min Summer	0.346	0.346	0.7	112.4	O K
360 min Summer	0.380	0.380	0.7	125.0	O K
480 min Summer	0.404	0.404	0.7	134.1	O K
600 min Summer	0.422	0.422	0.7	141.0	O K
720 min Summer	0.436	0.436	0.7	146.4	O K
960 min Summer	0.456	0.456	0.7	154.1	O K
1440 min Summer	0.477	0.477	0.7	162.6	O K
2160 min Summer	0.487	0.487	0.7	166.6	O K
2880 min Summer	0.489	0.489	0.7	167.7	O K
4320 min Summer	0.487	0.487	0.7	166.6	O K
5760 min Summer	0.479	0.479	0.7	163.5	O K
7200 min Summer	0.469	0.469	0.7	159.5	O K
8640 min Summer	0.458	0.458	0.7	154.9	O K
10080 min Summer	0.445	0.445	0.7	149.9	O K
15 min Winter	0.160	0.160	0.7	48.3	O K
30 min Winter	0.210	0.210	0.7	64.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	46.501	0.0	38.7	19
30 min Summer	31.331	0.0	50.4	34
60 min Summer	20.231	0.0	73.2	64
120 min Summer	12.791	0.0	91.8	124
180 min Summer	9.722	0.0	103.1	184
240 min Summer	7.991	0.0	109.9	244
360 min Summer	6.050	0.0	112.9	362
480 min Summer	4.961	0.0	110.7	482
600 min Summer	4.252	0.0	108.4	602
720 min Summer	3.747	0.0	106.4	722
960 min Summer	3.070	0.0	103.2	962
1440 min Summer	2.316	0.0	98.9	1440
2160 min Summer	1.747	0.0	210.9	2012
2880 min Summer	1.430	0.0	204.9	2368
4320 min Summer	1.078	0.0	190.1	3156
5760 min Summer	0.882	0.0	316.1	3984
7200 min Summer	0.755	0.0	337.3	4832
8640 min Summer	0.664	0.0	353.8	5704
10080 min Summer	0.596	0.0	354.8	6464
15 min Winter	46.501	0.0	43.0	19
30 min Winter	31.331	0.0	54.4	33

Summary of Results for 10 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	0.264	0.264	0.7	83.1	O K
120 min Winter	0.322	0.322	0.7	103.7	O K
180 min Winter	0.358	0.358	0.7	116.9	O K
240 min Winter	0.385	0.385	0.7	126.8	O K
360 min Winter	0.423	0.423	0.7	141.4	O K
480 min Winter	0.450	0.450	0.7	151.8	O K
600 min Winter	0.470	0.470	0.7	159.7	O K
720 min Winter	0.485	0.485	0.7	166.0	O K
960 min Winter	0.509	0.509	0.7	175.5	O K
1440 min Winter	0.535	0.535	0.7	186.6	O K
2160 min Winter	0.552	0.552	0.7	193.4	O K
2880 min Winter	0.554	0.554	0.7	194.4	O K
4320 min Winter	0.548	0.548	0.7	192.0	O K
5760 min Winter	0.536	0.536	0.7	186.9	O K
7200 min Winter	0.519	0.519	0.7	180.0	O K
8640 min Winter	0.500	0.500	0.7	172.1	O K
10080 min Winter	0.480	0.480	0.7	163.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	20.231	0.0	81.8	64
120 min Winter	12.791	0.0	101.7	122
180 min Winter	9.722	0.0	111.4	182
240 min Winter	7.991	0.0	113.6	240
360 min Winter	6.050	0.0	111.1	358
480 min Winter	4.961	0.0	108.6	476
600 min Winter	4.252	0.0	106.6	594
720 min Winter	3.747	0.0	105.1	708
960 min Winter	3.070	0.0	103.0	942
1440 min Winter	2.316	0.0	102.0	1398
2160 min Winter	1.747	0.0	213.3	2056
2880 min Winter	1.430	0.0	207.7	2680
4320 min Winter	1.078	0.0	198.3	3332
5760 min Winter	0.882	0.0	353.6	4272
7200 min Winter	0.755	0.0	376.4	5256
8640 min Winter	0.664	0.0	385.4	6144
10080 min Winter	0.596	0.0	369.1	7064

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.180	0.180	0.7	54.8	O K
30 min Summer	0.238	0.238	0.7	74.0	O K
60 min Summer	0.296	0.296	0.7	94.4	O K
120 min Summer	0.359	0.359	0.7	117.1	O K
180 min Summer	0.397	0.397	0.7	131.5	O K
240 min Summer	0.425	0.425	0.7	142.2	O K
360 min Summer	0.464	0.464	0.7	157.5	O K
480 min Summer	0.491	0.491	0.7	168.5	O K
600 min Summer	0.512	0.512	0.7	176.7	O K
720 min Summer	0.528	0.528	0.7	183.3	O K
960 min Summer	0.550	0.550	0.7	192.9	O K
1440 min Summer	0.576	0.576	0.7	203.9	O K
2160 min Summer	0.590	0.590	0.7	209.8	O K
2880 min Summer	0.592	0.592	0.7	210.7	O K
4320 min Summer	0.589	0.589	0.7	209.2	O K
5760 min Summer	0.581	0.581	0.7	205.7	O K
7200 min Summer	0.570	0.570	0.7	201.3	O K
8640 min Summer	0.558	0.558	0.7	196.3	O K
10080 min Summer	0.546	0.546	0.7	191.1	O K
15 min Winter	0.200	0.200	0.7	61.5	O K
30 min Winter	0.264	0.264	0.7	83.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	59.026	0.0	48.1	19
30 min Summer	39.977	0.0	57.7	34
60 min Summer	25.672	0.0	92.2	64
120 min Summer	16.114	0.0	110.8	124
180 min Summer	12.182	0.0	113.7	184
240 min Summer	9.975	0.0	112.1	244
360 min Summer	7.507	0.0	109.1	362
480 min Summer	6.129	0.0	107.1	482
600 min Summer	5.235	0.0	105.8	602
720 min Summer	4.601	0.0	104.9	722
960 min Summer	3.751	0.0	104.4	962
1440 min Summer	2.813	0.0	105.6	1442
2160 min Summer	2.108	0.0	215.2	2160
2880 min Summer	1.717	0.0	210.5	2484
4320 min Summer	1.285	0.0	203.8	3244
5760 min Summer	1.046	0.0	373.9	4088
7200 min Summer	0.891	0.0	394.1	4904
8640 min Summer	0.782	0.0	387.8	5784
10080 min Summer	0.700	0.0	367.3	6560
15 min Winter	59.026	0.0	52.5	19
30 min Winter	39.977	0.0	59.0	34

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	0.328	0.328	0.7	105.9	O K
120 min Winter	0.398	0.398	0.7	131.6	O K
180 min Winter	0.440	0.440	0.7	147.9	O K
240 min Winter	0.470	0.470	0.7	160.0	O K
360 min Winter	0.514	0.514	0.7	177.5	O K
480 min Winter	0.544	0.544	0.7	190.1	O K
600 min Winter	0.567	0.567	0.7	199.8	O K
720 min Winter	0.585	0.585	0.7	207.6	O K
960 min Winter	0.612	0.612	0.7	219.3	O K
1440 min Winter	0.644	0.644	0.7	233.5	O K
2160 min Winter	0.665	0.665	0.7	243.0	O K
2880 min Winter	0.670	0.670	0.7	245.4	O K
4320 min Winter	0.664	0.664	0.7	242.4	O K
5760 min Winter	0.652	0.652	0.7	237.2	O K
7200 min Winter	0.636	0.636	0.7	230.0	O K
8640 min Winter	0.618	0.618	0.7	221.8	O K
10080 min Winter	0.598	0.598	0.7	213.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	25.672	0.0	102.1	64
120 min Winter	16.114	0.0	114.1	122
180 min Winter	12.182	0.0	112.1	182
240 min Winter	9.975	0.0	110.2	240
360 min Winter	7.507	0.0	107.8	358
480 min Winter	6.129	0.0	106.8	476
600 min Winter	5.235	0.0	106.6	594
720 min Winter	4.601	0.0	107.1	710
960 min Winter	3.751	0.0	109.0	944
1440 min Winter	2.813	0.0	110.3	1400
2160 min Winter	2.108	0.0	219.0	2076
2880 min Winter	1.717	0.0	218.0	2712
4320 min Winter	1.285	0.0	214.5	3420
5760 min Winter	1.046	0.0	416.2	4376
7200 min Winter	0.891	0.0	419.9	5328
8640 min Winter	0.782	0.0	404.2	6224
10080 min Winter	0.700	0.0	387.2	7160

Summary of Results for 100 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.230	0.230	0.7	71.3	O K
30 min Summer	0.303	0.303	0.7	96.9	O K
60 min Summer	0.375	0.375	0.7	123.1	O K
120 min Summer	0.450	0.450	0.7	151.9	O K
180 min Summer	0.494	0.494	0.7	169.6	O K
240 min Summer	0.526	0.526	0.7	182.8	O K
360 min Summer	0.571	0.571	0.7	201.7	O K
480 min Summer	0.602	0.602	0.7	215.2	O K
600 min Summer	0.626	0.626	0.7	225.4	O K
720 min Summer	0.644	0.644	0.7	233.6	O K
960 min Summer	0.671	0.671	0.7	245.6	O K
1440 min Summer	0.702	0.702	0.8	260.0	O K
2160 min Summer	0.721	0.721	0.8	268.8	O K
2880 min Summer	0.723	0.723	0.8	269.9	O K
4320 min Summer	0.718	0.718	0.8	267.4	O K
5760 min Summer	0.708	0.708	0.8	262.6	O K
7200 min Summer	0.696	0.696	0.7	257.1	O K
8640 min Summer	0.683	0.683	0.7	251.1	O K
10080 min Summer	0.670	0.670	0.7	245.0	O K
15 min Winter	0.255	0.255	0.7	80.0	O K
30 min Winter	0.336	0.336	0.7	108.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	76.658	0.0	57.0	19
30 min Summer	52.215	0.0	59.5	34
60 min Summer	33.329	0.0	112.8	64
120 min Summer	20.754	0.0	112.3	124
180 min Summer	15.597	0.0	110.0	184
240 min Summer	12.718	0.0	108.7	244
360 min Summer	9.510	0.0	108.1	364
480 min Summer	7.728	0.0	109.0	482
600 min Summer	6.575	0.0	110.9	602
720 min Summer	5.761	0.0	112.4	722
960 min Summer	4.674	0.0	114.2	962
1440 min Summer	3.479	0.0	115.2	1442
2160 min Summer	2.590	0.0	226.1	2160
2880 min Summer	2.098	0.0	227.7	2736
4320 min Summer	1.558	0.0	222.9	3416
5760 min Summer	1.260	0.0	439.1	4208
7200 min Summer	1.069	0.0	427.8	5040
8640 min Summer	0.934	0.0	411.3	5872
10080 min Summer	0.833	0.0	395.8	6664
15 min Winter	76.658	0.0	58.8	19
30 min Winter	52.215	0.0	59.1	34

Summary of Results for 100 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	0.414	0.414	0.7	138.1	O K
120 min Winter	0.496	0.496	0.7	170.4	O K
180 min Winter	0.545	0.545	0.7	190.5	O K
240 min Winter	0.580	0.580	0.7	205.6	O K
360 min Winter	0.630	0.630	0.7	227.2	O K
480 min Winter	0.664	0.664	0.7	242.7	O K
600 min Winter	0.691	0.691	0.7	254.7	O K
720 min Winter	0.711	0.711	0.8	264.3	O K
960 min Winter	0.742	0.742	0.8	278.8	O K
1440 min Winter	0.780	0.780	0.8	297.0	O K
2160 min Winter	0.807	0.807	0.8	310.2	O K
2880 min Winter	0.816	0.816	0.8	314.5	O K
4320 min Winter	0.808	0.808	0.8	310.7	O K
5760 min Winter	0.796	0.796	0.8	304.7	O K
7200 min Winter	0.779	0.779	0.8	296.7	O K
8640 min Winter	0.761	0.761	0.8	287.6	O K
10080 min Winter	0.740	0.740	0.8	277.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	33.329	0.0	114.2	64
120 min Winter	20.754	0.0	110.5	122
180 min Winter	15.597	0.0	109.1	182
240 min Winter	12.718	0.0	108.9	240
360 min Winter	9.510	0.0	111.1	360
480 min Winter	7.728	0.0	114.1	478
600 min Winter	6.575	0.0	116.1	596
720 min Winter	5.761	0.0	117.5	714
960 min Winter	4.674	0.0	119.2	944
1440 min Winter	3.479	0.0	119.7	1412
2160 min Winter	2.590	0.0	237.4	2096
2880 min Winter	2.098	0.0	238.5	2740
4320 min Winter	1.558	0.0	232.9	3892
5760 min Winter	1.260	0.0	455.6	4448
7200 min Winter	1.069	0.0	444.3	5400
8640 min Winter	0.934	0.0	433.9	6312
10080 min Winter	0.833	0.0	423.0	7256

Summary of Results for 200 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.264	0.264	0.7	83.0	O K
30 min Summer	0.348	0.348	0.7	113.2	O K
60 min Summer	0.428	0.428	0.7	143.3	O K
120 min Summer	0.510	0.510	0.7	176.1	O K
180 min Summer	0.558	0.558	0.7	196.2	O K
240 min Summer	0.593	0.593	0.7	211.1	O K
360 min Summer	0.641	0.641	0.7	232.4	O K
480 min Summer	0.675	0.675	0.7	247.5	O K
600 min Summer	0.700	0.700	0.8	259.1	O K
720 min Summer	0.720	0.720	0.8	268.3	O K
960 min Summer	0.749	0.749	0.8	282.0	O K
1440 min Summer	0.783	0.783	0.8	298.5	O K
2160 min Summer	0.805	0.805	0.8	309.3	O K
2880 min Summer	0.809	0.809	0.8	311.1	O K
4320 min Summer	0.802	0.802	0.8	307.6	O K
5760 min Summer	0.790	0.790	0.8	301.8	O K
7200 min Summer	0.776	0.776	0.8	295.3	O K
8640 min Summer	0.762	0.762	0.8	288.5	O K
10080 min Summer	0.748	0.748	0.8	281.6	O K
15 min Winter	0.292	0.292	0.7	93.0	O K
30 min Winter	0.385	0.385	0.7	126.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	89.106	0.0	59.1	19
30 min Summer	60.894	0.0	58.7	34
60 min Summer	38.734	0.0	113.7	64
120 min Summer	24.009	0.0	110.1	124
180 min Summer	17.982	0.0	109.1	184
240 min Summer	14.628	0.0	109.4	244
360 min Summer	10.898	0.0	112.3	364
480 min Summer	8.831	0.0	115.2	482
600 min Summer	7.497	0.0	117.2	602
720 min Summer	6.557	0.0	118.6	722
960 min Summer	5.304	0.0	120.2	962
1440 min Summer	3.933	0.0	120.8	1442
2160 min Summer	2.915	0.0	238.8	2160
2880 min Summer	2.355	0.0	239.9	2852
4320 min Summer	1.741	0.0	234.0	3540
5760 min Summer	1.403	0.0	455.8	4272
7200 min Summer	1.187	0.0	443.3	5112
8640 min Summer	1.035	0.0	431.0	5888
10080 min Summer	0.922	0.0	418.7	6760
15 min Winter	89.106	0.0	59.6	19
30 min Winter	60.894	0.0	57.0	34

Summary of Results for 200 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	0.472	0.472	0.7	160.7	O K
120 min Winter	0.562	0.562	0.7	197.6	O K
180 min Winter	0.614	0.614	0.7	220.3	O K
240 min Winter	0.652	0.652	0.7	237.3	O K
360 min Winter	0.706	0.706	0.8	261.6	O K
480 min Winter	0.743	0.743	0.8	279.1	O K
600 min Winter	0.771	0.771	0.8	292.5	O K
720 min Winter	0.793	0.793	0.8	303.4	O K
960 min Winter	0.826	0.826	0.8	319.8	O K
1440 min Winter	0.867	0.867	0.8	340.5	O K
2160 min Winter	0.897	0.897	0.8	356.1	O K
2880 min Winter	0.908	0.908	0.8	361.7	O K
4320 min Winter	0.902	0.902	0.8	358.6	O K
5760 min Winter	0.887	0.887	0.8	350.9	O K
7200 min Winter	0.870	0.870	0.8	342.1	O K
8640 min Winter	0.851	0.851	0.8	332.2	O K
10080 min Winter	0.830	0.830	0.8	321.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	38.734	0.0	112.0	64
120 min Winter	24.009	0.0	109.5	122
180 min Winter	17.982	0.0	110.4	182
240 min Winter	14.628	0.0	113.2	242
360 min Winter	10.898	0.0	117.7	360
480 min Winter	8.831	0.0	120.6	478
600 min Winter	7.497	0.0	122.5	596
720 min Winter	6.557	0.0	123.8	714
960 min Winter	5.304	0.0	125.2	946
1440 min Winter	3.933	0.0	125.2	1412
2160 min Winter	2.915	0.0	250.2	2096
2880 min Winter	2.355	0.0	250.5	2764
4320 min Winter	1.741	0.0	243.6	4016
5760 min Winter	1.403	0.0	471.7	4504
7200 min Winter	1.187	0.0	465.7	5472
8640 min Winter	1.035	0.0	458.1	6400
10080 min Winter	0.922	0.0	445.4	7352

Summary of Results for 200 year Return Period (+39%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.355	0.355	0.7	115.6	O K
30 min Summer	0.465	0.465	0.7	157.7	O K
60 min Summer	0.567	0.567	0.7	199.8	O K
120 min Summer	0.671	0.671	0.7	245.9	O K
180 min Summer	0.733	0.733	0.8	274.4	O K
240 min Summer	0.777	0.777	0.8	295.8	O K
360 min Summer	0.840	0.840	0.8	326.6	O K
480 min Summer	0.883	0.883	0.8	348.9	O K
600 min Summer	0.917	0.917	0.8	366.3	O K
720 min Summer	0.943	0.943	0.9	380.4	O K
960 min Summer	0.983	0.983	0.9	402.1	O K
1440 min Summer	1.034	1.034	0.9	430.4	O K
2160 min Summer	1.074	1.074	0.9	453.1	O K
2880 min Summer	1.091	1.091	0.9	463.0	O K
4320 min Summer	1.093	1.093	0.9	464.4	O K
5760 min Summer	1.086	1.086	0.9	460.0	O K
7200 min Summer	1.075	1.075	0.9	453.5	O K
8640 min Summer	1.062	1.062	0.9	446.3	O K
10080 min Summer	1.049	1.049	0.9	438.9	O K
15 min Winter	0.392	0.392	0.7	129.5	O K
30 min Winter	0.512	0.512	0.7	176.7	O K

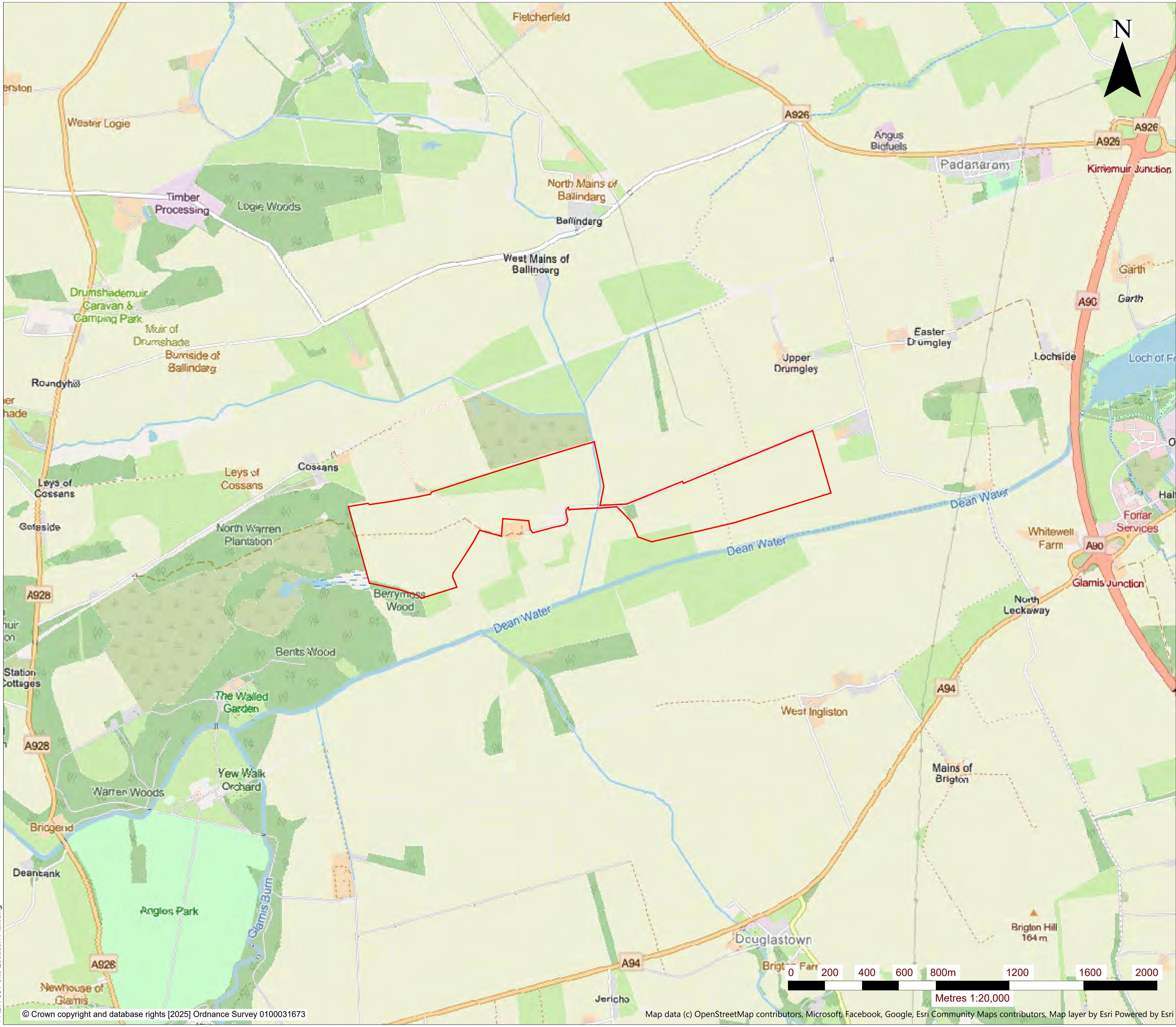
Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	123.858	0.0	58.7	19
30 min Summer	84.643	0.0	53.0	34
60 min Summer	53.840	0.0	110.0	64
120 min Summer	33.372	0.0	115.0	124
180 min Summer	24.995	0.0	120.4	184
240 min Summer	20.333	0.0	124.1	244
360 min Summer	15.148	0.0	128.8	364
480 min Summer	12.275	0.0	131.7	484
600 min Summer	10.421	0.0	133.7	604
720 min Summer	9.114	0.0	135.0	722
960 min Summer	7.373	0.0	136.3	962
1440 min Summer	5.466	0.0	136.2	1442
2160 min Summer	4.052	0.0	275.0	2160
2880 min Summer	3.273	0.0	274.8	2880
4320 min Summer	2.420	0.0	266.8	3936
5760 min Summer	1.951	0.0	525.0	4664
7200 min Summer	1.650	0.0	521.2	5408
8640 min Summer	1.439	0.0	511.1	6224
10080 min Summer	1.281	0.0	495.9	7056
15 min Winter	123.858	0.0	56.7	19
30 min Winter	84.643	0.0	53.2	34

Summary of Results for 200 year Return Period (+39%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	0.623	0.623	0.7	224.0	O K
120 min Winter	0.736	0.736	0.8	275.8	O K
180 min Winter	0.803	0.803	0.8	308.1	O K
240 min Winter	0.851	0.851	0.8	332.3	O K
360 min Winter	0.919	0.919	0.8	367.4	O K
480 min Winter	0.967	0.967	0.9	393.0	O K
600 min Winter	1.003	1.003	0.9	413.1	O K
720 min Winter	1.032	1.032	0.9	429.4	O K
960 min Winter	1.077	1.077	0.9	455.0	O K
1440 min Winter	1.135	1.135	0.9	489.2	O K
2160 min Winter	1.184	1.184	0.9	518.6	O K
2880 min Winter	1.209	1.209	1.0	533.7	O K
4320 min Winter	1.222	1.222	1.0	542.4	O K
5760 min Winter	1.213	1.213	1.0	536.6	O K
7200 min Winter	1.200	1.200	1.0	528.3	O K
8640 min Winter	1.185	1.185	0.9	519.2	O K
10080 min Winter	1.168	1.168	0.9	508.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	53.840	0.0	111.3	64
120 min Winter	33.372	0.0	120.6	122
180 min Winter	24.995	0.0	126.1	182
240 min Winter	20.333	0.0	129.8	242
360 min Winter	15.148	0.0	134.5	360
480 min Winter	12.275	0.0	137.3	478
600 min Winter	10.421	0.0	139.1	596
720 min Winter	9.114	0.0	140.3	714
960 min Winter	7.373	0.0	141.3	952
1440 min Winter	5.466	0.0	140.6	1414
2160 min Winter	4.052	0.0	286.3	2116
2880 min Winter	3.273	0.0	285.2	2796
4320 min Winter	2.420	0.0	275.4	4108
5760 min Winter	1.951	0.0	552.1	5304
7200 min Winter	1.650	0.0	546.8	5696
8640 min Winter	1.439	0.0	535.9	6648
10080 min Winter	1.281	0.0	520.5	7560

Drawings



FRDA-001 Site Location Plan.dwg

LEGEND

PLANNING BOUNDARY

REV	DATE	DESCRIPTION	BY	CHK
00	04/25	INITIAL ISSUE	GD	SD

CLIENT:
TRIO POWER LIMITED

PROJECT:
COSSANS SOLAR & BESS

DRAWING TITLE:
SITE LOCATION PLAN

SCALE:
1:20,000 @ A3

DATE:
APRIL 2025

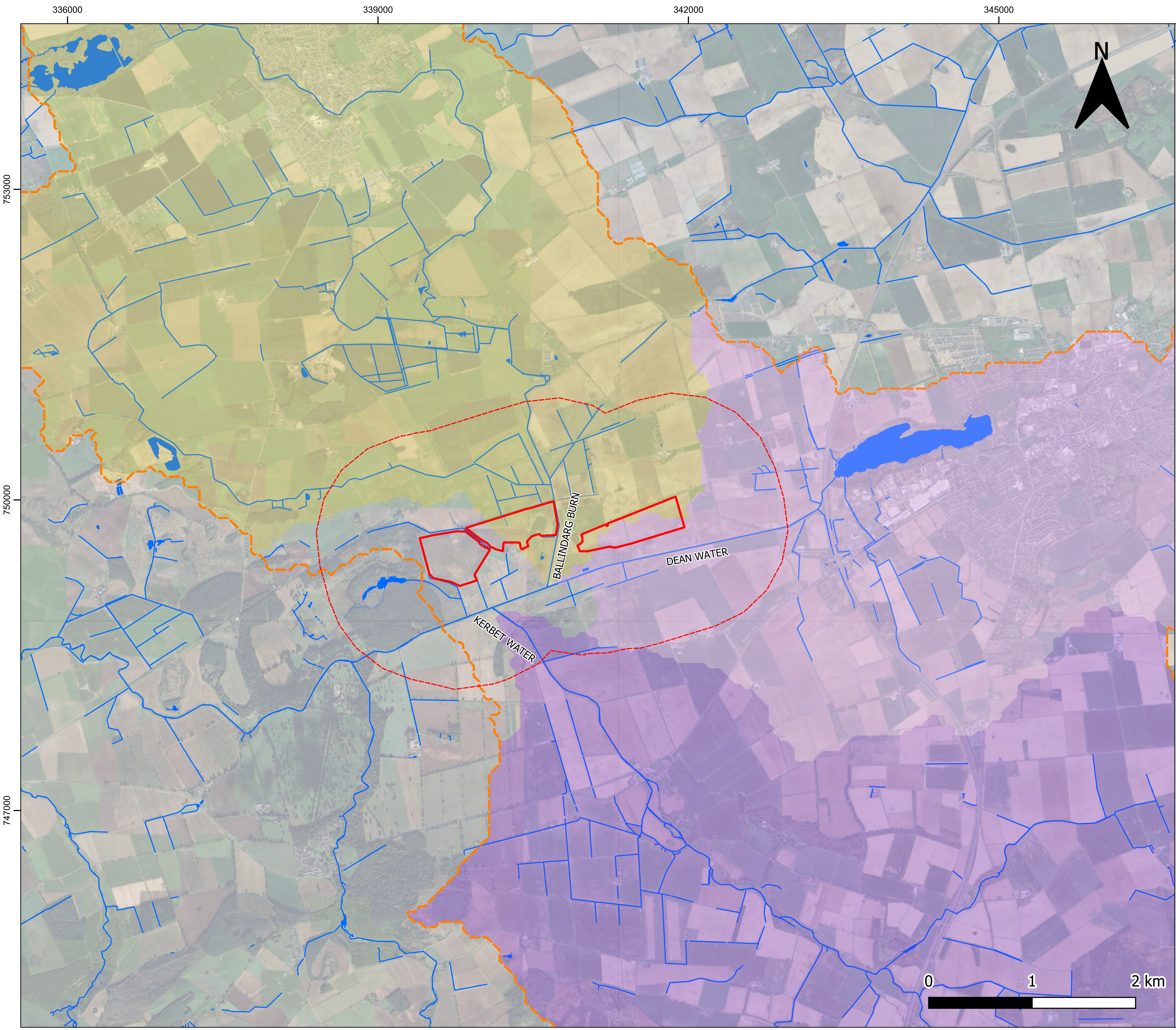
DRAWING NUMBER:
FRDA-001

REV:
00

DRAWING STATUS:
FOR PLANNING

GONDOLIN LAND & WATER LTD
15 Quayside Street
Edinburgh
EH6 6EJ
Registered Company No. SC706920

GONDOLIN
Land & Water



LEGEND

SITE BOUNDARY
1KM BUFFER
WATERCOURSE
SURFACE WATER AREA
DEAN WATER US CATCHMENT
KERBET WATER CATCHMENT
BALLINDARG BURN CATCHMENT
DEAN WATER DS CATCHMENT

REV	DATE	DESCRIPTION	BY	CHK
00	04/25	INITIAL ISSUE	AS	SD

CLIENT:
TRIO POWER LTD

PROJECT:
COSSANS SOLAR AND BESS

DRAWING TITLE:
HYDROLOGICAL OVERVIEW

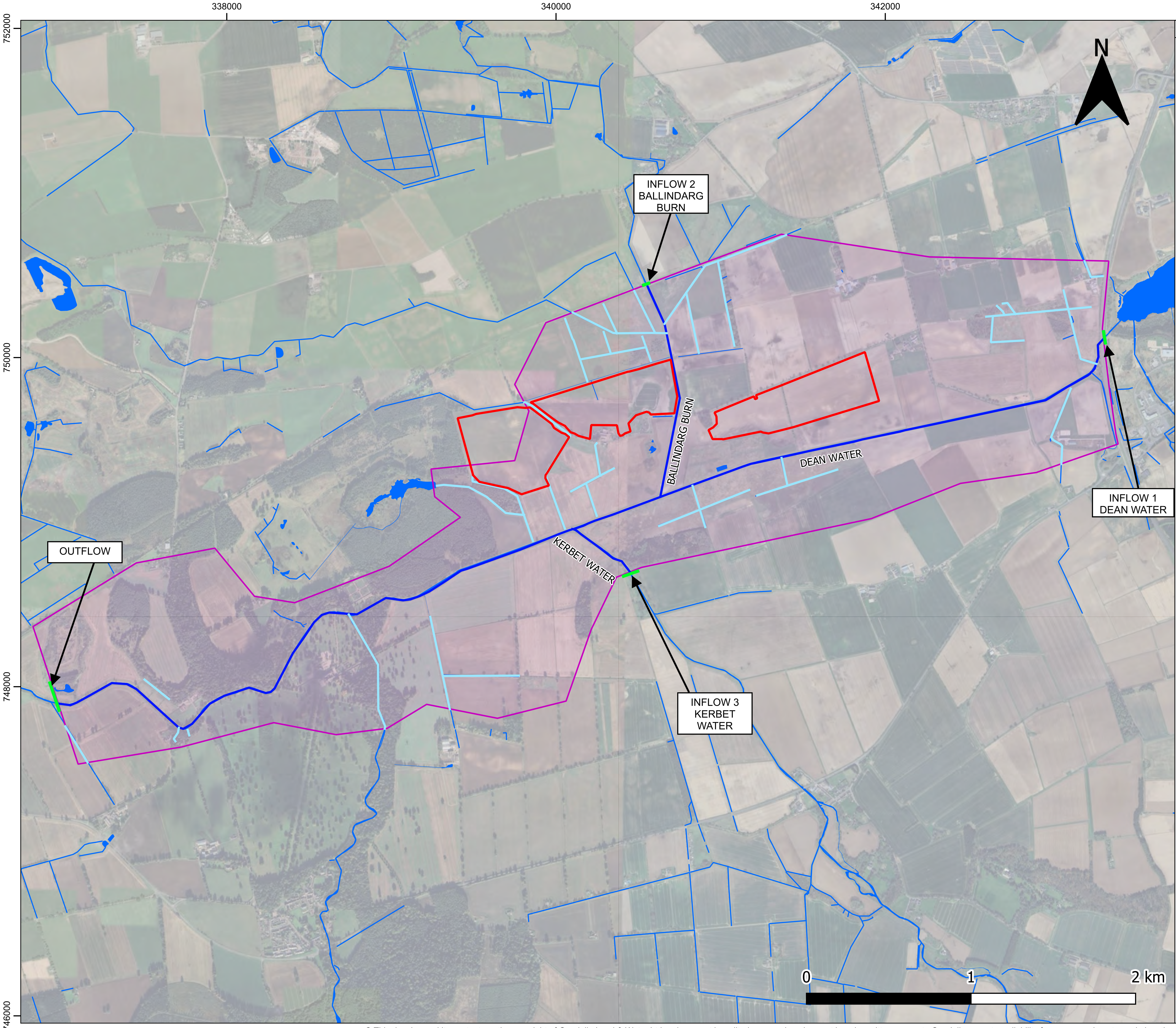
SCALE: 1:35,000 @ A3
DATE: APRIL 2025

DRAWING NUMBER: **FRDA-002**
REV: **00**

DRAWING STATUS:
FOR PLANNING

GONDOLIN LAND & WATER LTD
15 Quayside St
Edinburgh
EH6 6EJ
Registered Company No. SC706920

GONDOLIN Land & Water



LEGEND

- SITE BOUNDARY
- MODELLED WATERCOURSE
- DITCH
- 2D FLOW AREA PERIMETER
- BOUNDARY CONDITION LINE

REV	DATE	DESCRIPTION	BY	CHK
00	04/25	INITIAL ISSUE	AS	SD

CLIENT:
TRIO POWER LTD

PROJECT:
COSSANS SOLAR AND BESS

DRAWING TITLE:
FLOOD MODEL OVERVIEW

SCALE:
1:22,000 @ A3

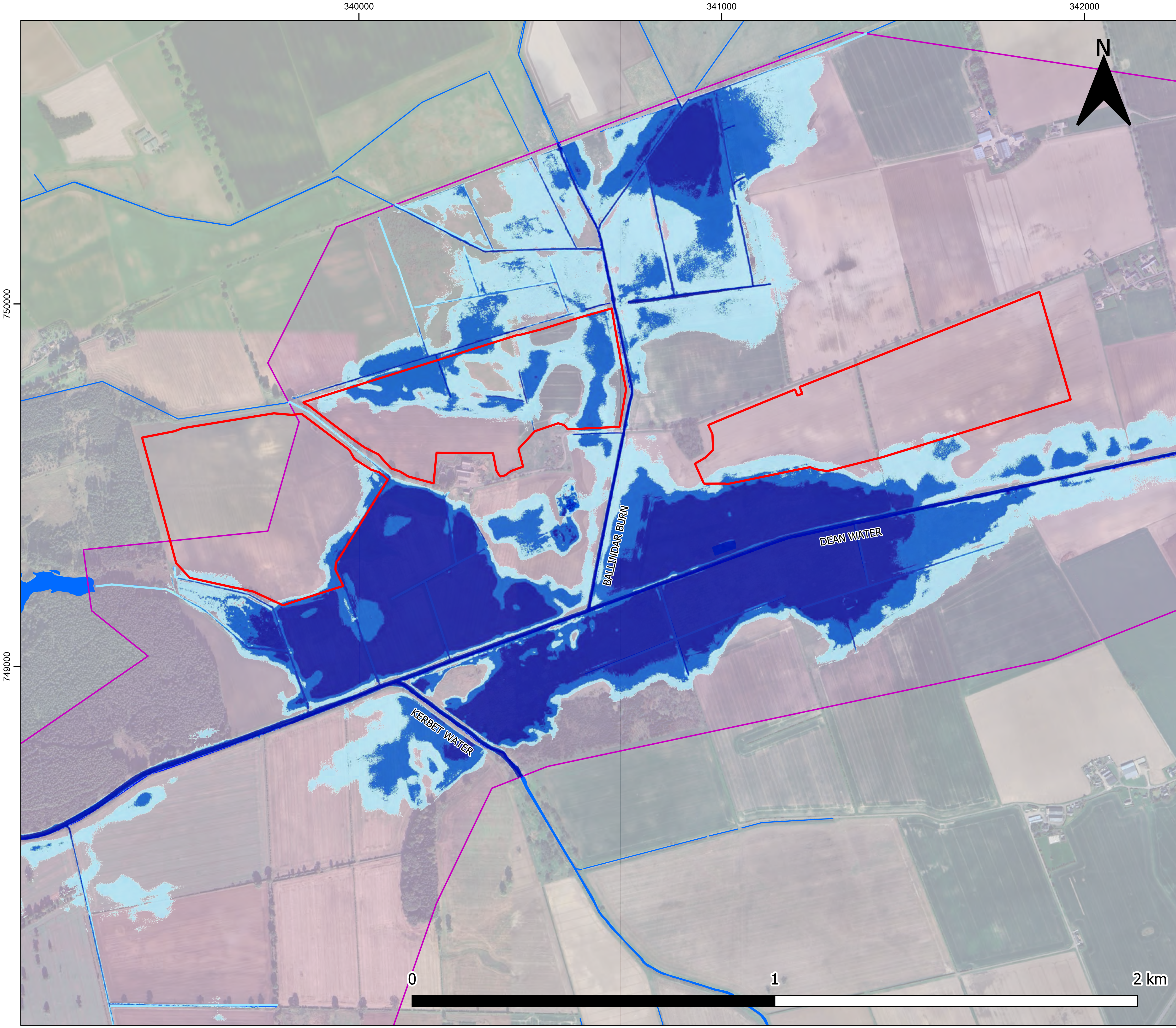
DATE:
APRIL 2025

DRAWING NUMBER:
FRDA-003

REV:
00

DRAWING STATUS:
FOR PLANNING

GONDOLIN LAND & WATER LTD
15 Quayside St
Edinburgh
EH6 6EJ
Registered Company No. SC706920



LEGEND

- SITE BOUNDARY
- MODELLED WATERCOURSE
- DITCH
- 2D FLOW AREA PERIMETER

FLOOD DEPTH (M)

- <= 0.5
- 0.5 - 1.0
- >1.0

REV	DATE	DESCRIPTION	BY	CHK
00	04/25	INITIAL ISSUE	AS	SD

CLIENT:
TRIO POWER LTD

PROJECT:
COSSANS SOLAR AND BESS

DRAWING TITLE:
200YR EVENT FLOOD DEPTH

SCALE: 1:10,000 @ A3

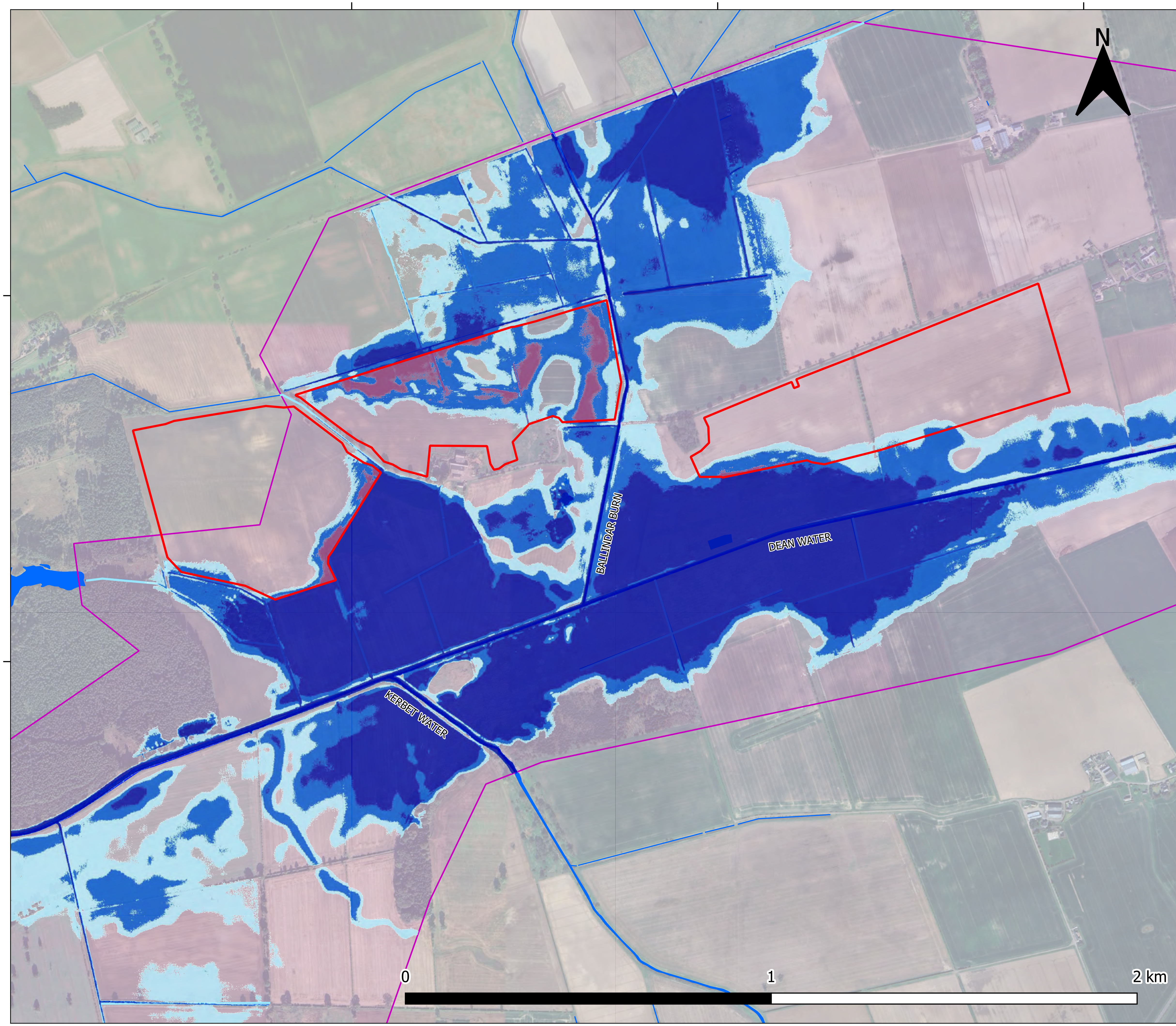
DATE: APRIL 2025

DRAWING NUMBER: **FRDA-004**

REV: **00**

DRAWING STATUS: FOR PLANNING

GONDOLIN LAND & WATER LTD
15 Quayside St
Edinburgh
EH6 6EJ
Registered Company No. SC706920



LEGEND

- SITE BOUNDARY
- MODELLED WATERCOURSE
- DITCH
- 2D FLOW AREA PERIMETER

FLOOD DEPTH (M)

- <= 0.5
- 0.5 - 1.0
- >1.0

- NO DEVELOPMENT AREA (FLOOD DEPTH >0.9M)

REV	DATE	DESCRIPTION	BY	CHK
00	04/25	INITIAL ISSUE	AS	SD

CLIENT:
TRIO POWER LTD

PROJECT:
COSSANS SOLAR AND BESS

DRAWING TITLE:
200YR + 53% CC EVENT FLOOD DEPTH

SCALE:
1:10,000 @ A3

DATE:
APRIL 2025

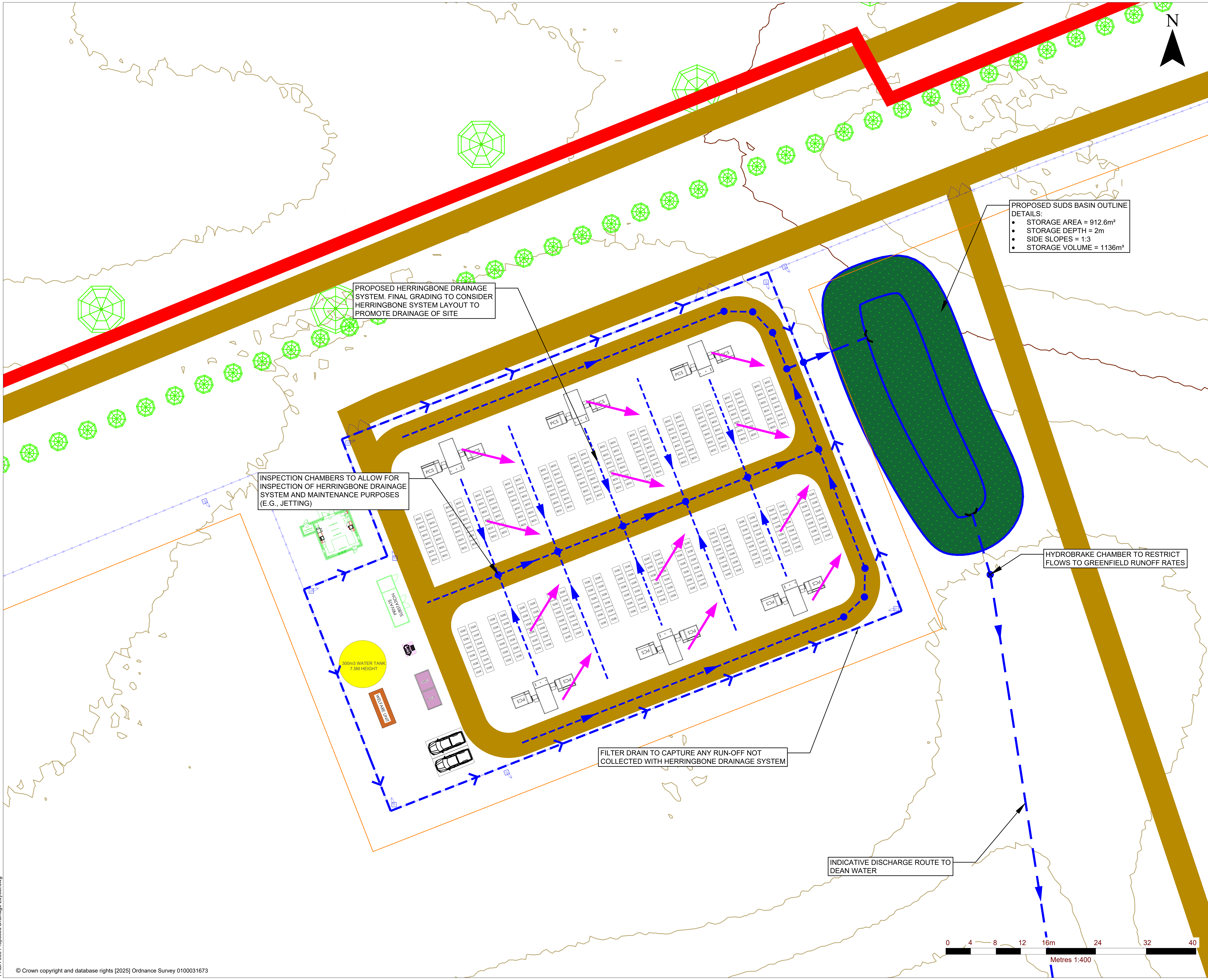
DRAWING NUMBER:
FRDA-005

REV:
00

DRAWING STATUS:
FOR PLANNING

GONDOLIN LAND & WATER LTD
15 Quayside St
Edinburgh
EH6 6EJ
Registered Company No. SC706920

GONDOLIN Land & Water



FRDA-006 Proposed Drainage Layout.dwg

NOTES

1. DTM DATA TAKEN FROM SCOTTISH REMOTE SENSING PORTAL.
2. SITE LAYOUT TAKEN FROM DRAWING 'DESIGN_CONSTRAINTS_250305' PROVIDED BY SLR.
3. DRAWING TO BE READ IN CONJUNCTION WITH ALL OTHER SCHEME DRAWINGS
4. DESIGN SHOULD BE CONSIDERED PROVISIONAL OUTLINE DETAIL TO BE REFINED AT DETAILED DESIGN STAGE.

LEGEND

- PLANNING BOUNDARY
- EXISTING MAJOR CONTOURS (5m INTERVALS)
- EXISTING MINOR CONTOURS (1m INTERVALS)
- PROPOSED FILTER DRAIN
- PROPOSED CONVENTIONAL PIPEWORK
- PROPOSED PERFORATED PIPEWORK
- PROPOSED MANHOLE CHAMBER
- PROPOSED HYDROBRAKE CHAMBER
- PROPOSED SUDS BASIN
- PROPOSED HEADWALL / RIP RAP
- PROPOSED GRADING DIRECTIONS (SUBSURFACE & SURFACE)

REV	DATE	DESCRIPTION	BY	CHK
00	04/25	INITIAL ISSUE	GD	SD

CLIENT:
TRIO POWER LIMITED

PROJECT:
COSSANS SOLAR & BESS

DRAWING TITLE:
PROPOSED DRAINAGE LAYOUT

SCALE: 1:400 @ A2

DATE: APRIL 2025

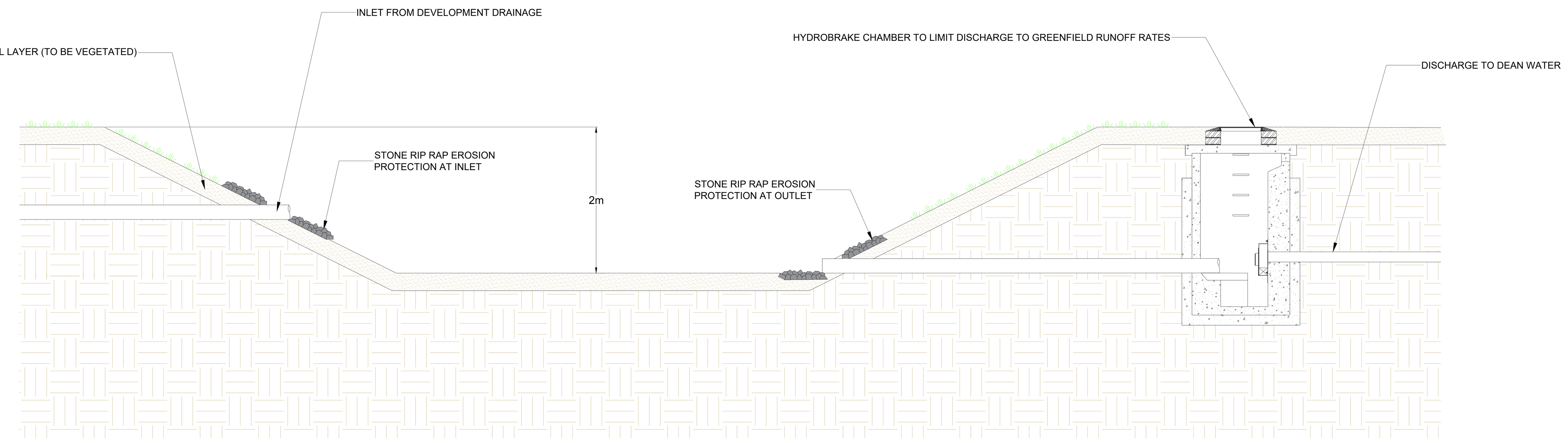
DRAWING NUMBER: **FRDA-006**

REV: **00**

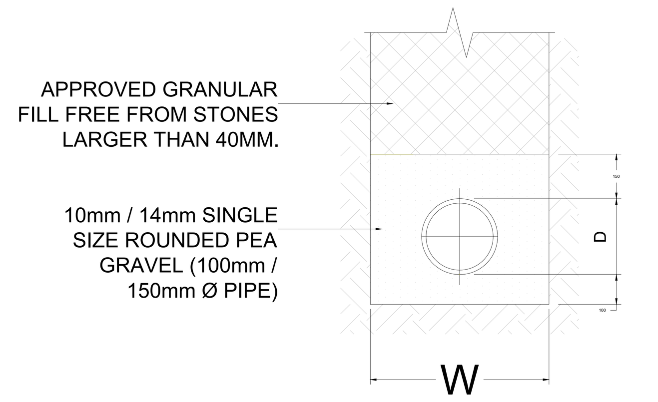
DRAWING STATUS: FOR PLANNING

GONDOLIN LAND & WATER LTD
15 Quayside Street
Edinburgh
EH6 6EJ
Registered Company No. SC706920

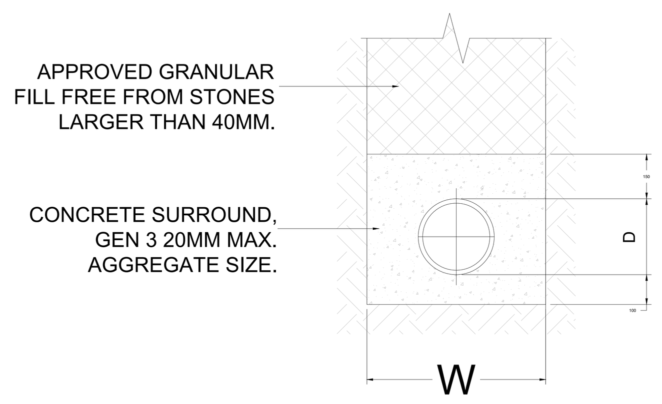
GONDOLIN Land & Water



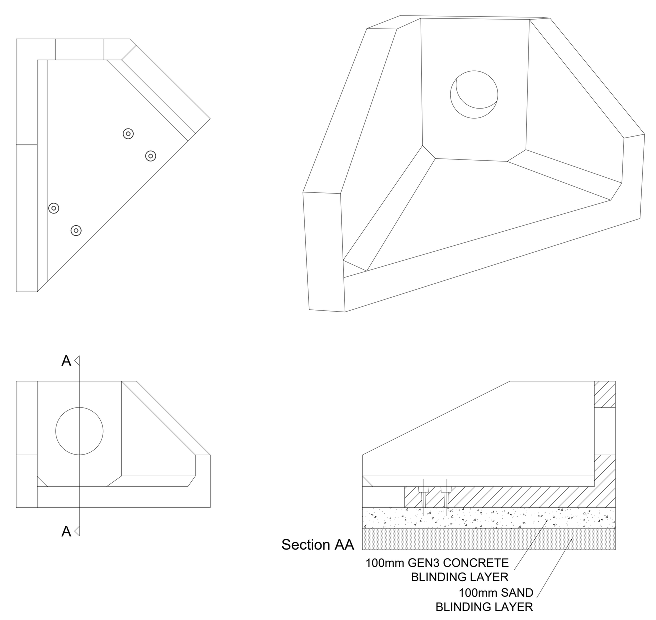
TYPICAL SECTION THROUGH ATTENUATION BASIN
NTS



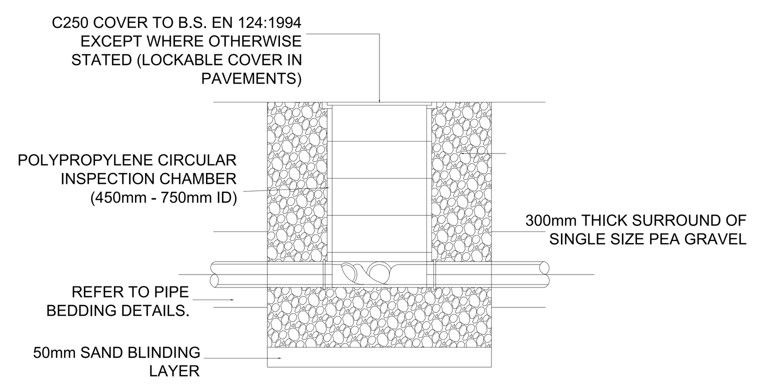
CLASS 'S' PIPE BEDDING & BACKFILLING DETAIL
NTS
PIPES WHERE COVER TO CROWN IS GREATER THAN 1200MM UNDER ROADS AND FOOTPATHS



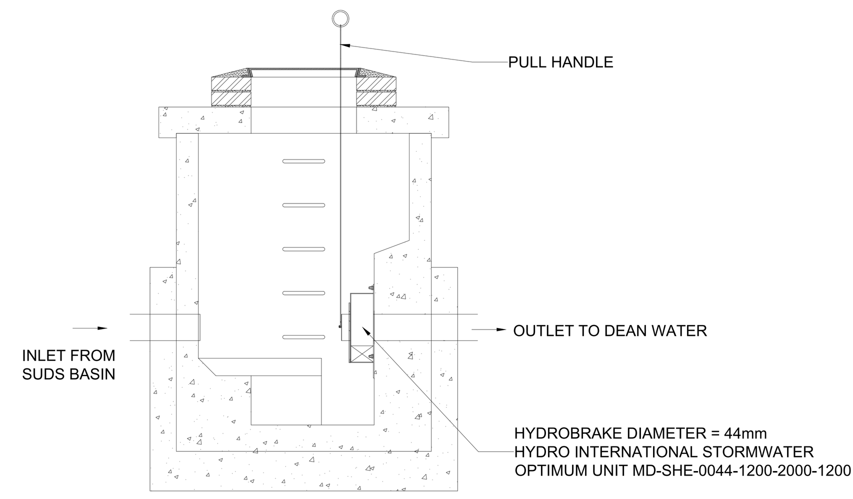
CLASS 'Z' PIPE BEDDING & BACKFILLING DETAIL
NTS
PIPES WHERE COVER TO CROWN IS LESS THAN 1200MM UNDER ROADS AND FOOTPATHS



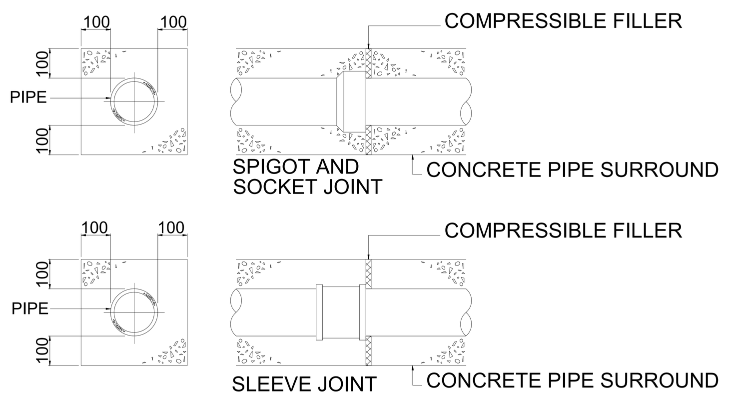
PRECAST CONCRETE ANGLED OUTLET HEADWALL - UP TO 300mm Ø
(ALTHON A4CA LH OR SIMILAR)
NTS



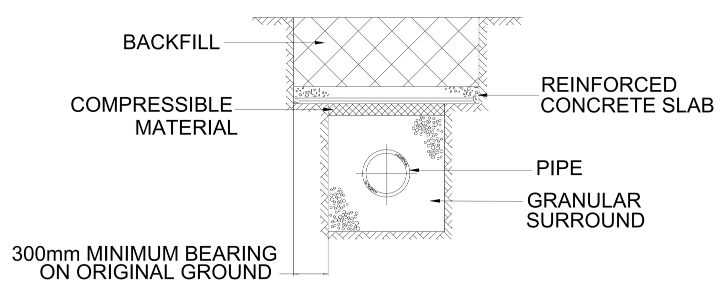
TYPICAL INSPECTION CHAMBER DETAIL (GRAVEL SURROUND - NON-TRAFFICKED AREAS)
NTS



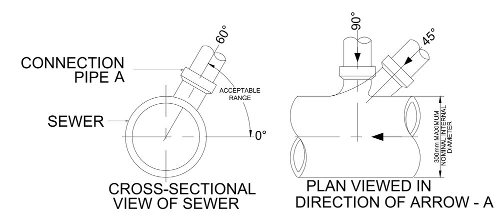
HYDROBRAKE OPTIMUM CHAMBER
NTS



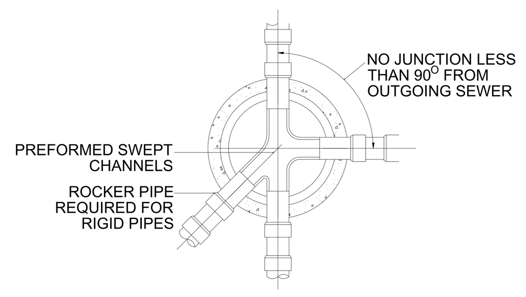
JOINTS FOR CONCRETE ENCASED PIPES
NTS



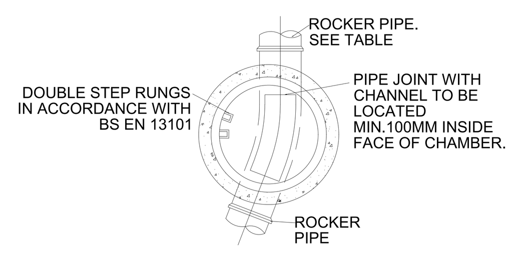
ALTERNATIVE PIPE PROTECTION DETAIL
NTS



BRANCH SEWER CONNECTION DETAIL
NTS



TYPICAL MANHOLE ARRANGEMENT OF PIPE JUNCTIONS
NTS



PLAN ON MANHOLE
NTS

NOTE: RIGID PIPES BUILT INTO MANHOLES SHALL HAVE A FLEXIBLE JOINT AS CLOSE AS FEASIBLE TO THE EXTERNAL FACE OF THE STRUCTURE AND THE LENGTH OF THE NEXT ROCKER PIPE SHALL BE AS IN THE TABLE BELOW

MIN ROCKER PIPE LENGTH

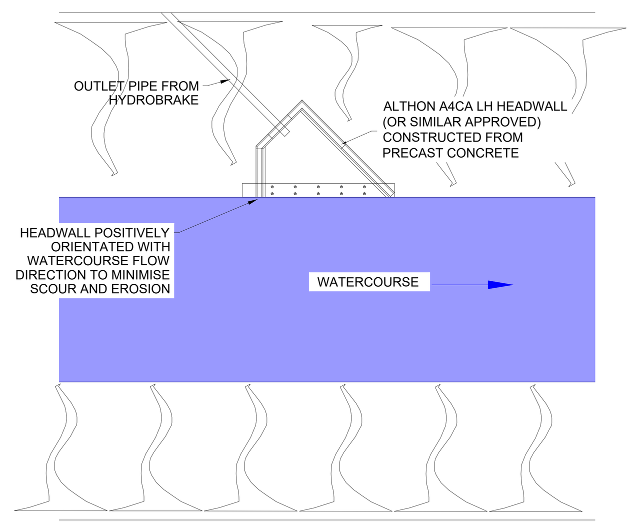
NOMINAL DIAMETER(mm)	L(mm)
150 to 600	600
over 600 to 750	1000
over 750	1250

INTERNAL DIAMETER OF MANHOLE

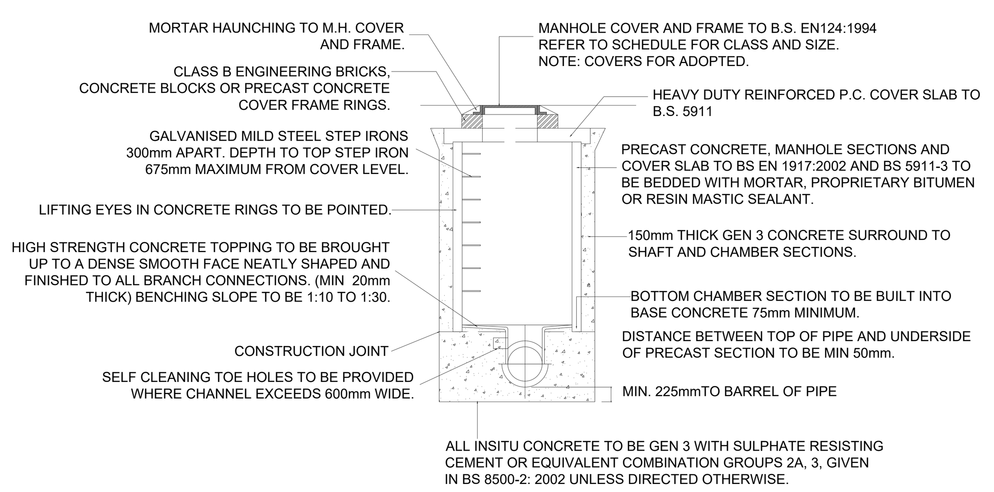
DIAMETER OF LARGEST PIPE IN MANHOLE (MM)	INTERNAL DIAMETER OF MANHOLE (MM)
LESS THAN 375	1200
375 to 450	1350
500 to 700	1500
750 to 900	1800
>900	PIPE DIAMETER +900

INTERNAL DIAMETER OF INSPECTION CHAMBERS

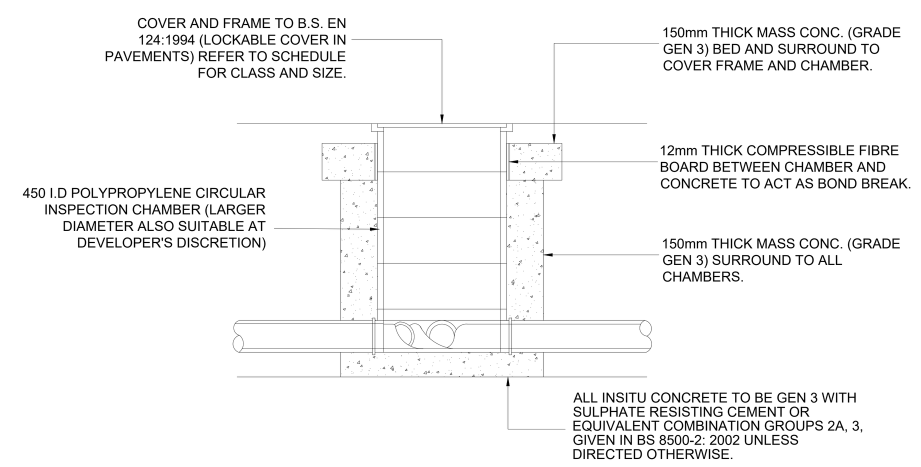
DIAMETER OF LARGEST PIPE IN MANHOLE (MM)	DIAMETER OF INSPECTION CHAMBER (MM)
LESS THAN 160	450
160 to 300	600
300 to 450	750



SURFACE WATER OUTLET DETAIL
NTS



TYPICAL MANHOLE CHAMBER
NTS



TYPICAL INSPECTION CHAMBER DETAIL
NTS

N

NOTES
1. REFER TO DRAWING FRDA-004 FOR DRAINAGE LAYOUT OVERVIEW.
2. DETAILS SHOWN ARE OUTLINE DETAIL AND SUBJECT TO REVISION AT THE DETAILED DESIGN STAGES

REV	DATE	DESCRIPTION	BY	CHK
00	04/25	INITIAL ISSUE	GD	SD

CLIENT: TRIO POWER LIMITED

PROJECT: COSSANS SOLAR & BESS

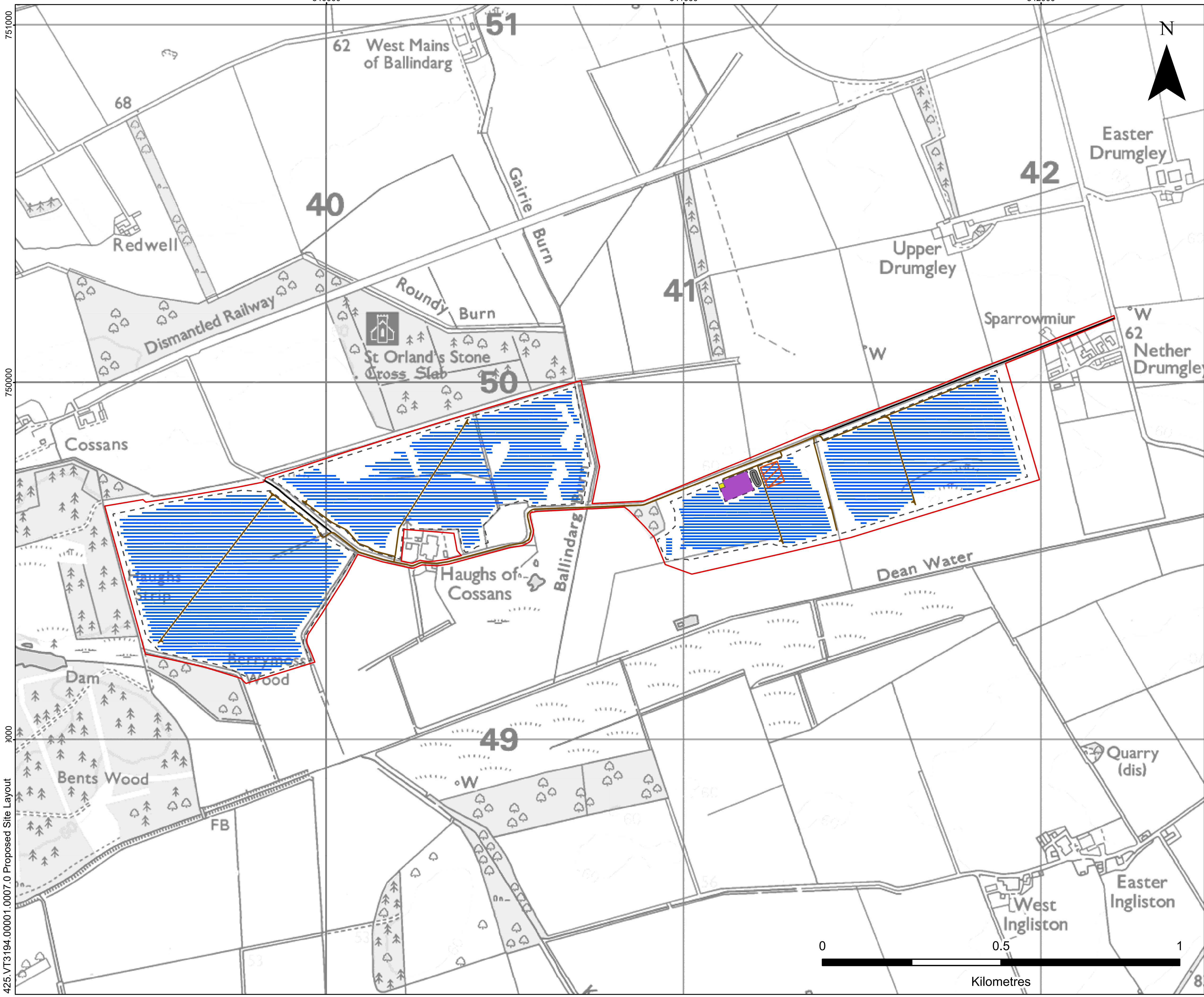
DRAWING TITLE: **TYPICAL DRAINAGE DETAILS**

SCALE: AS STATED @ A0
DATE: APRIL 2025

DRAWING NUMBER: **FRDA-007**
REV: **00**

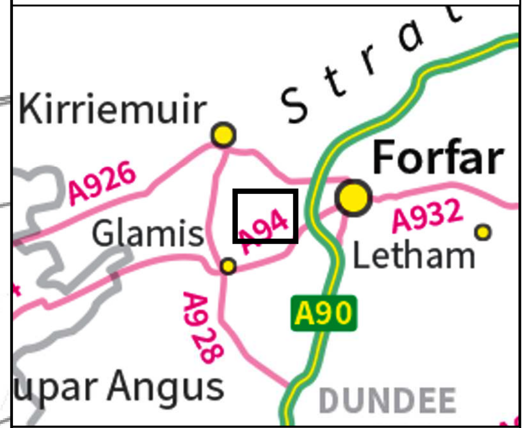
DRAWING STATUS: FOR PLANNING

GONDOLIN LAND & WATER LTD
15 Quayside Street
Edinburgh
EH6 6EJ
Registered Company No. SC706920



LEGEND

- Site Boundary
- Solar PV Module
- Battery Energy Storage System (BESS)
- Substation
- Sustainable Drainage System (SuDS)
- Temporary Construction Compound
- Security Fence
- Access Track
- Existing Track



trio

SLR

COSSANS SOLAR & BESS

FRDA

PROPOSED SITE LAYOUT

FRDA - 008

Scale 1:10,000 @ A3

Date MAY 2025

425.VT3194.00001.0007.0 Proposed Site Layout

Civil Engineering and Environmental Solutions

Gondolin Land and Water Ltd is a small, client friendly environmental and civil engineering consultancy business based in Scotland with coverage throughout the UK.

Office Address:

15 Quayside Street, Edinburgh, EH6 6EJ, UK

Registered Company No.

SC706920

Sectors:

Onshore Renewables & Storage | Infrastructure | Mining and Minerals | Rural Tourism & Recreation | Property & Urban Regeneration | Corporate, Industrial & Manufacturing | Waste Management