Corran Rèile
Flood Risk Assessment

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1 INTRODUCTION

1.1 Terms of Reference

EnviroCentre Limited has been commissioned by Aberfeldy Development Trust to undertake a flood risk assessment (FRA) for a proposed new housing development on the site of a former slaughterhouse in Aberfeldy. This report updates a previous report prepared by EnviroCentre in May 2024 for the same site, accounting for amended development proposals and site extents.

1.2 Scope of Report

The aim of the study is to assess flood risk to the proposed development from all sources. The report presents detailed assessment of potential fluvial flood risk to the site from the Tom Chulan watercourse, which runs northwards along the western perimeter of the site, as well as from an unmapped channel which runs along the southern perimeter of the site, noting that the flood risk from both features is not accounted for in SEPA flood mapping.

1.3 Report Usage

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1.4 Terminology & Glossary

There are two ways of expressing the likelihood of a flood event with a certain magnitude: one is quantifying as a percentage using the concept of Annual Exceedance Probability (AEP) and the other method is to express flood risk using the concept of Return Period (RP) measured in years. The relationship between AEP and RP is presented in Appendix A. In this report the two concepts are used interchangeably, as appropriate.

The following terminology and abbreviations are used within this report:

CC	Climate change
GIS	Geographic Information System
LiDAR DTM	A digital terrain model (DTM) of gridded ground elevations, obtained by remotely sensed measurements of distance (usually by aircraft) using laser light (LiDAR)
NGR	National Grid Reference; a geographic grid reference system used in the UK, also referred to as British National Grid
mAOD	Elevation, in metres above Ordnance Datum (where the Ordnance Datum is the mean sea level at Newlyn in Cornwall)
NPF4	National Planning Framework 4 (Scottish Government, 2023)
OS	Ordnance Survey
PKC	Perth & Kinross Council
SEPA	Scottish Environment Protection Agency

1.5 Regulatory Framework

1.5.1 National Planning Framework 4 (NPF4)

NPF4 was adopted by Scottish Ministers on 13 February 2023, replacing Scottish Planning Policy (2014). In relation to flood risk and water management, the intent of NPF4 is:

"To strengthen resilience to flood risk by promoting avoidance as a first principle and reducing the vulnerability of existing and future development to flooding."

Where development cannot avoid areas of flood risk, proposals will only be supported if they are for:

i. essential infrastructure where the location is required for operational reasons;

ii. water compatible uses;

iii. redevelopment of an existing building or site for an equal or less vulnerable use; or.

iv. redevelopment of previously used sites in built up areas where the Local Development Plan (LDP) has identified a need to bring these into positive use and where proposals demonstrate that long-term safety and resilience can be secured in accordance with relevant SEPA advice.

In relation to surface water flood risk, development proposals will:

i. not increase the risk of surface water flooding to others, or itself be at risk.

ii. manage all rain and surface water through sustainable urban drainage systems (SuDS), which should form part of and integrate with proposed and existing blue-green infrastructure. All proposals should presume no surface water connection to the combined sewer;

iii. seek to minimise the area of impermeable surface.

For planning purposes, “at risk of flooding” and “in a flood risk area” means land or built form with an annual probability of being flooded of greater than 0.5% which must include an appropriate allowance for future climate change.

1.5.2 SEPA Guidance

SEPA’s *Technical Flood Risk Guidance for Stakeholders* (v13) (SEPA, 2022)[1] details the requirements for undertaking flood risk assessments in relation to proposed developments. These requirements depend upon the complexity of the site, with more complex or high risk sites requiring detailed assessments. In summary, FRAs must include the following:

- Background site data, including suitable plans and/or photographs;
- Historic flood information;
- Description of methodologies used;
- Identification of relevant flood sources;
- In case of river flooding: assessment of river flows, flood levels, depths, extents, displaced flood storage volumes, etc.;
- Assessment of culverts, sewers or other structures affecting flood risk;
- Consideration of climate change impacts;
- Details of required flood mitigation measures; and
- Conclusions on flood risk related to relevant national and local policies.

Technical guidance on Flood Estimation Handbook (FEH) (CEH, 2008) methodologies and on land raising and compensatory storage are also provided as part of this guidance. SEPA require completion of a flood risk assessment checklist to accompany any assessment for which fluvial or coastal flood risk is predicted, with this provided as Appendix B.

1.5.3 Consultation

Consultation with PKC and SEPA was undertaken during progression of the original (2024) flood risk assessment. Email correspondence is included as Appendix C, for reference.

[1] https://www.sepa.org.uk/media/162602/ss-nfr-p-002-technical-flood-risk-guidance-for-stakeholders.pdf

2 SITE DETAILS

2.1 Site Location & Description

The site is located on the eastern periphery of the town of Aberfeldy (Perth & Kinross), opposite the Aberfeldy Caravan Park (Figure 2.1). The site was historically occupied by a slaughterhouse, but is currently unoccupied.

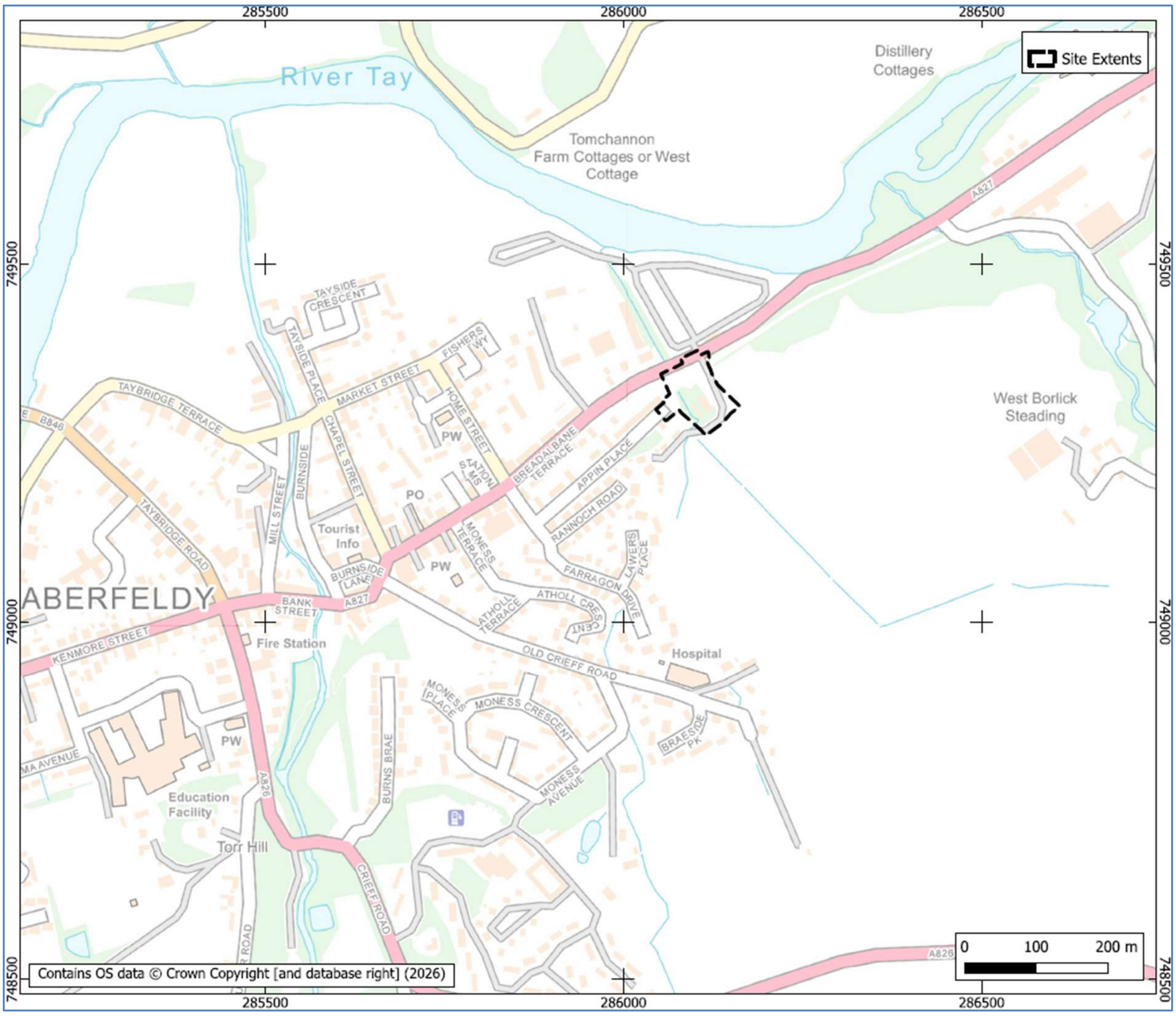


Figure 2.1: Site location

2.2 Proposed Development

The proposed development layout is provided in information accompanying this report as part of the planning application. Proposals entail residential (affordable housing) development and associated infrastructure.

2.3 Topography

Figure 2.2 presents the local topography within and adjacent to the site, based on a rasterised terrain model created from site topographic survey undertaken in 2023 extended using LiDAR for Scotland Phase 1 DTM data (2011-12) beyond the survey extents. This data indicates:

- A general topographic fall from south to north, towards the River Tay.
- Ground levels within the site vary between approximately 85 to 93 mAOD, with the Tom Chulan watercourse deeply incised upstream of the A827 culvert inlet.
- Land downstream (north) of the culvert inlet is embanked relative to land further north and south, corresponding with a former east-to-west running railway embankment. The existing site access road connects to the A827 via an underpass through this embankment, towards the north-eastern corner of the site.

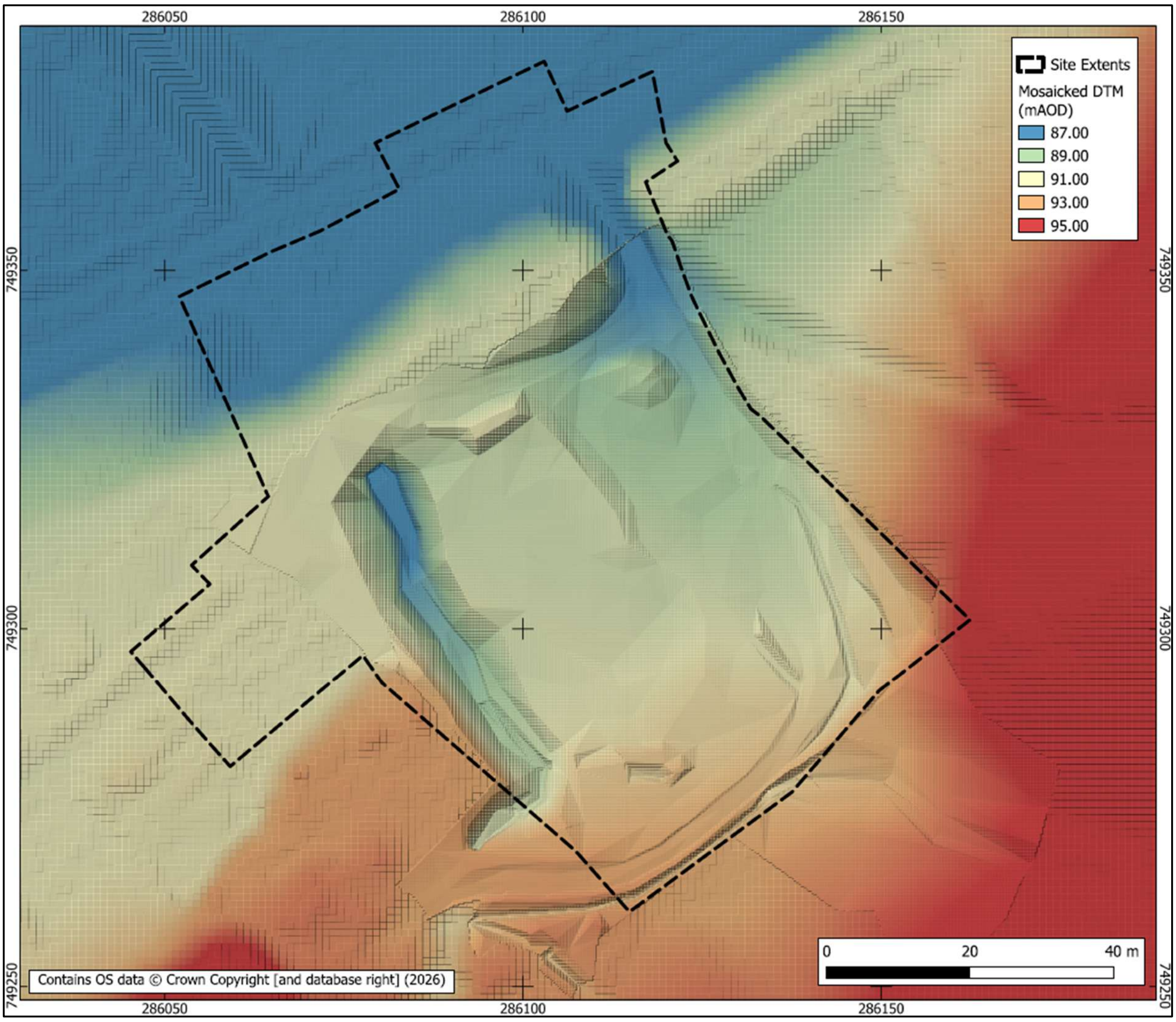


Figure 2.2: Site topography, based on site topographic survey supplemented with LiDAR DTM

2.4 Flooding History

Consultation with PKC noted no records of flooding at the site, although due to no existing housing within or overlooking the site any flooding incidents are unlikely to have been observed and reported.

3 FLOOD RISK SCREENING

SEPA's technical guidance (SEPA, 2022) advises that a site-specific FRA should be undertaken where any available information indicates there may be a risk of flooding (from any source) to the site, and/or where the development of the site may increase flood risk elsewhere. Where a site-specific FRA may be required, screening will determine the scope of the assessment and may also be used to inform an appropriate and proportionate approach for the assessment.

3.1 Land Use Vulnerability Classification

The proposed development will comprise residential development and associated infrastructure, replacing a currently vacant/derelict site. Residential development is classified as a Highly Vulnerable usage under SEPA's *Flood Risk and Land Use Vulnerability Guidance* (2024), with this proposed development increasing the vulnerability classification of the site compared to current use.

NPF4 specifies that development, with exception of essential infrastructure, water compatible usages and redevelopment which does not increase the vulnerability classification, must avoid flood risk areas, which are defined as areas at risk of flooding from a 1 in 200 year plus climate change event. Proposed development does not satisfy any of these exceptions, such that development must be demonstrated to avoid flood risk areas.

3.2 Flood Protection Schemes

There are no known formal or informal flood protection schemes with the potential to impact flood risk to the proposed development site.

3.3 Screening By Source

3.3.1 Fluvial Flood Risk

A minor watercourse, known as the Tom Chulan watercourse, runs northwards through the western half of the site, discharging into the River Tay approximately 200 m to the north of the site. Based on site observation, local knowledge and aerial photography, a minor unmapped channel or land drain runs towards the site from the south-east, entering a ditch that runs along the southern edge of the existing site access road which forms the eastern and southern perimeter of the site; this watercourse/drain is conveyed by culvert under the site to discharge into the Tom Chulan watercourse. These minor watercourses (including their culverted sections) are denoted in Figure 3.1, with the River Tay running approximately west to east to the north of the site.

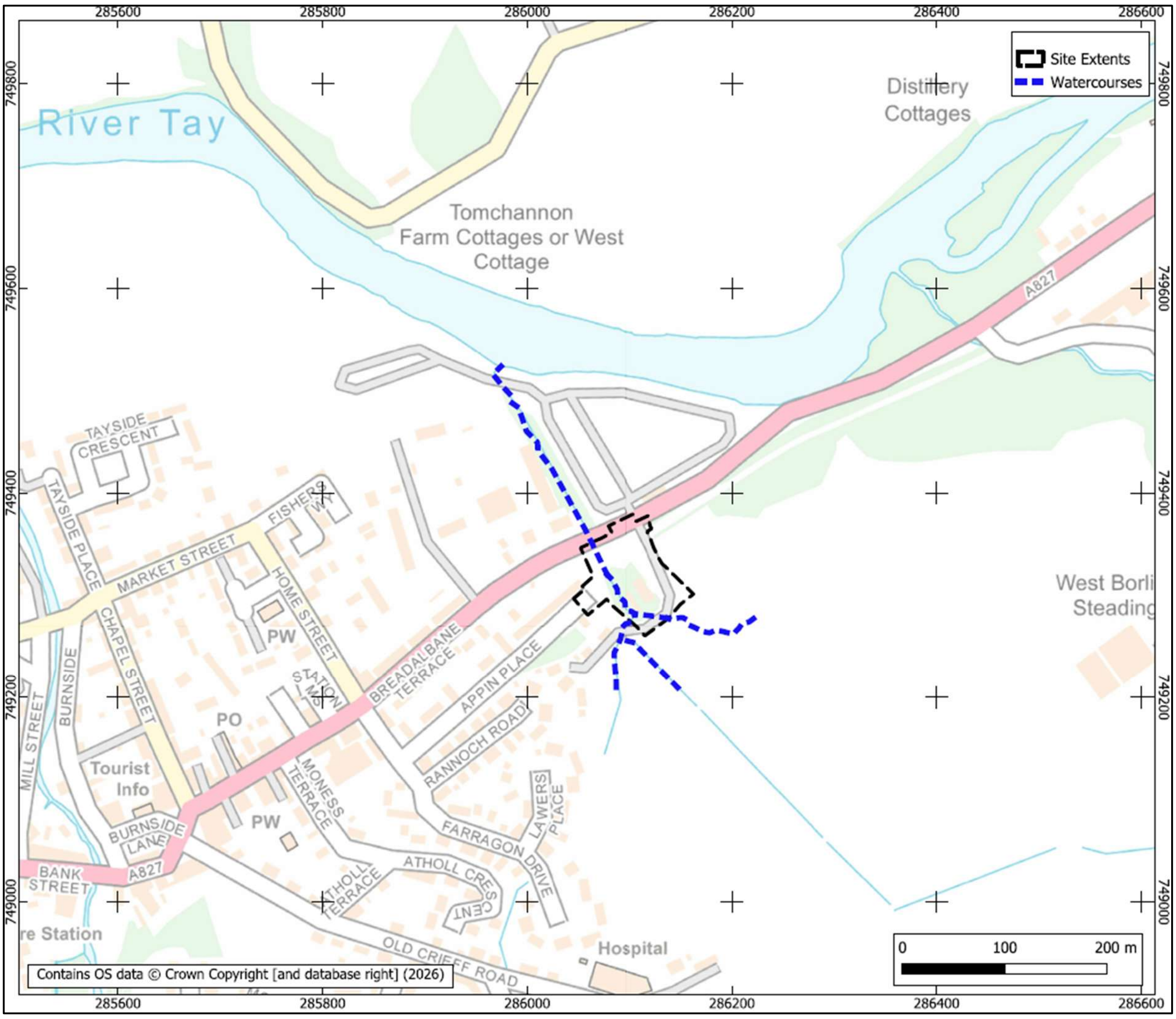


Figure 3.1: Water features in the site vicinity

SEPA's "Future River Medium Likelihood" flood map[2], which represented approximate 1 in 200 year plus climate change conditions, indicates that flood risk from the River Tay inundates the section of the A827 within the northern part of the site, with more extensive intrusion at the Tom Chulan watercourse and where the existing site access meets the A827. Flood risk from the Tom Chulan watercourse, and from the unmapped channel/drain to the south-east of the site, are not accounted for in SEPA's fluvial flood mapping.

Perth & Kinross Council have provided flood predictions obtained from their 2018 Aberfeldy Flood Study, with Figure 3.2 presenting an overlay comparison of predicted flood extents from this study compared to SEPA's mapping, noting that predictions obtained from detailed local modelling are generally considered to be more reliable than SEPA's (indicative) mapping. The Aberfeldy Flood Study predictions indicate that land to the north of the former railway embankment (where no dwellings are proposed) is at risk of direct flooding from the River Tay, with additional flood risk to the south of this embankment from the Tom Chulan watercourse, due to incapacity or backup at or upstream of the A827 culvert inlet. This is predicted to result in spill over the eastern bank of the watercourse, which discharges eastwards towards the existing site access road underpass (as shown on the cover page photograph of this report) and onto the A827.

[2] https://map.sepa.org.uk/floodmaps/

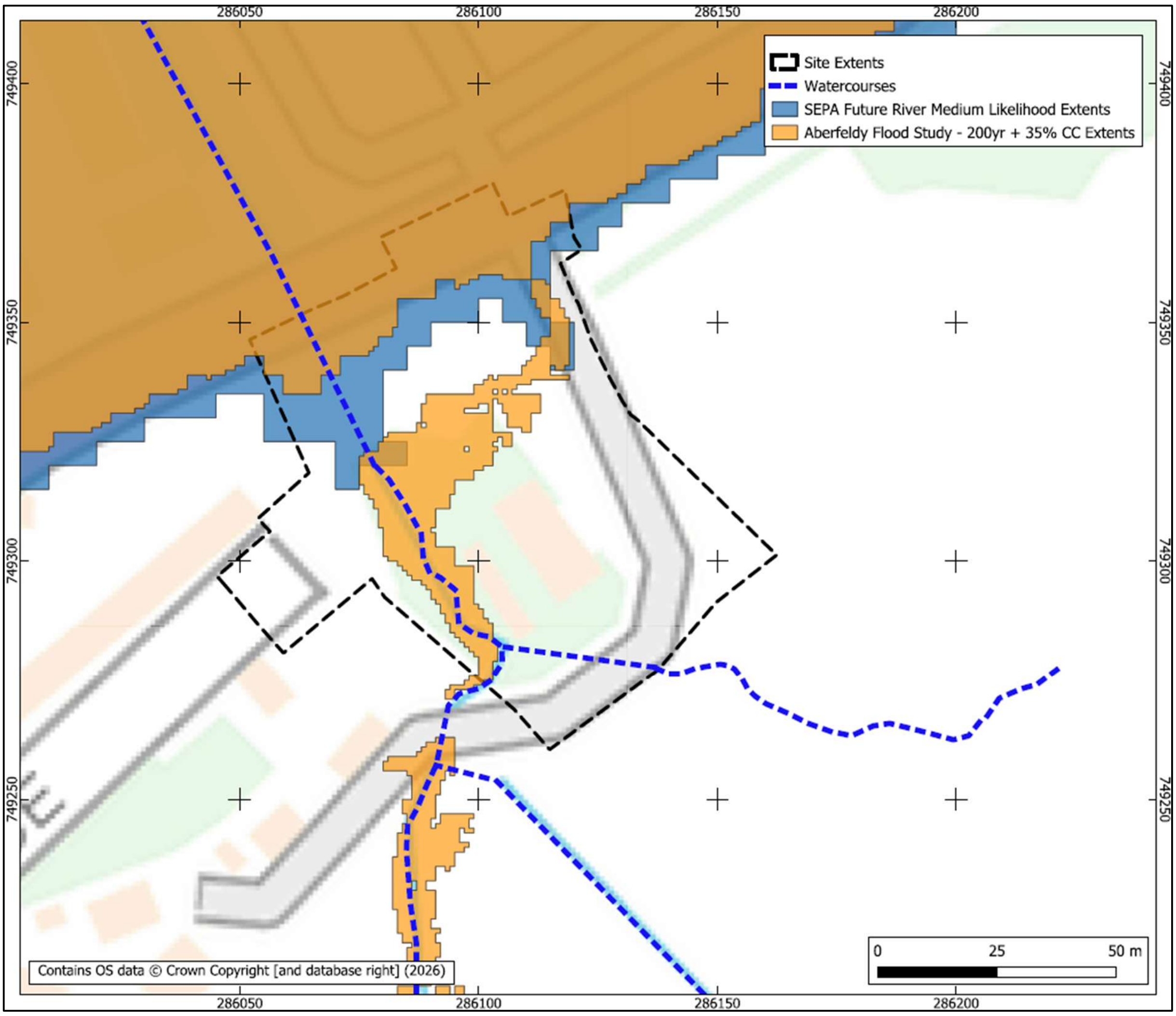


Figure 3.2: Comparison of pre-existing fluvial flood predictions

Neither SEPA mapping nor the Aberfeldy Flood Study account for potential flood risk to the site from the unmapped channel/drain to the south-east of the site. SEPA have confirmed, through consultation, that flood risk to the site associated with all three watercourses should be assessed in further detail.

3.3.2 Coastal Flood Risk

Minimum site levels exceed 80 mAOD. On this basis, coastal flood risk to the site can be scoped out.

3.3.3 Surface Water Flood Risk

SEPA Flood Maps indicate surface water flood risk impacting a majority of the site. Flood risk in the western portion of the site is actually fluvial in nature, associated with the Tom Chulan watercourse (which has an associated catchment area of less than 3 km^2 and is therefore not accounted for in SEPA's fluvial mapping). Likewise, flood risk in the eastern portion of the site is associated with the minor unmapped channel spilling through the site, northwards along the existing site access road through the underpass and beyond.

Overland flowpath and local topographic depression analysis was undertaken using GIS analysis based on the mosaicked ground model described in Section 2.3, with outcomes presented in Figure 3.3. Analysis outcomes indicate that:

- Overland flow is generally south to north, as per the general direction of topographic fall.
- Overland flows from south and immediately east of the site will flow northwards along the existing site access road, exiting the site via the underpass towards the A827.
- If the incised channel of the Tom Chulan watercourse overtops (due to extreme high flow and/or surcharge of the downstream culvert), flows will spill eastwards towards the underpass.
- Excepting the Tom Chulan watercourse channel and drainage channel along the southern site boundary, there are no significant topographic depressions within the site.

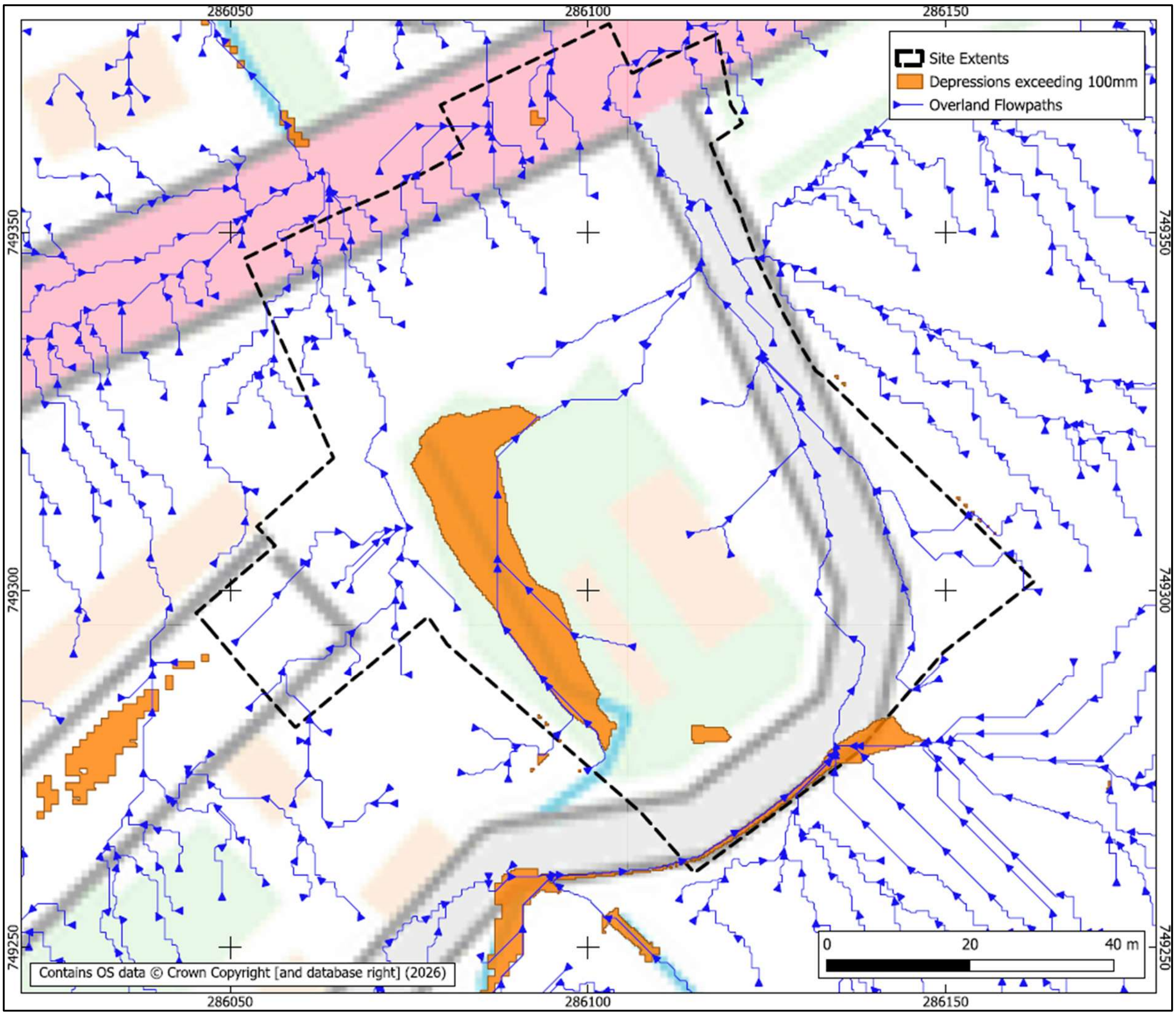


Figure 3.3: Overland flowpath and topographic depression analysis

The central area of the site, where dwellings will be located, will only be at risk from "simple" surface water flood risk associated with locally-generated runoff, provided fluvial flood risk is acceptably low or else can be appropriately managed. Simple surface water flood risk will be adequately managed by SuDS-compliant site drainage provision. On this basis, further site-specific investigation of surface water flood risk is not required.

3.3.4 Asset Failure Flood Risk

As stated in Section 3.2, there are no known formal flood risk management assets in the vicinity of the site capable of directly impacting flood risk at the site.

SEPA's Reservoir Inundation Map[3] indicates that the adjacent reach of the River Tay may be impacted by reservoir embankment failure/breach from Loch Tay, Loch Lyon, Loch An Daimh and Farleyer Loch. In all cases, reservoir failure would result in additional discharge into the River Tay, potentially contributing to peak flood flows, levels and extents. SEPA's mapping suggests that failure/breach of the Loch Lyon embankment poses the greatest risk to Aberfeldy and the site. It is noted that SEPA's Reservoir Inundation Map presents a worst-case scenario, with the risk of failure of an appropriately inspected and maintained reservoir being extremely low.

3.3.5 Groundwater Flood Risk

Groundwater flooding, as a primary source, is uncommon in Scotland, due to the nature of the underlying geology. Groundwater levels tend to correspond with water levels in adjacent watercourses and seas, and will not pose an independent flood risk to the development site.

3.3.6 Screening Summary

Table 3.1 presents the flood risk screening outcomes for the development site. Further assessment is required in relation to fluvial flood risk only, with risk posed from all other sources determined to be acceptably low.

[3] http://map.sepa.org.uk/reservoirsfloodmap/Map.htm

Table 3.1: Summary of flood risk scoping

Flooding Source	Preliminary Risk Classification	Comments/Explanation	Screening Outcome
Fluvial (River)	Medium to High Risk	Existing information suggests that the site map be at risk of flooding from the Tom Chulan watercourse; this risk may be exacerbated by high water levels in the adjacent reach of the River Tay. Flood risk posed by the unmapped channel is unknown.	Requires site-specific assessment. See Section 4.
Coastal	No risk	Site elevations exceed 80 mAOD.	Acceptable risk
Surface Water (Pluvial & Drainage)	Low Risk	SEPA Flood Maps indicate surface water flood risk, but this is associated with the Tom Chulan watercourse and unmapped channel. GIS analysis indicates the site is only at risk from “simple” surface water flooding associated with locally-generated runoff, which (as per standard requirements) will be managed by SuDS-compliant site drainage provision.	Acceptable risk
Infrastructure/Asset Failure	Little or no risk	No formal flood protection assets in vicinity. Failure/breach of Loch Lyon may pose a risk to the site, but the associated likelihood is very low.	Acceptable risk
Groundwater	Little or no risk	Low risk due to site location and elevation.	Acceptable risk

4 FLUVIAL FLOOD RISK ASSESSMENT

Site-specific assessment of flood risk posed by the Tom Chulan watercourse and unmapped channel was undertaken based on 1D-2D hydraulic modelling of these watercourses and their associated floodplains. Flood risk associated with the River Tay was assessed through sensitivity analysis associated with the downstream boundary assumption.

4.1 Hydrology

4.1.1 Catchment Delineation

The Tom Chulan watercourse is delineated in the FEH online database[4] to a point a short distance upstream of its confluence with the River Tay (at NGR 286000, 749450) to have a catchment area of 1.54 km^2. This preliminary catchment extent was modified based on overland flowpath analysis of the LiDAR for Scotland Phase 1 DTM, to:

- Include an additional catchment area to the east of Mains of Croftness, along the western edge of the catchment extent, which OS mapping indicates drains into a tributary stream of the Tom Chulan watercourse.
- Include an additional catchment area near Pitilie, along the eastern edge of the catchment extent, which overland flowpath analysis indicates drains towards the unmapped channel south-east of the site.
- Make other minor refinements around the upstream (southern) extremities of the catchment extent, to reflect overland flowpath analysis outcomes.

The revised catchment area, which covers the Tom Chulan watercourse and unmapped channel, is 1.64 km^2. The FEH and amended catchment extents are presented in Figure 4.1. The amended catchment extent was subsequently divided into subcatchments to separate the unmapped channel from the Tom Chulan watercourse, and to account for the catchment area upstream of each culvert within the modelled reach of the Tom Chullan watercourse; subcatchments employed in subsequent modelling are presented in Figure 4.2.

[4] https://fehweb.ceh.ac.uk/Map

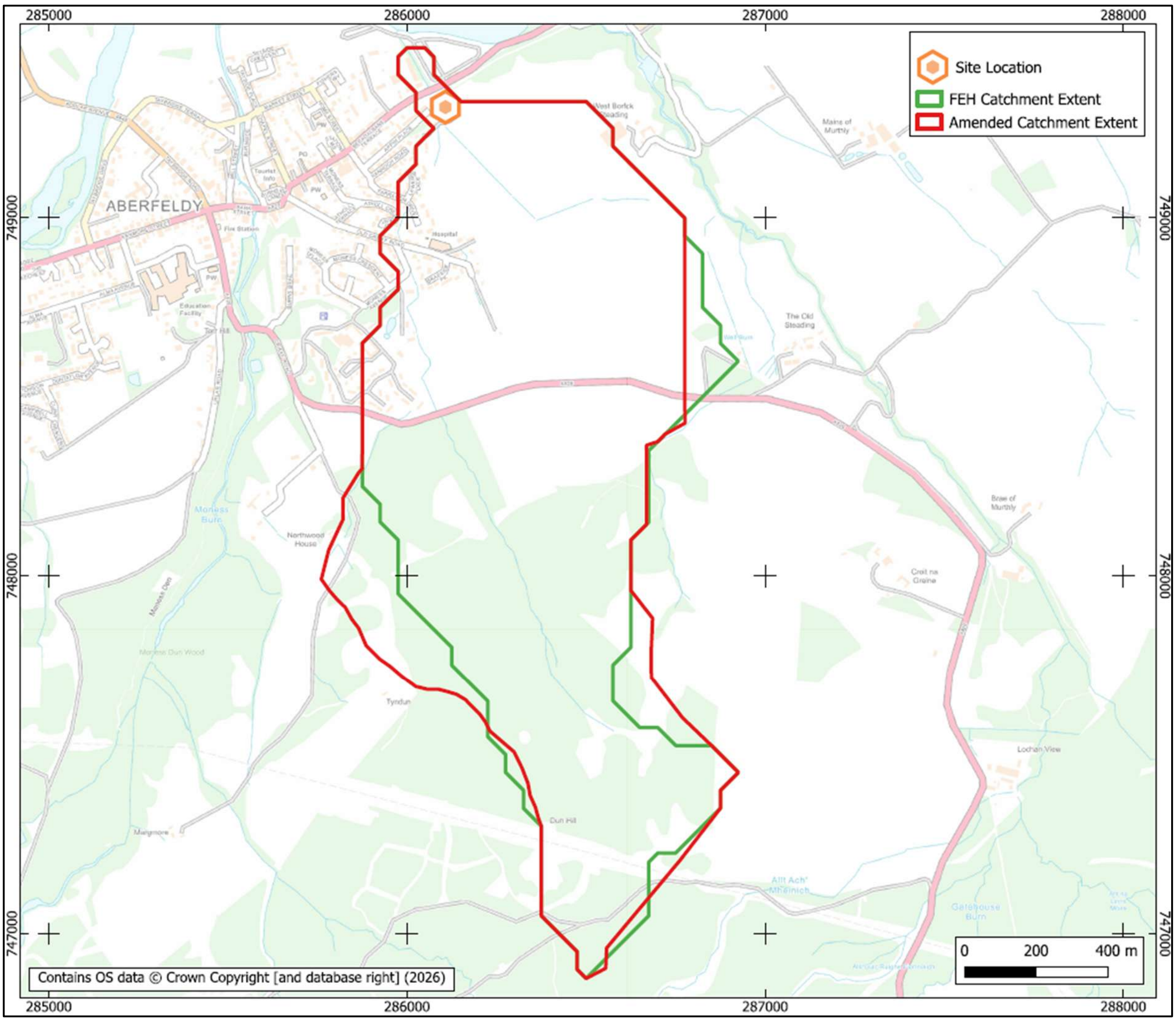


Figure 4.1: Catchment delineation

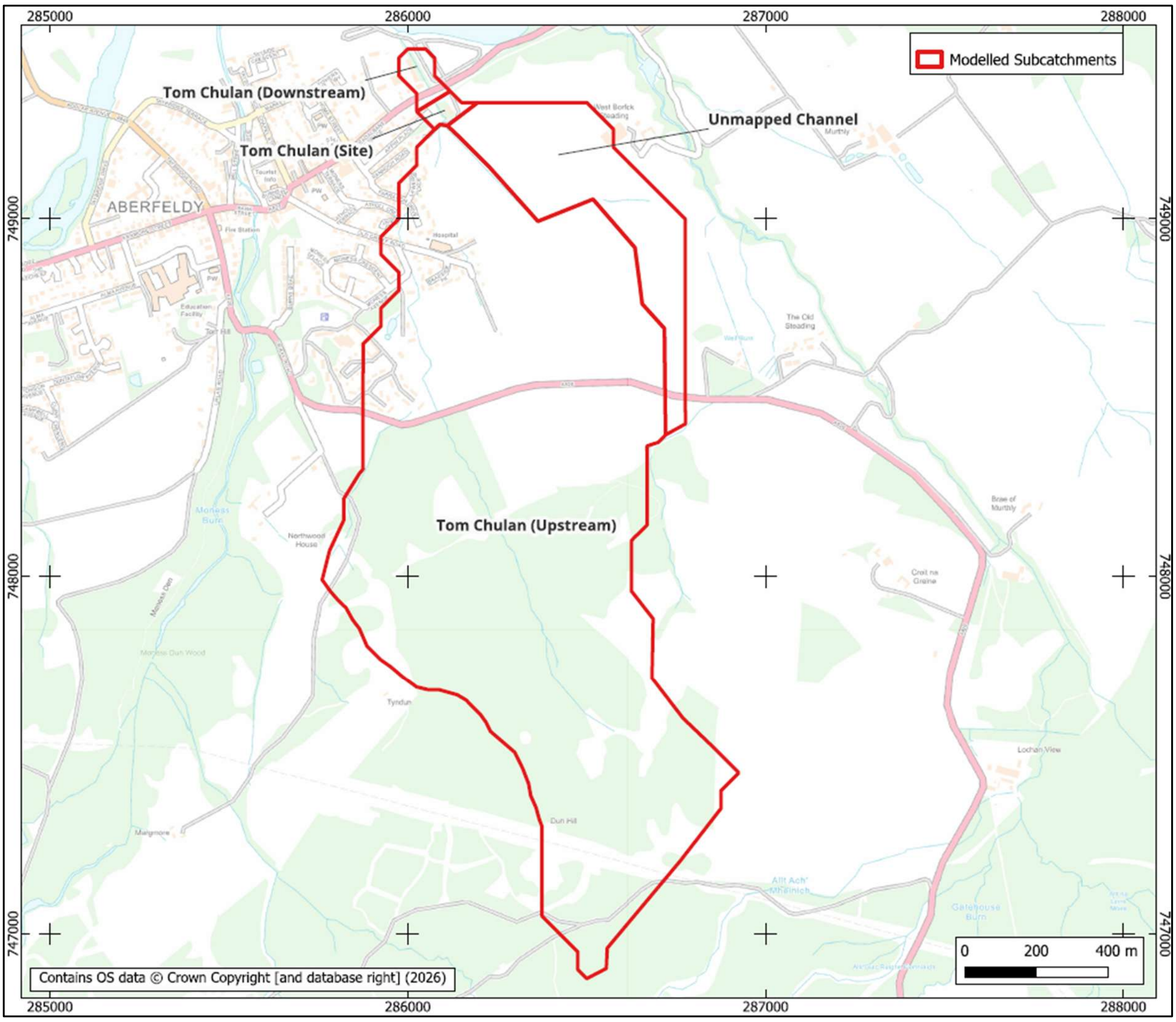


Figure 4.2: Subcatchments used in modelling

4.1.2 Hydrological Assessment

The Tom Chulan watercourse is a small ungauged watercourse. Design flows for the FEH catchment were estimated using two different flood estimation methods: the Revitalised Flood Hydrograph Method, version 2 (ReFH2) using the Scotland-specific calibration parameters (WHS, 2015a, 2015b) and FEH22 design rainfall data, and the FEH Rainfall-Runoff (FEH RR) method using FEH99 rainfall data.

SEPA's (2025) climate change guidance[5] advises that a 39% uplift should be applied to design rainfall to account for climate change to the year 2100 for small (< 30 km^2) watercourse catchments in Tay River Basin Region. Peak flow estimates for the 1 in 200 year event, with and without climate change, for the FEH delineated catchment are summarised in Table 4.1. The estimates presented in the table indicate that the FEH RR method provides precautionary estimates of design flows; based on guidance, the FEH RR method is therefore used in modelling.

[5] https://www.sepa.org.uk/media/jjwpxuso/climate-change-allowances-guidance_v6.pdf

Table 4.1: Design peak flow estimates (m^3/s) for the FEH catchment

Catchment	200 year event		200 year plus climate change event	
	FEH RR	ReFH2	FEH RR	ReFH2
FEH Delineated (1.54 km^2) Catchment	3.19	2.37	4.77	3.49

The FEH99 design rainfall depth for the amended total catchment area (1.64 km^2) is 47.74 mm for the critical 2.4 hour duration event for the 1 in 200 year event, increasing to 66.36 mm when uplifted by 39% to account for climate change. This rainfall depth and duration has been retained, along with all other catchment descriptors other than area, to generate design input for each modelled subcatchment, as summarised in Table 4.2.

Table 4.2: Design peak flow estimates (m^3/s) for subcatchments used in modelling

Catchment	Area (ha)	200 year	200 year + climate change
Tom Chulan (Upstream)	143.45	3.032	4.537
Tom Chulan (Site)	0.83	0.018	0.026
Tom Chulan (Downstream)	1.38	0.029	0.044
Unmapped Channel	18.38	0.389	0.582

4.2 Model Construction

4.2.1 One-Dimensional Model Setup

Cross-sectional surveying of the local reach of the Tom Chulan watercourse and its structures, extending from a short distance upstream of the existing site access road culvert to downstream of the A827, was undertaken in 2023 and used to inform the 1D model build. Additional sections, covering the reach of the Tom Chulan watercourse within the site, have been cut from a site DTM created from fine-scale site topographic survey. Sections representing the unmapped channel have been cut from either the LiDAR for Scotland Phase 1 DTM (in the upstream reaches) or from the site DTM (in the downstream reaches adjacent to the existing site access road).

The model represents 3 culvert structures (Figure 4.3):

- Culverting of the Tom Chulan watercourse under the existing site access road, at the south-western corner of the site, via a masonry rectangular culvert (1.47 m wide x 1.81 m high) which transitions to a masonry arch culvert (0.99 m wide, with 0.89 m springing height and 0.48 m crown height) along its 9.3 m length.
- Culverting of the Tom Chulan watercourse under the A827, with inlet within the site and upstream of the former railway embankment, via a masonry arch culvert (2.32 m wide, with 1.43 m springing height and 0.87 m crown height) which transitions to a masonry rectangular culvert (2.18 m wide x 0.56 m high) along its 43.2 m length.
- Culverting of the unmapped channel through the southern parts of the site to discharge into the Tom Chulan, via a circular pre-cast concrete culvert (650 mm diameter) which transitions to a rectangular masonry culvert (0.64 m wide x 0.39 m high) along its 31.2 m length. Due to unresolvable instability issues associated with this culvert, it is represented as a simple circular orifice in modelling. For unblocked scenarios, it is represented as a circular orifice with equivalent flow area to the minimum (rectangular) dimension (i.e. with a diameter of 563

mm), while blockage is assumed to cause a 50% reduction in the flow area of the upstream (circular) section (i.e. 460 mm diameter).

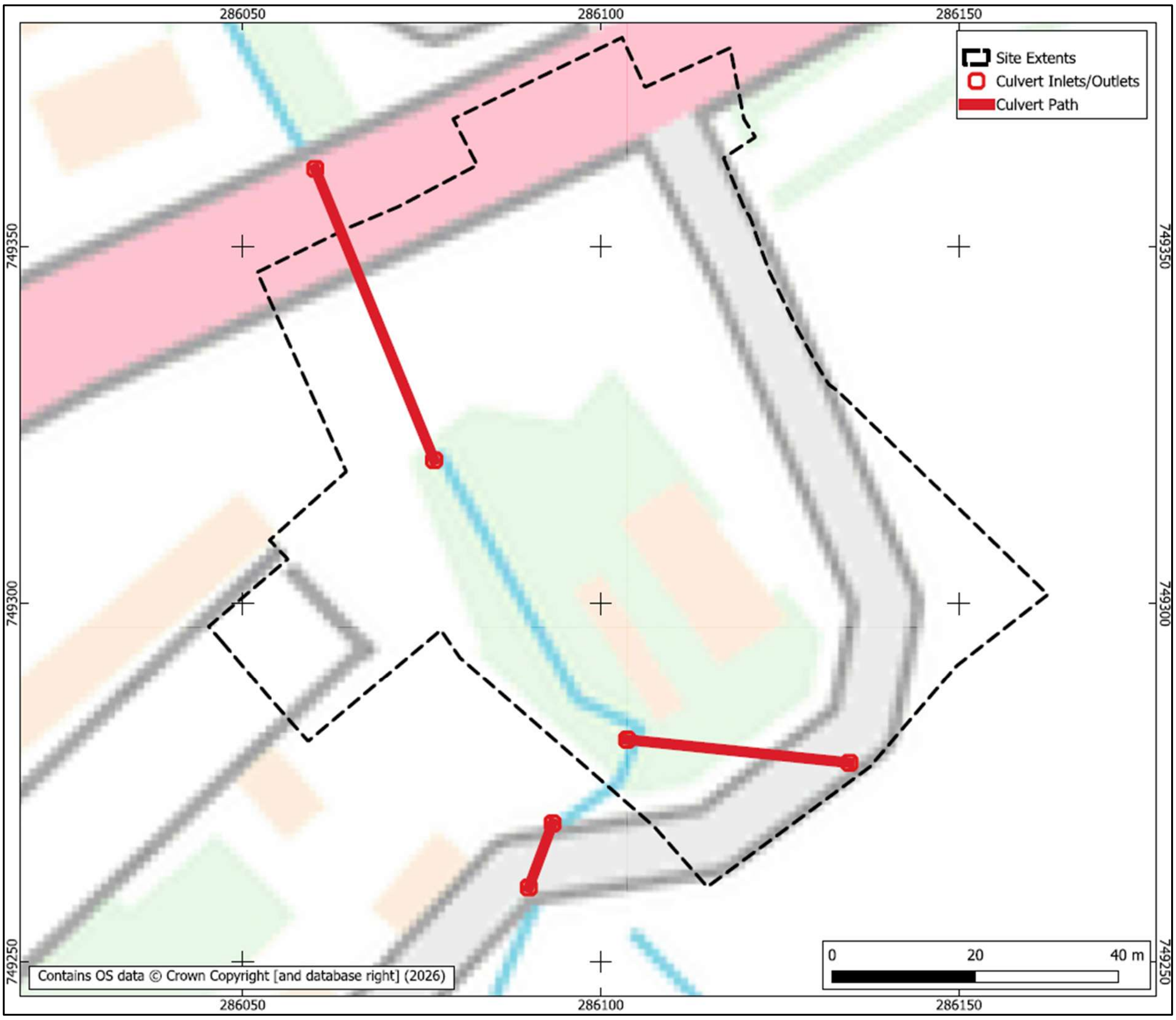


Figure 4.3: Culverts within the model extent

The unmapped channel rises towards its western end (refer to the long section bed profile presented in Appendix F), with bed elevations at the western end of the reach more than 1.5 m above bed levels in the adjacent section of the Tom Chulan watercourse; the two watercourses are connected in the model using an irregular weir spill unit, allowing hydraulic connection between the two watercourses when water levels in either watercourse exceed 92.379 mAOD (based on a local maxima in surveyed bed levels in the unmapped channel in this location).

4.2.2 Two-Dimensional Model Setup

The site and floodplain were represented as a 2D domain, using ground elevations obtained from site topographic survey extended using LiDAR DTM data (as per Figure 2.2). The domain extents were derived iteratively to ensure that the lateral (eastern and western) extents of predicted flooding remain clear of the model boundary. The southern floodplain of the unmapped channel is higher lying than the northern floodplain and is not represented in the model.

4.2.3 1D-2D Linkage

The 1D and 2D domains are linked at 1D domain edges; the location of the domain edges is based on straight-line joining of 1D section ends, with the 1D-2D link line elevations based on 1D section end elevations.

4.2.4 Roughness

Within the 1D domain, a Manning's roughness of 0.05 is used for all in-bank areas, with a value of 0.07 used for out-of-bank areas. A uniform roughness of 0.07 was assumed for the 2D domain.

4.2.5 Boundary Conditions

Within the 1D domain, inflows are applied at 4 locations:

- Tom Chulan (Upstream) flows are applied at the upstream end of this watercourse within the model (at section XS_01).
- Tom Chulan (Site) flows are applied immediately downstream of the existing site access road culvert outlet (at section XS_05).
- Tom Chulan (Downstream) flows are applied immediately downstream of the A827 culvert outlet (at section XS_07).
- Unmapped Channel flows are applied at the upstream end of this watercourse within the model (at section South_000).

A normal depth downstream boundary, based on local bed gradient, is applied by default to the 1D domain, although sensitivity scenarios consider the impact of a high water level boundary (to represent the potential impact of high River Tay levels upon flooding behaviour).

A normal depth 2D boundary condition is also applied along the northern boundary of the 2D domain, using an arbitrary 0.1 (1:10) gradient.

4.2.6 Model Schematic & Run Parameters

A simplified schematic of the 1D-2D model representing the existing (pre-development) site is presented in Figure 4.4.

Modelling employs a 1 m grid resolution in the 2D domain, with a 0.5 s 2D timestep and 2 s 1D timestep.

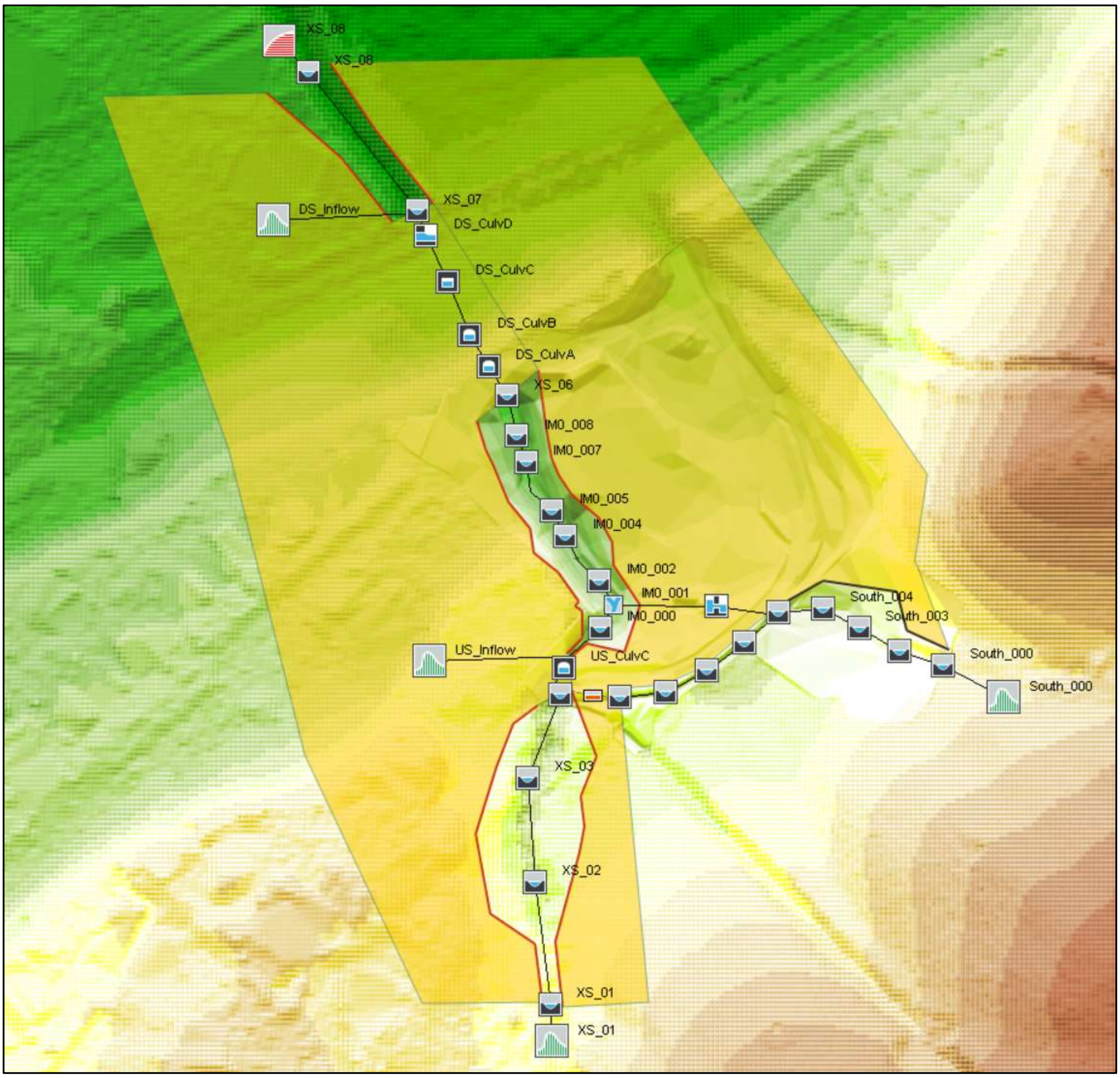


Figure 4.4: Simplified schematic of the pre-development model

4.3 Model Scenarios

Table 4.3 presents the scenarios modelled to assess flood risk to the site, including standard sensitivity scenarios. For planning purposes, flood risk assessment is primarily based upon predictions obtained for Scenario B, accounting for partial blockage of all culvert structures; all sensitivity scenarios are therefore assessed relative to this scenario.

Table 4.3: Evaluated scenarios

Scenario	Description	Purpose
A	1 in 200 year plus climate change event	Design flood event
B	Scenario A, with 50% blockage of all culverts	SEPA require consideration of partial structure blockage when defining flood extents.

Scenario	Description	Purpose
C	Scenario B, with 20% global increase in (1D and 2D) roughness	Standard roughness sensitivity scenario.
D	Scenario B, with 20% increase in inflows	Standard sensitivity scenario.
E	Scenario B, with downstream boundary set to fixed high level (87 mAOD)	Assess sensitivity of predictions to very high levels in the River Tay (noting that the Aberfeldy FPS estimates the 200 year plus climate change peak water level of 86.65 mAOD at the Tom Chulan confluence).

4.4 Model Predictions

4.4.1 Flood Predictions for the Pre-Existing Site

Peak predictions for all state variables (i.e. flowrate, stage, Froude number and velocity) for all scenarios are presented in Appendix D, with peak water level predictions presented in Table 4.4. Peak flood depth and extent predictions for Scenarios A and B are presented in Figure 4.5 and Figure 4.6, respectively, while Figure 4.7 indicates the worst-case sensitivity scenario extents relative to Scenario B extents. Time varying Scenario B predictions of stage within the reach of the Tom Chulan watercourse through the site, as well as selected sections of the unmapped channel, are presented in Appendix E. Long sections of Scenario B predictions of peak stage for each modelled watercourse reach are presented in Appendix F.

Model predictions are summarised as follows:

- Flows are not predicted to overtop the eastern bank or intervening ground in the local reach of the Tom Chulan watercourse for all scenarios, with a freeboard of at least 760 mm achieved between peak water levels and crest levels. As such, the site is not predicted to be at direct flood risk from the local watercourse reach.
- However, the site is at risk of flooding due to surcharge of the two culverts under the existing site access road to the south of the site, with surcharge flows spilling northwards over the road and through the site. For Scenario A, only the smaller eastern culvert is predicted to surcharge and cause flooding; for all other scenarios, both culverts surcharge causing flooding which inundates the majority of the site to small depths (as per Figure 4.6), with flows discharging from the site via the underpass at the existing site entry (with a smaller amount of flooding to the west of the Tom Chulan channel spilling overland over the A827 and back towards the watercourse).
- Surcharge of the Tom Chulan culvert under the existing site access road, at the south-western corner of the site, generates water levels which are high enough to cause backflow in the unmapped channel, with flow from west to east adding to inflows from the unmapped channel catchment and contributing to flooding around the smaller eastern culvert; this is illustrated in the peak stage profile presented in Appendix F.
- Predictions are not particularly sensitive to uncertainty in assumed roughness values, with a 20% increase in roughness (Scenario C) associated with an increase in peak 1D water levels of 100 mm or less and negligible changes to 2D flood extents.
- A fixed very high water level at the downstream boundary (Scenario E) significantly increases peak water levels within the Tom Chulan reach within the site without causing bank overtopping in this reach, with negligible impact upon 2D flood extents.

- A 20% increase in inflows (Scenario D) is predicted to increase peak 1D water levels by 133 mm or less. This scenario has the greatest impact upon predicted 2D flood extents of all the sensitivity scenarios, but this impact remains minor.
- For Scenarios A and B, peak flow velocities for the Tom Chulan reach through the site vary between 2-3.5 m/s; the range is similar for Scenario D. Increased roughness (Scenario C) and high downstream water levels (Scenario E) reduce this range to between 2-3 m/s.
- Model predictions are generally stable, with small-scale instability in the unmapped channel (likely due to steep gradients have relatively low flow depths), and around the peak in some sections (usually associated with slight numerical oscillation in 1D-2D flow transfers) (Appendix E). These minor instabilities will not have a bearing upon predicted outcomes.

Table 4.4: Predicted peak water levels (mAOD) for all scenarios, with bank or intervening ground crest levels beyond the eastern bank of the Tom Chulan watercourse within the site indicated. Highlighted rows correspond to the reach of the Tom Chulan watercourse through the site.

Label	Bank/Intervening Ground Crest Level	A (200yr+CC)	B (Blockage)	C (Roughness)	D (Flow)	E (River Tay)
XS_01		94.617	94.619	94.695	94.696	94.619
XS_02		93.441	93.451	93.519	93.513	93.451
XS_03		93.073	93.246	93.278	93.282	93.246
XS_04		93.077	93.272	93.282	93.312	93.272
XS_05	93.022	91.717	91.701	91.801	91.834	91.701
IM0_000	93.196	90.994	90.965	91.039	91.036	90.965
IM0_001	91.893	90.533	90.492	90.558	90.548	90.492
IM0_002	90.880	90.085	90.062	90.111	90.108	90.062
IM0_003	90.674	89.600	89.572	89.627	89.621	89.572
IM0_004	90.522	89.163	89.128	89.192	89.184	89.130
IM0_005	90.674	88.862	88.833	88.882	88.871	88.879
IM0_006	90.579	88.241	88.215	88.268	88.266	88.737
IM0_007	90.427	87.654	87.654	87.707	87.740	88.765
IM0_008	90.197	87.363	87.469	87.489	87.561	88.770
XS_06	90.597	87.165	87.460	87.447	87.571	88.768
XS_07		84.853	84.806	84.895	84.881	87.033
XS_08		84.458	84.411	84.498	84.487	87.000
South_000		95.264	95.268	95.281	95.281	95.268
South_002		94.298	94.300	94.312	94.312	94.301
South_003		93.314	93.318	93.329	93.329	93.318
South_004		92.613	92.641	92.651	92.650	92.641
South_005		92.590	92.628	92.631	92.635	92.628
South_009		93.039	93.214	93.240	93.249	93.214
South_010		93.077	93.272	93.282	93.312	93.272
South_006		92.640	92.718	92.730	92.741	92.718
South_007		92.819	93.016	93.039	93.036	93.016
South_008		92.950	93.096	93.114	93.105	93.096

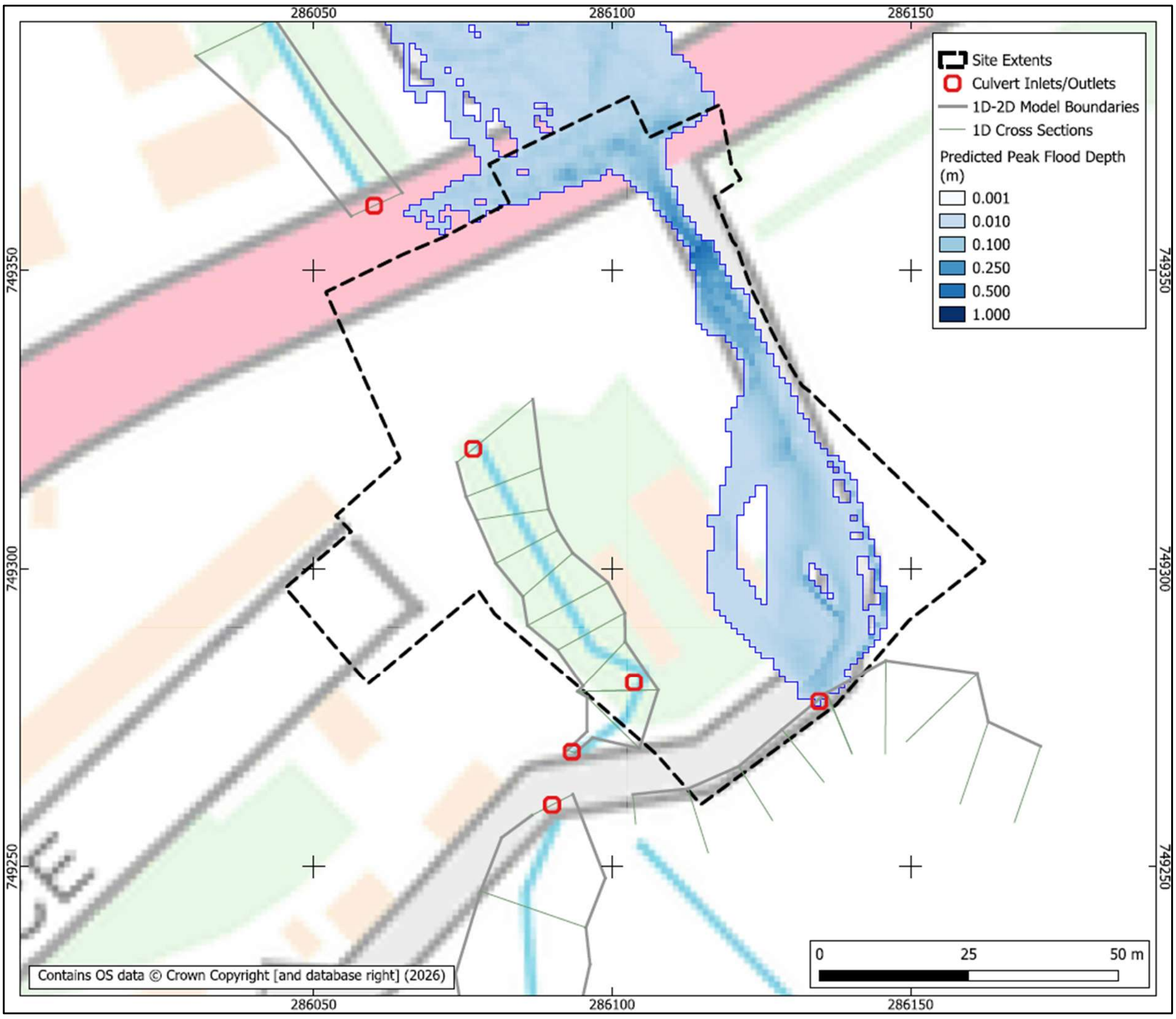


Figure 4.5: Predicted peak flood depths and extents (Scenario A)

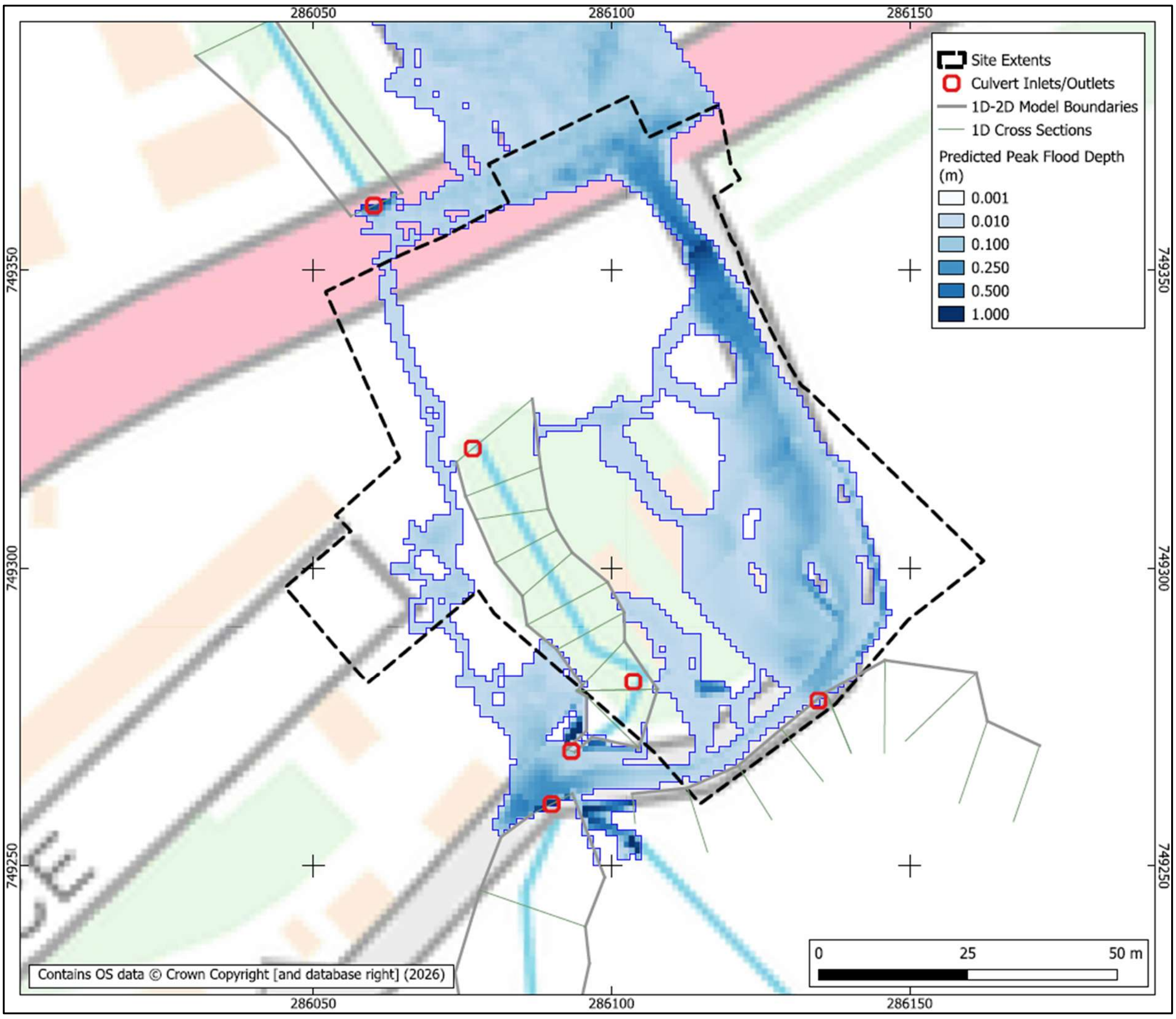


Figure 4.6: Predicted peak flood depths and extents (Scenario B)

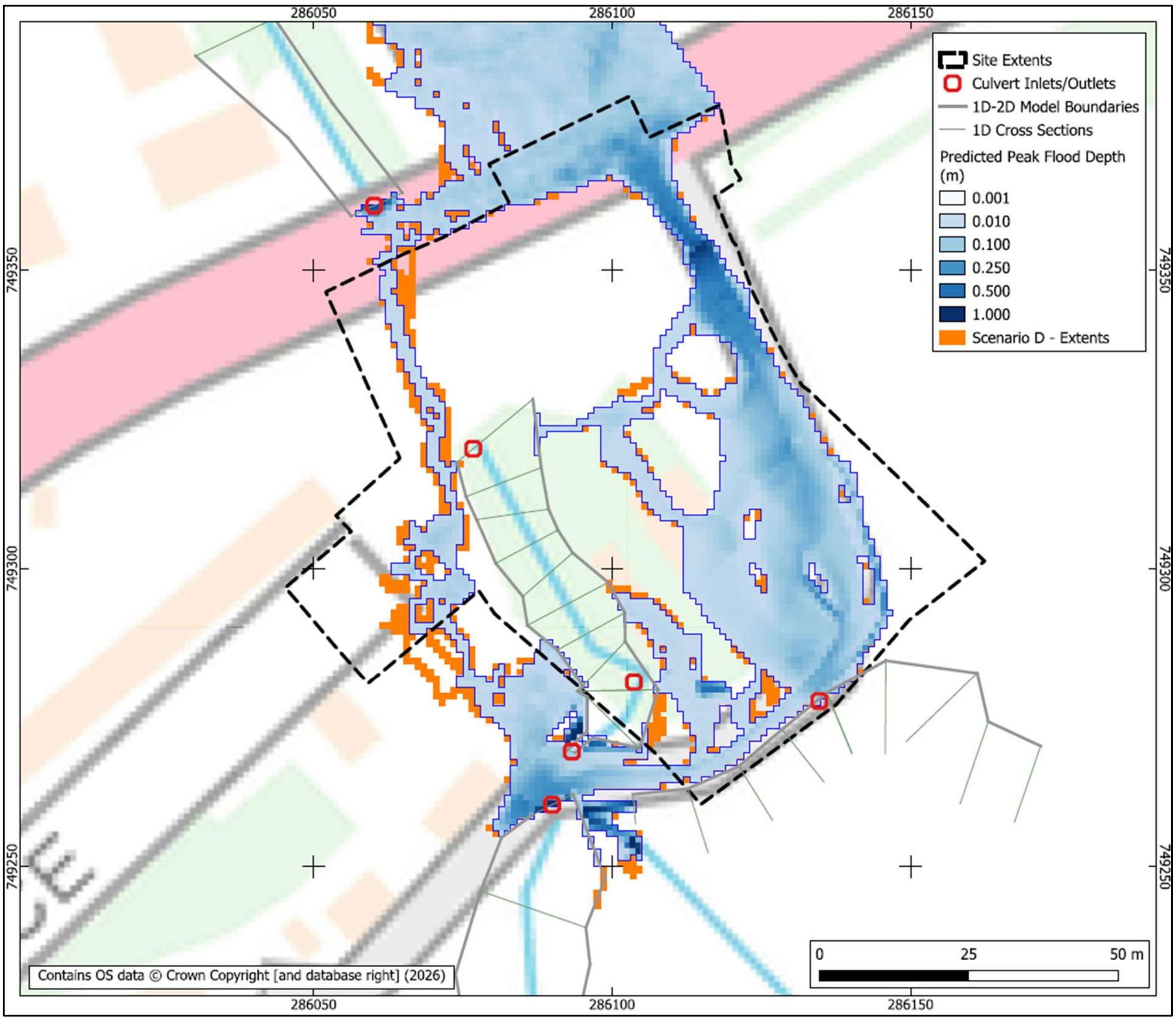


Figure 4.7: Predicted peak flood depths and extents (Scenario B) with overlay of the worst-case sensitivity scenario extents (Scenario D)

4.4.2 Mass Balance

The reported mass balance error for the Scenario B run is 1.03% (-10 m^3 volume error) for the combined 1D-2D model, with a 0.2% of peak (-1.3 m^3 volume error) within the 1D domain. These errors are acceptably low and will have negligible impact upon flood predictions.

4.4.3 Implications for Development & Consultation

Scenario B provides the best estimate of the flood risk area (as defined under NPF4) in relation to fluvial flooding, predicting that the majority of the site is at flood risk, primarily due to insufficient culvert capacity. If not managed, this flood risk would preclude development of the site.

Based on preliminary model predictions, consultation with SEPA was sought, with a response provided by Jessica Taylor on 30 August 2023. SEPA's position is summarised as follows:

- Where culvert upgrades are proposed to manage flood risk to the site, the FRA should show how such mitigation reduces flood risk for a range of blockage scenarios, including 25%, 50%, and 75%. Any increase in downstream flood risk must be shown to be negligible.
- Although the River Tay is not expected to provide a flood risk to the site, it could cause the Tom Chulan watercourse to back up via the culvert under the A827. It may also cause the existing site access road to be inaccessible for vehicles. Information regarding the flood risk to the site for each of these issues should be provided in the FRA (noting that this issue is addressed via Scenario E).
- Flood risk associated with the unmapped channel along the southern boundary of the site (at that time described as a channel) must be assessed as part of the FRA (noting that this has been addressed in subsequent revisions to the model build).
- No development should occur over culverts, and an appropriate maintenance buffer should be retained either side of culverts. Ideally, culverts should be daylighted as part of development where feasible to do so.

Based on teleconferencing consultation with Gavin Bissett of PKC on 25 January 2024, the principle of managing flood risk to the site via amendments to culverting arrangements is accepted by the Council.

4.5 Mitigation Design & Modelling

4.5.1 Constraints & Selection of a Preferred Mitigation Concept

Additional flow capacity under the section of the existing site access road that forms the southern perimeter of the site is needed to resolve predicted flooding. The following considerations impact the choice and location of mitigation measures:

- Following discussion with the landowner, amendment/upsizing of the existing Tom Chulan culvert under the existing site access road, at the south-western corner of the site, is not viable, nor is creation of a secondary culvert within land to the west of the site.
- The smaller eastern culvert cuts across the site, and may constrain development proposals for the site. There is, therefore, a desire to deprecate and remove this culvert.
- Discussion with the landowner to the south of the site confirms that works aimed at managing flood risk, and improving flow conveyance under the existing site access road, are acceptable.

Based on these considerations, the preference is to install a new culvert under the existing site access road to the east of the existing Tom Chulan watercourse culvert, within the site boundary (Figure 4.8). The level of the existing site access road falls appreciably from west to east, favouring a culvert placed as close as possible to the western boundary of the site in order to ensure sufficient cover between the culvert soffit and road surface. Noting that the bed levels of the unmapped channel rise at its western end, regrading (lowering) of the bed levels to achieve a consistent westwards fall towards the new culvert will also be required.

4.5.2 Model Representation of Mitigation

The following amendments are made to the pre-development 1D model:

- The existing culvert at section South_005 of the unmapped channel was removed.
- The bed levels of unmapped channel model sections to the west of the existing culvert (i.e. downstream of section South_005) have been lowered by up to 1.2 m to create a consistent westwards fall in this watercourse.
- These sections are assumed to have a 1 m bed width, as part of this reprofiling.
- A box culvert is added at section South_008, connecting to the Tom Chulan watercourse at section IM0_001 (Figure 4.8). As manufactured box culvert units typically have bevelled internal corners, giving an effective flow area slightly below that implied by their internal width and height, the outlet of the culvert is represented in modelling using a rectangular orifice with the appropriate levels and a bore area based on dimensional information taken from manufacturer's information[6].
- Existing site access road levels at the proposed crossing location are slightly above 93 mAOD. Mitigation design was based on an 800 mm internal height box culvert with internal invert level of 91.2 mAOD. Typical wall thicknesses for box culverts vary between 150-250 mm, such that this design will achieve a depth to cover of approximately 750-850 mm. Culverts with a greater than 800 mm internal height may be viable, depending upon anticipated vehicle loading and potential reinforcement above the culvert, but this would be confirmed by the designers at design stage; modelling considers only an 800 mm culvert height.

[6] https://fpmccann.co.uk/portfolio-items/box-culverts/

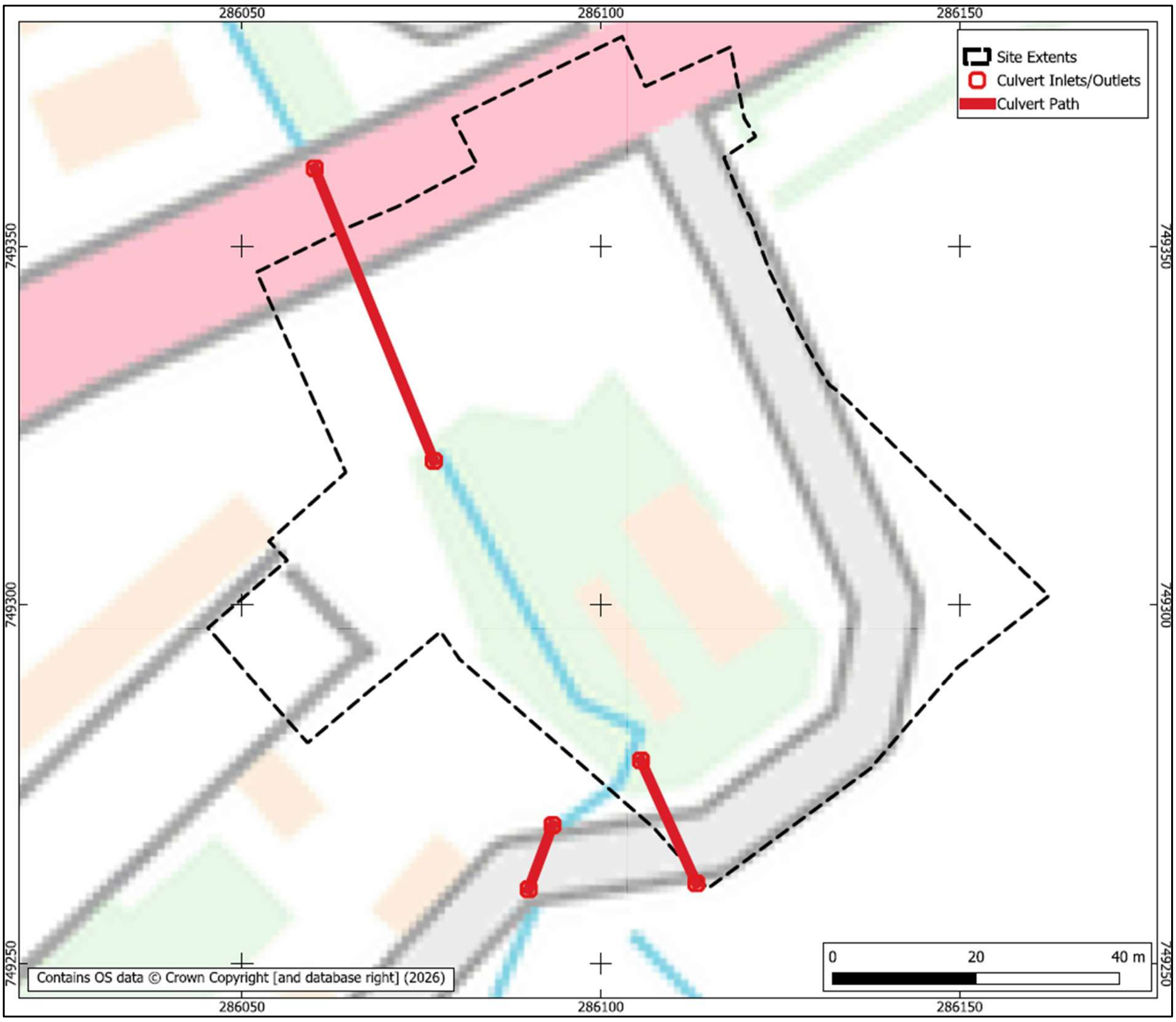


Figure 4.8: Culverts within the model extent for the proposed mitigation design

4.5.3 Mitigation Scenarios & Predictions

Preliminary modelling was undertaken using Scenario B as a basis, inclusive of an assumed 50% blockage of existing culverts. If the proposed new culvert is assumed to be unblocked, of the standard internal widths available for an 800 mm internal height culvert based on manufacturer information[5], a 2,100 mm width culvert was predicted to be the minimum width capable of conveying all flows without causing any 2D flooding.

Subsequent modelling considered the new culvert to also be 50% blocked. Figure 4.9 presents predicted flood extents for culvert widths of 2,100, 2,400, 2,700, and 3,000 mm, noting that a 3,300 mm width culvert is predicted to convey all flows without causing any 2D flooding. With increasing width, the predicted westward extent of 2D flooding flowing northwards through the site reduces, with the 3,000 mm culvert largely restricting flooding to the existing site access road.

As per Section 4.4.3, SEPA also require sensitivity scenarios considering very high culvert blockage. Figure 4.10 presents predicted flood extents for a 3,300 mm width culvert, with all culverts blocked to a high percentage. Where all three culverts within the system are assumed to have 55% blockage, no 2D flooding is predicted. For blockages of 60% and above, progressively more significant 2D flooding is predicted, with blockages of 70% and above predicted to result in flooding to the majority of the site.

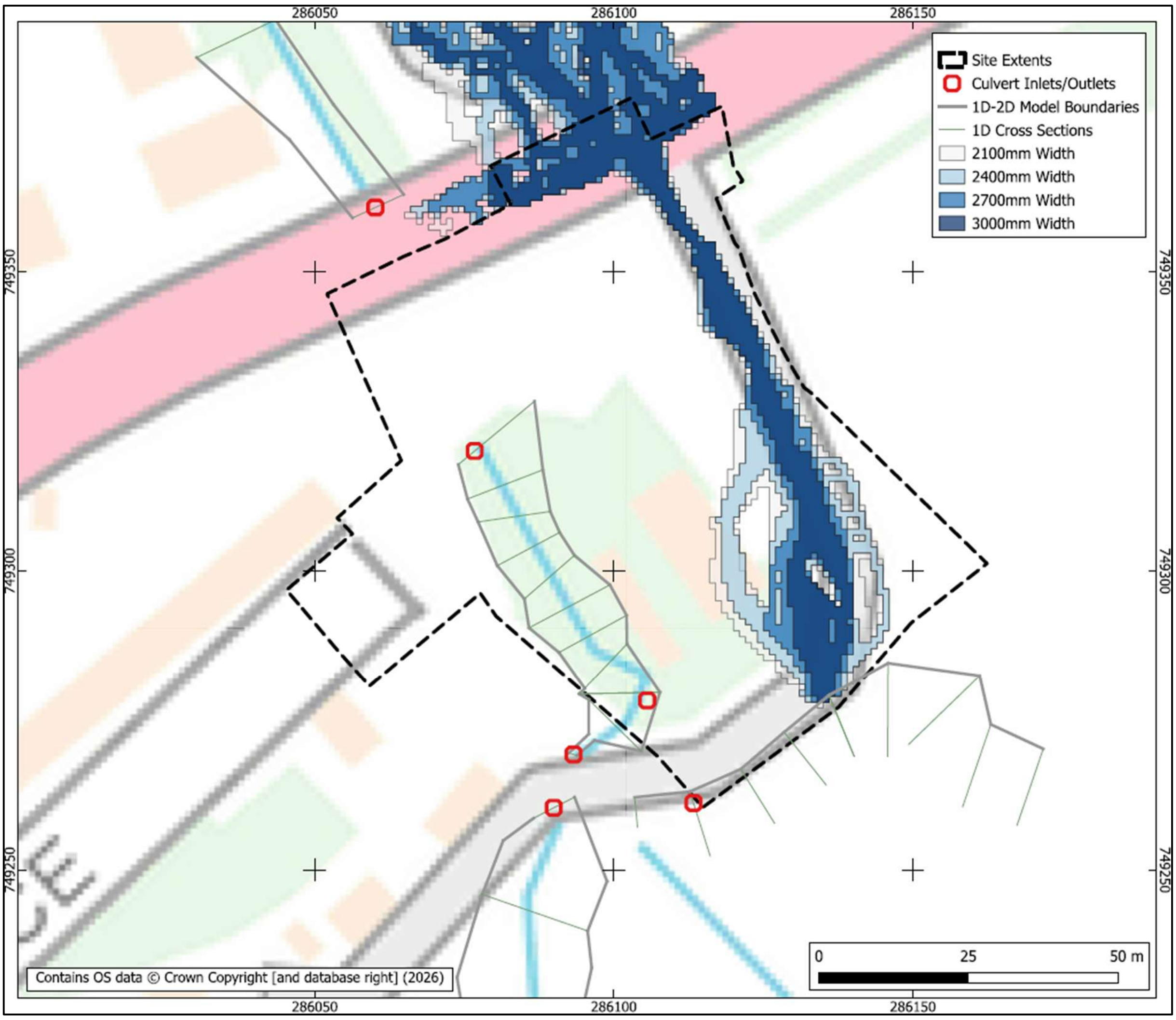


Figure 4.9: Predicted flood extents for varying culvert widths (50% blockage of all culverts)

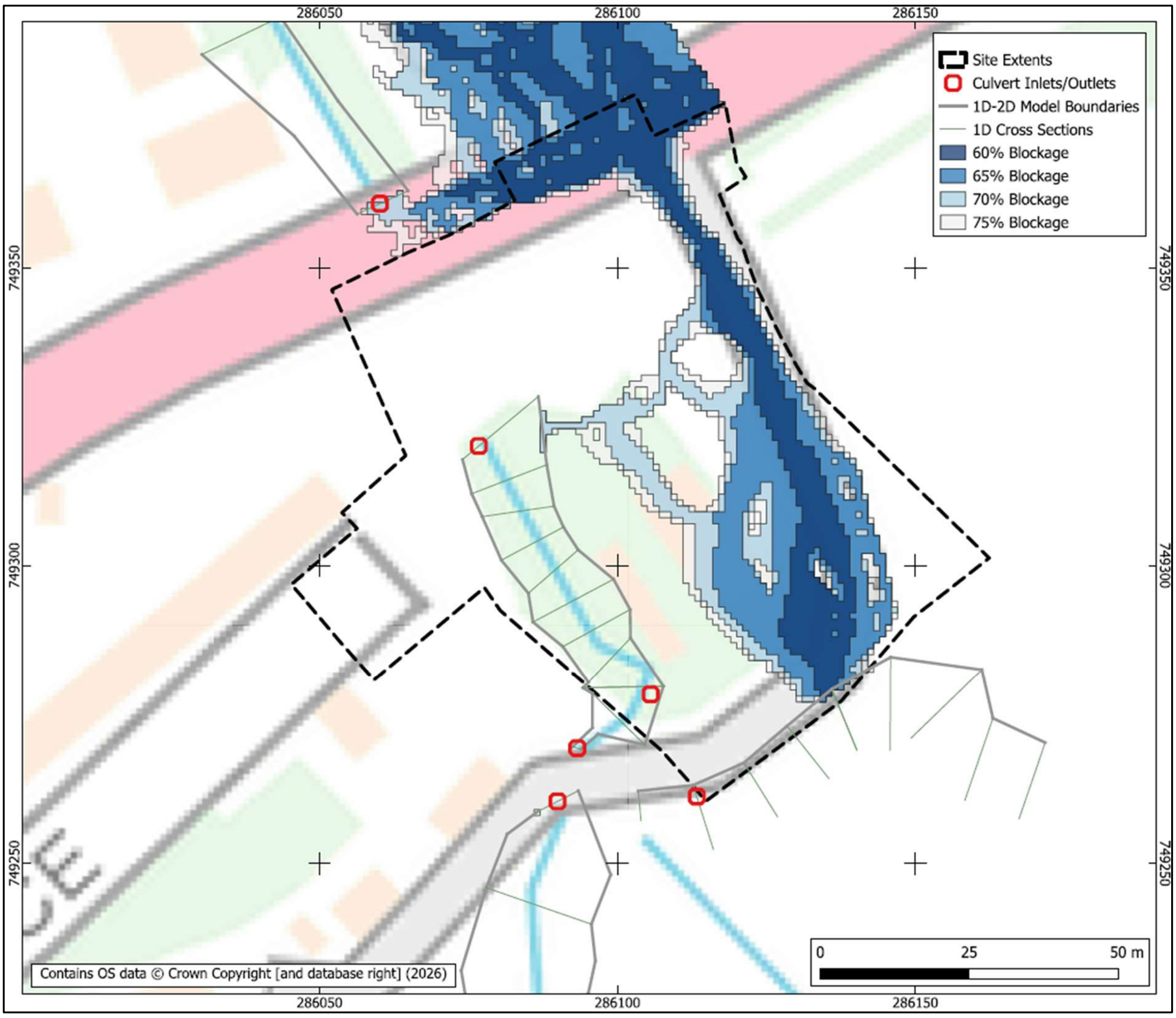


Figure 4.10: Predicted flood extents for a 3,300 mm culvert width, with varying high blockage of all culverts

4.5.4 Assessment of Downstream Impact

The potential impact of the replacement culvert upon downstream flood risk was assessed, firstly, for fully unblocked scenarios, comparing Scenario A predictions with those obtained with a replacement (unblocked) 2,100 mm and 3,300 mm width box culverts. Table 4.5 presents peak 200 year plus climate change water level predictions for pre- and post-mitigation scenarios, indicating that replacement of the existing undersized culvert through the site with a larger box culvert (along with regrading of the unmapped channel) is predicted to:

- Reduce backup of flows to the south of the existing site access road in both the Tom Chulan watercourse and unmapped channel.
- Consequently, flows and peak water levels in the section of the Tom Chulan watercourse through the site are higher (by up to 143 mm), but remain well within-bank.
- Peak water levels in the reach of the Tom Chulan watercourse downstream of the site are predicted to slightly increase, by just under 40 mm, but remain well below the lowest bank level at each model section. It is important to note that the post-mitigation scenarios resolve 2D flooding predicted to impact the Aberfeldy Caravan Park to the east of the watercourse in this area; in essence, floodwater impacting this existing receptor is returned to channel, resulting in a clear flood reduction benefit to this receptor and an inconsequential minor increase in peak watercourse levels.
- The width of the replacement culvert impacts upon peak water levels within the unmapped channel, but not within the Tom Chulan watercourse section through or downstream of the site.

Table 4.5: Predicted 200 year plus climate change peak water levels (mAOD) for unblocked pre- and post-mitigation scenarios (minimum and maximum candidate box culvert widths). Highlighted rows correspond to the reach of the Tom Chulan watercourse through the site.

Label	Bank/Intervening Ground Crest Level	Pre-Mitigation (Scenario A)	2,100 mm culvert	3,300 mm culvert
XS_01		94.617	94.619	94.619
XS_02		93.441	93.445	93.446
XS_03		93.073	92.791	92.79
XS_04		93.077	92.335	92.322
XS_05	93.022	91.717	91.567	91.564
IM0_000	93.196	90.994	90.913	90.911
IM0_001	91.893	90.533	90.563	90.563
IM0_002	90.880	90.085	90.109	90.109
IM0_003	90.674	89.600	89.626	89.626
IM0_004	90.522	89.163	89.192	89.192
IM0_005	90.674	88.862	88.882	88.882
IM0_006	90.579	88.241	88.269	88.269
IM0_007	90.427	87.654	87.713	87.713
IM0_008	90.197	87.363	87.482	87.482
XS_06	90.597	87.165	87.308	87.308
XS_07	85.491	84.853	84.891	84.891
XS_08	84.846	84.458	84.497	84.497
South_000		95.264	95.267	95.267
South_002		94.298	94.301	94.301
South_003		93.314	93.316	93.317
South_004		92.613	92.532	92.529
South_005		92.590	92.222	92.181
South_009		93.039	92.227	92.207
South_010		93.077	92.335	92.322
South_006		92.640	92.143	92.073
South_007		92.819	92.061	91.922
South_008		92.950	92.021	91.842

The possible risk that mitigation may increase downstream flood risk for partial culvert blockage conditions was also assessed for the "worst case" (i.e. the 3,300 mm width culvert, which maximises conveyance towards the lower reaches of the modelled system). Table 4.6 presents peak water level predictions for pre- and post-mitigation 50% blockage scenarios, indicating that replacement of the existing undersized culvert through the site with a larger box culvert (along with regrading of the unmapped channel) is predicted to:

- Reduce peak water levels around the inlet of the Tom Chulan culvert under the existing site access road (at XS_04), as high flows are instead diverted eastwards along the (regraded) unmapped channel to discharge through the box culvert.
- Likewise, reduce peak water levels around the outlet of the Tom Chulan culvert under the existing site access road (at XS_05), for the same reason.
- Increase peak water levels at and downstream of where the box culvert discharges into the Tom Chulan watercourse (at IM0_001).
- Increase peak water levels in the reach of the Tom Chulan watercourse downstream of the site by 85 mm, although flows remain well within-bank. Noting that a 3,300 mm box culvert is predicted to resolve flooding to the Aberfeldy Caravan Park (for culvert blockage of 55% of less), and to otherwise reduce flood risk to the caravan park (for culvert blockage of 60% or greater), mitigation provides a clear flood reduction benefit to this receptor while causing an inconsequential minor increase in peak watercourse levels through and downstream of the site.

Table 4.6: Predicted 200 year plus climate change peak water levels (mAOD) for 50% blockage pre- and post-mitigation scenarios (maximum candidate box culvert width). Highlighted rows correspond to the reach of the Tom Chulan watercourse through the site.

Label	Bank/Intervening Ground Crest Level	Pre-Mitigation (Scenario B)	3,300 mm culvert
XS_01		94.619	94.619
XS_02		93.451	93.438
XS_03		93.246	92.935
XS_04		93.272	92.755
XS_05	93.022	91.701	91.377
IM0_000	93.196	90.965	90.825
IM0_001	91.893	90.492	90.563
IM0_002	90.880	90.062	90.109
IM0_003	90.674	89.572	89.626
IM0_004	90.522	89.128	89.193
IM0_005	90.674	88.833	88.865
IM0_006	90.579	88.215	88.287
IM0_007	90.427	87.654	87.84
IM0_008	90.197	87.469	87.812
XS_06	90.597	87.460	87.83
XS_07	85.491	84.806	84.891
XS_08	84.846	84.411	84.496
South_000		95.268	95.267
South_002		94.300	94.301
South_003		93.318	93.316
South_004		92.641	92.547
South_005		92.628	92.343
South_009		93.214	92.595
South_010		93.272	92.755
South_006		92.718	92.299
South_007		93.016	92.258
South_008		93.096	92.238

4.5.5 Recommended Mitigation

Mitigation design and modelling undertaken as part of this assessment demonstrates the concept of a workable mitigation design for managing flood risk to the site, while also protecting the Aberfeldy Caravan Park from flood risk due to the Tom Chulan watercourse and unmapped channel. However, further consultation with PKC and SEPA may be required to confirm the minimum design standard with respect to flood risk management, noting:

- A 2,100 mm wide x 800 mm high box culvert is sufficient to protect the site from flooding if this culvert can reasonably be considered to be at low risk of appreciable blockage, even if existing culverts on the Tom Chulan watercourse are 50% blocked. The catchment area of the unmapped channel is agricultural fields, with the risk of large debris entrainment very low. Even if the (2,100 mm x 800 mm) box culvert is 50% blocked, predicted flooding to the site (as shown in Figure 4.9) might be managed through landscaping of the site and/or platforming of proposed dwellings, to ensure no flood risk is posed to the dwellings, provided low-depth flood risk to the existing site access road is considered acceptable.
- Otherwise, if higher protection is required, a 3,300 mm wide x 800 mm high box culvert is predicted to be capable of preventing flooding from the modelled system even if all culverts are blocked equivalent to 55% of their flow area, noting that the high culvert width reduces the risk of such substantial blockage occurring. With the risk of higher blockage considered to be extremely low, this residual risk can be managed through landscaping and platforming of proposed dwellings.

4.5.6 Proposed Mitigation

On the basis of analysis presented in the preceding sections, the proposed design is based upon a 3,300 mm wide x 800 mm high box culvert with inlet invert level below 91.1 mAOD (slightly lower than assumed in modelling) and longitudinal gradient of 1 in 40 (matching the assumed value in modelling), such that the flood mitigation performance of the proposed design will match or exceed that modelled for a box culvert of this dimension.

5 FLOOD RISK IMPACT & MANAGEMENT

5.1 Impact of Flood Risk Upon the Development

Table 5.1 provides a summary of flood risk from all sources, inclusive of proposed mitigation and management measures.

Table 5.1: Summary of flood risk

Flood source or mechanism	Risk Classification (with mitigation & management)	Proposed Management Measures
Fluvial	Low risk	Install a new large-width box culvert under the existing site access road in the unmapped channel at the south-west corner of the site, along with regrading of the channel bed to create a consistent westwards fall, to protect the site against flooding from the Tom Chulan watercourse and flows from the unmapped channel culvert.
Coastal	No risk	None
Surface Water (Pluvial & Drainage)	Little or no risk	Effective post development sustainable drainage system (SuDS).
Infrastructure / Asset Failure	Little or no risk	None
Groundwater	Little or no risk	None

5.2 Compliance with Development Management Guidance

5.2.1 Flood Risk Context

The majority of the proposed development site is predicted to be within the 1 in 200 year plus climate change flood extents due to flows from the Tom Chulan watercourse and an unmapped channel draining a catchment to the south-east of the site for existing site conditions when partial blockage of culverts is accounted for (i.e. Scenario B). However, based on consultation with PKC and SEPA, mitigation in the form of enhanced culverting arrangements is acceptable for managing this risk provided no detriment to other receptors is induced.

A large-width box culvert mitigation design is proposed, which is predicted to be capable of protecting the site from flooding, while also resolving flood risk (from the Tom Chulan watercourse and unmapped channel) to Aberfeldy Caravan Park to the north of the site. Very high culvert blockage may cause residual flooding, but this residual flood risk to proposed development can be managed by landscaping and/or platforming; the caravan park will also flood in such a scenario, but to lower extents and depths than for current (pre-development) conditions.

With proposed mitigation implemented, flood risk to the site is acceptably low.

5.2.2 Flood Impacts

SuDS-compliant site drainage should be provided to ensure no increase in site runoff, and therefore no impact upon fluvial or surface water flood risk to other receptors. In addition, with proposed mitigation implemented, development will have a neutral or beneficial impact upon flood risk to existing receptors (i.e. the Aberfeldy Caravan Park).

5.2.3 Access and Egress

With proposed mitigation implemented, the existing site access road is not predicted to flood, although the existing site access road will remain at flood risk from the River Tay at the point it joins the A827. Proposals therefore entail creation of a new site access road approaching proposed dwellings from the north and connecting onto Appin Place to the west of the site, with this public road not predicted to be at flood risk from the River Tay, nor from the Tom Chulan watercourse. Flood-free access and egress is therefore achievable via the proposed new site access road.

5.2.4 Freeboard

Predicted peak water levels within the reach of the Tom Chulan watercourse passing through the site are contained below eastern bank or intervening ground levels by at least 600 mm, such that freeboard is achieved (with respect to this watercourse) without the need for platforming of dwellings.

Floodwater levels within the unmapped channel are higher lying than site ground levels, and contained within relatively low banks, such that it is not feasible to achieve freeboard with respect to these levels. If this channel overtops (due to an exceedance event or extreme culvert blockage), floodwater spills northwards towards the underpass at relatively low depths (typically less than 100 mm) through the site, with higher predicted flood depths only in the vicinity of the underpass itself. To protect against residual flood risk from the unmapped channel (due to an exceedance event or extreme culvert blockage):

- Site landscaping should remove, or development should not be placed adjacent to, existing local topographic depressions.
- Landscaping should achieve an easterly fall to the east of development elements, directing any spilling floodwater towards the existing site access road.
- Finished floor levels should be raised at least 150 mm above surrounding ground levels.

(Note that these same measures will also protect dwellings from residual surface water flood risk, associated with blockage or exceedance of the SuDS-compliant site drainage system.)

5.2.5 Summary

The proposed development, inclusive of mitigation, is compliant with SEPA's Development Management Guidance on Flood Risk (2018a), and therefore compliant with National Planning Framework 4 in terms of flood risk.

6 CONCLUSIONS AND RECOMMENDATIONS

Site-specific modelling has been undertaken to assess fluvial flood risk to the proposed development site from the Tom Chulan watercourse and an unnamed channel to the south of the site. This modelling has determined that:

- The site is at flood risk from the 200 year plus climate change event from these watercourses, exacerbated by any blockage of culverts under the section of the existing site access road along the southern boundary of the site.
- Flood risk to the site is not exacerbated by high water levels in the River Tay, which the Tom Chulan watercourse discharges into (noting that the Aberfeldy Flood Study does not predict direct flood risk to the site from the River Tay either, for events up to and including the 200 year plus climate change event).

Proposals entail removal and in-filling of the existing small culvert draining the unmapped channel and replacement with a 3,300 mm wide x 800 mm high box culvert under the existing site access road further west, along with channel regrading to achieve a consistent westwards fall, with mitigation modelling undertaken as part of this assessment predicting that these measures will protect the development from fluvial flood risk while reducing flood risk to the existing caravan park site to the north of the site and otherwise causing no predicted flood risk detriment to other receptors. A new site access road connecting onto Appin Place is predicted to achieve flood-free access and egress for the development.

Residual flood risk, associated with an exceedance event or extreme culvert blockage, will cause low depths of flooding impacting the eastern areas of the site, and should be managed through landscaping of the site (ensuring eastward falls beyond the eastern extent of development towards the existing site access road) and by raising finished floor levels at least 150 mm above surrounding ground levels. These measures will also manage residual surface water flood risk, associated with exceedance or blockage of the site drainage system.

REFERENCES

CEH (2024). Flood Estimation Handbook (FEH) Web Service. Centre for Ecology & Hydrology. Retrieved from https://fehweb.ceh.ac.uk/

Scottish Government (2014). *Scottish Planning Policy*. Edinburgh: Scottish Government.

Scottish Government (2023). *National Planning Framework 4 (NPF4)*. Edinburgh: Scottish Government.

SEPA (2022). *Technical Flood Risk Guidance for Stakeholders - SEPA Requirements for Undertaking a Flood Risk Assessment; Version 13*. Scottish Environment Protection Agency. Retrieved from https://www.sepa.org.uk/media/162602/ss-nfr-p-002-technical-flood-risk-guidance-for-stakeholders.pdf

SEPA (2024). *Flood Risk and Land Use Vulnerability Guidance.* Scottish Environment Protection Agency.

SEPA (2025). *Climate Change allowances for flood risk asessment in land use planning (Version 6)*. Scottish Environment Protection Agency.

WHS (2015). *The Revitalised Flood Hydrograph Model ReFH2: Technical Guidance*. Wallingford: Wallingford HydroSolutions Ltd.

APPENDICES

A ANNUAL EXCEEDANCE PROBABILITY – RETURN PERIOD CONVERSION

Flood Frequency Statistics

The magnitudes of flood flows are typically expressed in terms of their long-term average frequency of recurrence, as ‘return periods’ (e.g. 1 in 200 year flood) or ‘annual exceedance probabilities’ (e.g. 0.5% AEP).

The return period (or recurrence interval) of a flood is the long-term average period between flood conditions of such magnitude (or greater). The annual exceedance probability of particular flood conditions is the chance these conditions (or more severe) occur in any given year.

Relationship between return periods and annual exceedance probability

Return period, T (year)	Annual exceedance probability, AEP (%)	Probability of occurrence over a 50 year period (%)	Comment
2	50	100	Median annual flood (also known as **QMED**). In the long-term this occurs every other year, on average. As a rule of thumb, this flow generally equates to ‘bankfull’ conditions in most natural channels.
5	20	100	
10	10	99	
20	5	92	
30	3.3	82	Typical design standard for urban drainage systems.
50	2	64	
100	1	39	
200	0.5	22	Typical design standard for river or coastal flooding for most developments. NPF4 defines “flooding areas” based on this event, with inclusion of climate change uplift.
500	0.2	10	
1,000	0.1	4.9	Typical design conditions standard for sensitive or vulnerable developments/contexts.

Lifetime Probabilities, or Design Life Probabilities

The probability of a flood event occurring at least once over a set period of time (e.g. an individual’s lifetime or the design life of a built structure) can be evaluated against the following table.

Age, or Design Period (years)	Flood Return period (years)				
	2	10	30	200	1000
10	100%	65%	29%	5%	1%
25	100%	93%	57%	12%	2%
80	100%	100%	93%	33%	8%
100	100%	100%	97%	39%	10%

B SEPA CHECKLIST

Flood Risk Assessment (FRA) Checklist

SEPA Scottish Environment Protection Agency

(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:		Corran Reile, Aberfeldy		
Grid Reference:	Easting:	286100	Northing:	749300
Local Authority:		Perth and Kinross Council		
Planning Reference number (if known):				
Nature of the development:		Residential	If residential, state type:	4 flats + 4 semi-detached dwellings
Size of the development site:		0.73	Ha	
Identified Flood Risk:	Source:	Fluvial	Source name:	Tom Chulan watercourse, unmapped channel/watercourse to south-east

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 m³ *(spilling floodwater; deflected, not displaced)*
Is the site identified within the local development plan?	No	Local Development Plan Name: / Allocation Number / Reference:	Year of Publication:
If yes, what is the proposed use for the site as identified in the local plan?	Residential	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?	Highly Vulnerable	Do the proposals represent an increase in land use vulnerability?	Yes

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:	None
Is a formal flood prevention scheme present?	No	If known, state the standard of protection offered:	
Current / historical site use:	Former commercial site, but site currently derelict		
Is the site considered vacant or derelict?	Yes		

Development Requirements

Freeboard on design water level:		0.6	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:	Varies	mAOD

Mitigation

Can development be designed to avoid all areas at risk of flooding?	No	
Is mitigation proposed?	Yes	*(culvert upgrades to resolve flood risk to the site, without causing detriment to other receptors)*
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:	1.64	km^2 (total)	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?	Select from List
	Single Site Analysis ☐			
	Enhanced Single Site ☐			
	ReFH2 ☑			
	FEH RRM ☑			
	Other ☐		If other (please specify methodology used):	
Estimate of 200 year design flood flow:	3.19	m^3/s		
Qmed estimate:	N/A	m^3/s	Method:	Catchment Descriptors
Statistical Distribution Selected:	N/A		Reasons for selection:	EH RR much more conservative than ReFH

Hydraulics

Hydraulic modelling method:		Linked 1D 2D		Software used:	Flood Modeller
				If other please specify:	
Number of cross sections:		28			
Source of data (i.e. topographic survey, LiDAR etc):		Topo survey plus LiDAR		Date obtained / surveyed:	Nov-23
Modelled reach length:		305	m		
Any changes to default simulation parameters?		No		If yes please provide details:	
Model timestep:		2s (1D) / 0.5s (2D)			
Model grid size:		1 x 1m			
Any structures within the modelled length?		Culvert		Specify, if combination:	3 existing culverts
Maximum observed velocity:		3.5	m/s		
Brief summary of sensitivity tests, and range:					
variation on flow (%)		200yr+CC+20%	%	Please specify climate change scenario considered:	Tay Rainfall Uplift (39%)
variation on channel roughness (%)		20	%		
blockage of structure (range of % blocked)		50-75	%		
boundary conditions:		**Upstream**			**Downstream**
(1) type		Flow			Normal depth
	Specify if other			Specify if other:	
(2) does it influence water levels at the site?		Yes			No
Has model been calibrated (gauge data / flood records)?		No			
Is the hydraulic model available to SEPA?		Yes			
Design flood levels:	200 year	N/A	m AOD	200 year plus climate change	87.46 - 91.70 m AOD
Cross section results provided?		Yes			
Long section results provided?		Yes			
Cross section ratings provided?		No			
Tabular output provided (i.e. levels, velocities)?		Yes			
Mass balance error:		0.2% (1D) / 1% (1D-2D)	%		

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:	**Dr Iain Struthers**	
Organisation:	**EnviroCentre Ltd**	
Date:		**13/05/2026**

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

C CORRESPONDENCE

From: Iain Struthers
Sent: 12 June 2023 17:52
To: FloodingDevelopmentControl@pkc.gov.uk
Subject: Flood risk enquiry - Slaughter House Site, Aberfeldy

Good morning,

EnviroCentre have been appointed to undertake flood risk assessment for a potential development site in Aberfeldy, opposite the caravan park, as indicated on the map below.

While SEPA flood maps do not indicate the site to be at risk of flooding from the River Tay, the modelling underpinning these maps may not account for the underpass road entry to the site, and we are therefore seeking further information on flood risk for this reach of the River Tay. We would be very grateful if the Council were able to provide a copy of reporting produced for the Aberfeldy Flood Protection Scheme, or otherwise provide predicted 200 year peak water levels based on the latest climate change guidance (and therefore compliant with NPF4 requirements), to allow us to determine if the site is directly at flood risk from the river and also to inform setting of the downstream boundary condition for assessment of flood risk from the minor watercourse which is culverted under the A827 to the west of the site.

More generally, we would also be grateful if you could share historical records of flooding in the vicinity of the site, and advise of any other requirements the Council would have for undertaking our assessment.

Kind Regards,

Dr Iain Struthers BSc BE (Hons) PhD
Associate Director

From:	Communities Flooding Development Control <FloodingDevelopmentControl@pkc.gov.uk>
Sent:	17 July 2023 13:35
To:	Iain Struthers
Subject:	RE: Flood risk enquiry - Slaughter House Site, Aberfeldy
Attachments:	Aberfeldy 0.5% AEP + 35%CC.pdf; 1 in 200 year.pdf

Hello Iain,

Apologies for the delayed response.

We have no records of the proposed development site flooding, however this may be due to a lack of properties on the land as flooding is typically noted when properties are impacted.

Regarding the flood maps from the Aberfeldy Flood Study, I have attached copies of both 0.5% AEP and the 0.5% AEP + 35%CC. This shows that the site is not significantly impacted by flooding. However, as you mention, NPF4 states that the climate change uplift for models such as these must be 39%.

We would expect at least some more hydraulic modelling of the minor watercourse to be completed by the applicant before an application was approved. However, depending on the size of the proposed development, this may involve modelling the River Tay.

I hope this is helpful, but if you require anything else, please let me know.

Regards,
Andrew Gemmell,
Flooding Technician

From: Planning South <Planning.South@sepa.org.uk>
Sent: 30 August 2023 15:25
To: Iain Struthers; Communities Flooding Development Control
Subject: SEPA Ref: 10178 -Slaughter House Site, Aberfeldy - Pre-Application Flood Risk Advice

OFFICIAL

Dear Dr Struthers

Town and Country Planning (Scotland) Acts
Pre-application Flood Risk Advice
Slaughter House Site, Aberfeldy

In line with the advice in the Transitional Arrangements for National Planning Framework 4 letter, issued by the Chief Planner, Fiona Simpson, on 8 February 2023, our position and advice given below is based on the NPF4 policy.

We welcome pre-application engagement from developers of large-scale projects and local applications where we have a specific interest, such as flood risk. We have provided standing advice to cover many of the issues in relation to our interests, which can be found here. In this case we provide the following site-specific advice. Please note that our advice at this stage is based on emerging proposals and we cannot rule out potential further information requests as the project develops.

Flood risk position

If consulted by the Planning Authority at the full application stage, we would object to this application on the grounds of flood risk. This is because the proposed development is expected to put people or property at risk of flooding which is contrary to National Planning Framework 4.

However, if a Flood Risk Assessment (FRA) were to be provided showing that the suggested upgrade to the culvert in the southwest corner of the site removes the flood risk, then we would not object subject to a condition involving the proposed culvert upgrade. The FRA would also need to show that all other sources of flood risk had been fully assessed and did not pose a risk to the site. Please refer to our Technical Flood Risk Guidance.

Flood risk advice

The site is not shown to be at risk of flooding based on the SEPA Future Flood Maps.

You can view the SEPA Flood Maps and find out more about them at Flood Maps | SEPA - Flood Maps | SEPA

The site is close to a small watercourse. The SEPA Future Flood Maps don't cover small watercourses (catchments <3km^2) but they can still cause serious flooding.

The SEPA Surface Water Flood Maps show several flow paths entering the site from the surrounding ground to the south.

The supplied information shows that the site is at risk from flooding from the small watercourse that runs along the western boundary of the site. This is because there is an undersized culvert to the southwest of the site. During a 0.5% AEP + climate change event, the supplied information states that the flood water flows over the bridge and back into the watercourse, without affecting the site. If the culvert becomes blocked, then the site would be inundated. SEPA guidance states that when this is the case, the flood risk area should include an appropriate culvert blockage scenario. This scenario would also flood the access road, potentially compromising vehicular access.

It is suggested that a significant upgrade to this culvert would prevent out of bank flows and so reduce the risk of the site flooding. The proposed FRA should clearly show how this mitigation measure reduces the flood risk for a range of blockage scenarios, including 25%, 50%, and 75%. The upgrade should show that any increase in flood risk downstream of the culvert is negligible.

Although the River Tay is not expected to provide a flood risk to the site, it could cause the western watercourse to back up via the culvert under the A827. It may also cause the site access road to be inaccessible for vehicles. Information regarding the flood risk to the site for each of these issues should be provided.

Regarding the surface water flowpaths into the site, these may be intercepted by the linear channel to the south of the site's access road. We require any channel that can carry water to be modelled in the FRA. This will include the culverted part of this channel. Please also note that no development should occur over a culvert and an appropriate maintenance buffer should be designed on either side of the culvert, that would allow safe access to expose the culvert. Ideally any culvert like this should be daylighted as part of the development. SEPA do not hold any other information on the linear channel or the culvert.

I trust this is of assistance. Please contact me if you require further information.

Best wishes

Jessica Taylor
Senior Planning Officer
Planning Service

D TABULATED PEAK PREDICTIONS

Scenario A

Label	Flow (m^3/s)	Stage (mAOD)	Froude Number	Velocity (m/s)
XS_01	4.537	94.617	1.201	2.907
XS_02	4.536	93.441	0.715	1.534
XS_03	4.535	93.073	1.385	2.614
XS_04	4.532	93.077	0.375	0.665
XS_05	4.128	91.717	1.102	3.561
IM0_000	4.128	90.994	1.466	3.048
IM0_001	4.128	90.533	1.238	2.788
IM0_002	4.719	90.085	1.359	2.447
IM0_003	4.719	89.600	1.973	3.072
IM0_004	4.719	89.163	1.134	2.275
IM0_005	4.719	88.862	1.247	2.773
IM0_006	4.719	88.241	1.945	3.468
IM0_007	4.719	87.654	1.027	2.535
IM0_008	4.719	87.363	1.406	2.559
XS_06	4.719	87.165	0.851	1.552
XS_07	4.762	84.853	0.586	1.518
XS_08	4.762	84.458	0.575	1.437
South_000	0.582	95.264	1.460	1.338
South_002	0.582	94.298	1.273	1.302
South_003	0.582	93.314	1.233	1.164
South_004	0.582	92.613	1.034	0.995
South_005	0.464	92.590	0.261	0.511
South_009	0.000	93.039	0.000	0.000
South_010	0.000	93.077	0.162	0.369
South_006	0.000	92.640	0.004	0.008
South_007	0.000	92.819	0.003	0.006
South_008	0.000	92.950	0.001	0.003

Scenario B

Label	Flow (m^3/s)	Stage (mAOD)	Froude Number	Velocity (m/s)
XS_01	4.537	94.619	1.257	2.996
XS_02	4.537	93.451	0.746	1.529
XS_03	4.536	93.246	1.510	2.366
XS_04	4.183	93.272	0.209	0.417
XS_05	3.468	91.701	1.093	3.214
IM0_000	3.727	90.965	1.713	3.050
IM0_001	3.741	90.492	1.332	2.848
IM0_002	4.155	90.062	1.395	2.370
IM0_003	4.191	89.572	2.095	3.112
IM0_004	4.204	89.128	1.189	2.257
IM0_005	4.204	88.833	1.265	2.702
IM0_006	4.204	88.215	2.252	3.465
IM0_007	4.203	87.654	1.003	2.322
IM0_008	4.203	87.469	1.580	2.095
XS_06	4.207	87.460	0.543	1.017
XS_07	4.249	84.806	0.854	1.712
XS_08	4.249	84.411	0.583	1.407
South_000	0.582	95.268	1.727	1.449
South_002	0.582	94.300	1.469	1.431
South_003	0.582	93.318	1.368	1.243
South_004	0.588	92.641	1.113	1.001
South_005	0.330	92.628	0.182	0.361
South_009	0.000	93.214	0.000	0.000
South_010	0.000	93.272	0.162	0.369
South_006	0.002	92.718	0.159	0.097
South_007	0.001	93.016	0.249	0.111
South_008	0.000	93.096	0.209	0.091

Scenario C

Label	Flow (m³/s)	Stage (mAOD)	Froude Number	Velocity (m/s)
XS_01	4.537	94.695	1.088	2.642
XS_02	4.536	93.519	0.616	1.338
XS_03	4.536	93.278	1.245	2.055
XS_04	4.177	93.282	0.201	0.405
XS_05	3.536	91.801	0.933	2.953
IM0_000	3.801	91.039	1.383	2.633
IM0_001	3.816	90.558	1.144	2.537
IM0_002	4.232	90.111	1.181	2.099
IM0_003	4.269	89.627	1.779	2.643
IM0_004	4.281	89.192	0.988	1.976
IM0_005	4.281	88.882	1.119	2.493
IM0_006	4.281	88.268	1.783	3.014
IM0_007	4.281	87.707	0.881	2.172
IM0_008	4.281	87.489	1.299	1.931
XS_06	4.285	87.447	0.554	1.046
XS_07	4.327	84.895	0.667	1.495
XS_08	4.327	84.498	0.491	1.247
South_000	0.582	95.281	1.441	1.254
South_002	0.582	94.312	1.238	1.273
South_003	0.582	93.329	1.171	1.096
South_004	0.589	92.651	0.991	0.912
South_005	0.324	92.631	0.184	0.382
South_009	0.000	93.240	0.000	0.000
South_010	0.000	93.282	0.162	0.369
South_006	0.004	92.730	0.250	0.152
South_007	0.001	93.039	0.447	0.200
South_008	0.001	93.114	0.295	0.149

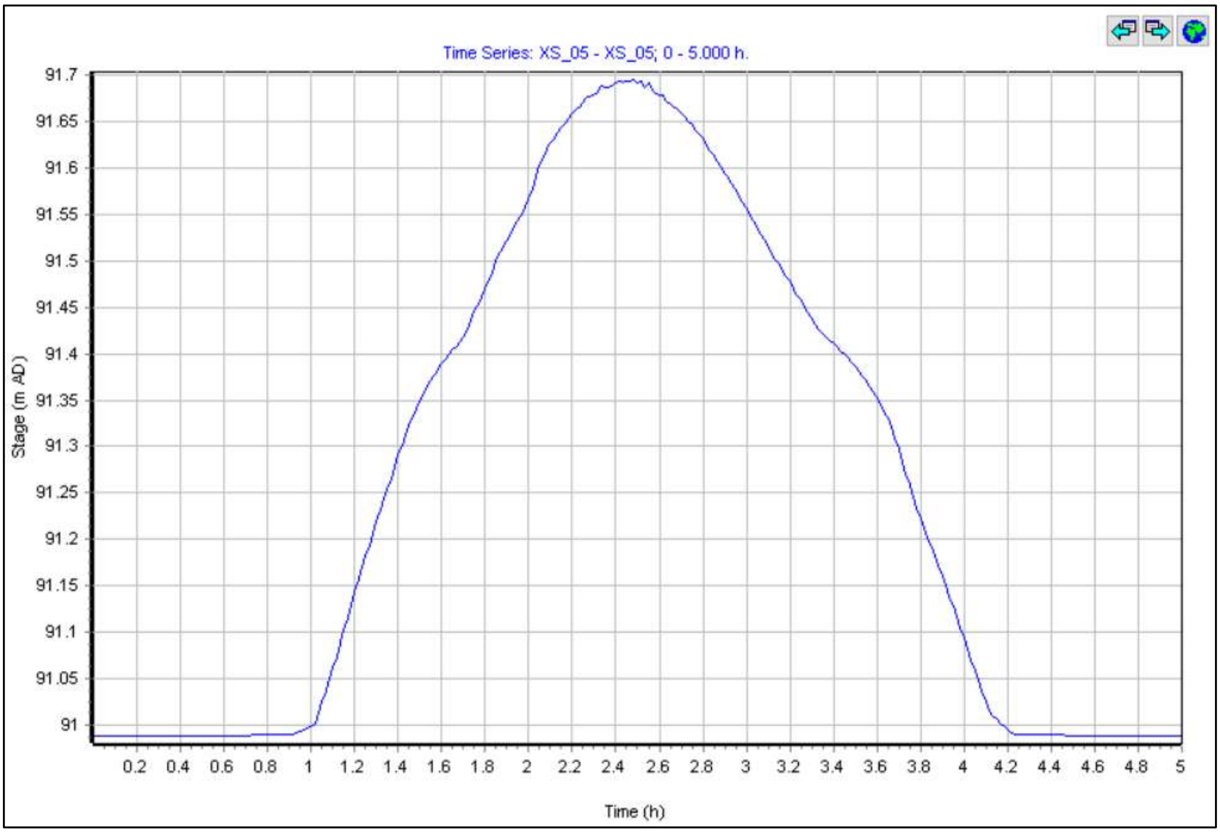
Scenario D

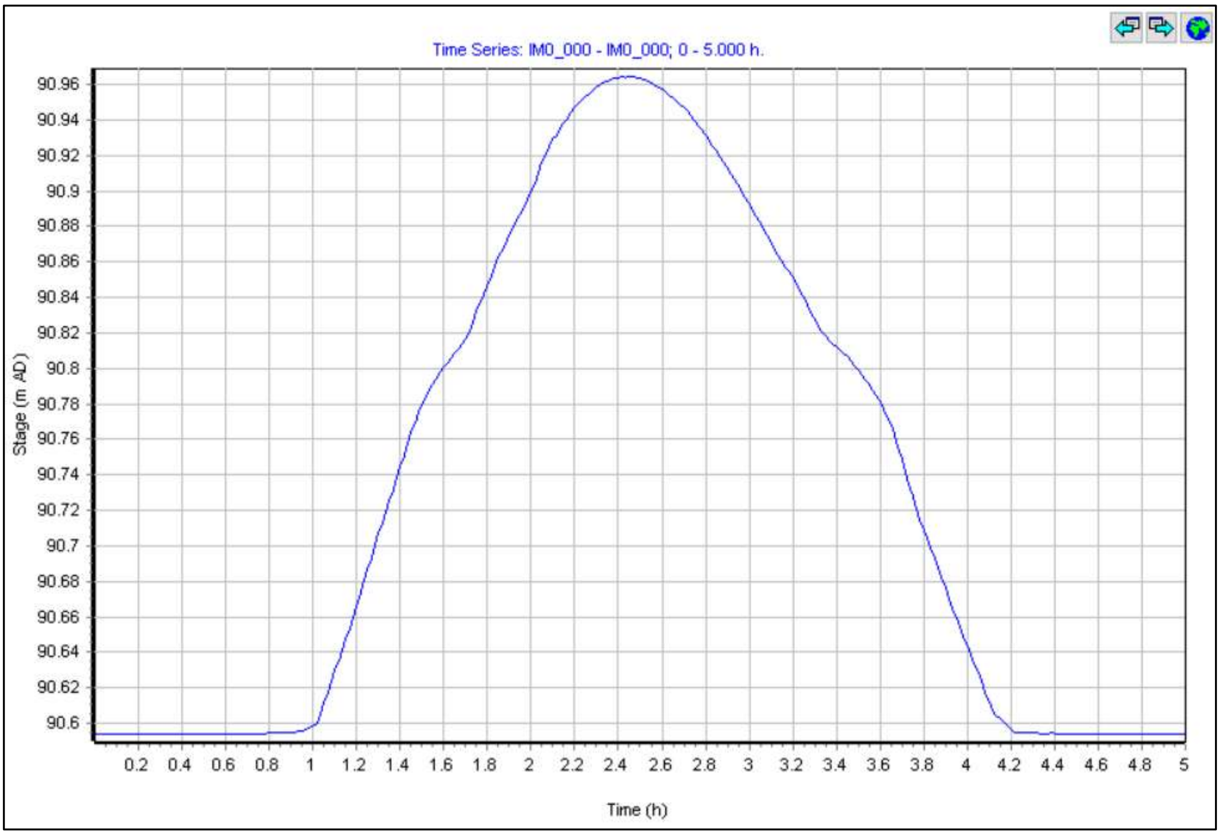
Label	Flow (m^3/s)	Stage (mAOD)	Froude Number	Velocity (m/s)
XS_01	5.444	94.696	1.305	3.168
XS_02	5.444	93.513	0.746	1.625
XS_03	5.444	93.282	1.502	2.368
XS_04	4.829	93.312	0.209	0.417
XS_05	4.028	91.834	1.095	3.337
IM0_000	4.484	91.036	1.714	3.134
IM0_001	4.505	90.548	1.388	3.055
IM0_002	4.921	90.108	1.396	2.460
IM0_003	4.990	89.621	2.100	3.145
IM0_004	5.016	89.184	1.189	2.356
IM0_005	5.016	88.871	1.352	2.985
IM0_006	5.015	88.266	2.253	3.557
IM0_007	5.015	87.740	1.003	2.428
IM0_008	5.014	87.561	1.580	2.095
XS_06	5.022	87.571	0.543	1.127
XS_07	5.070	84.881	0.854	1.712
XS_08	5.070	84.487	0.589	1.486
South_000	0.698	95.281	1.726	1.505
South_002	0.698	94.312	1.483	1.526
South_003	0.698	93.329	1.398	1.311
South_004	0.699	92.650	1.113	1.001
South_005	0.331	92.635	0.181	0.362
South_009	0.000	93.249	0.000	0.000
South_010	0.000	93.312	0.162	0.369
South_006	0.003	92.741	0.176	0.107
South_007	0.001	93.036	0.260	0.115
South_008	0.000	93.105	0.218	0.096

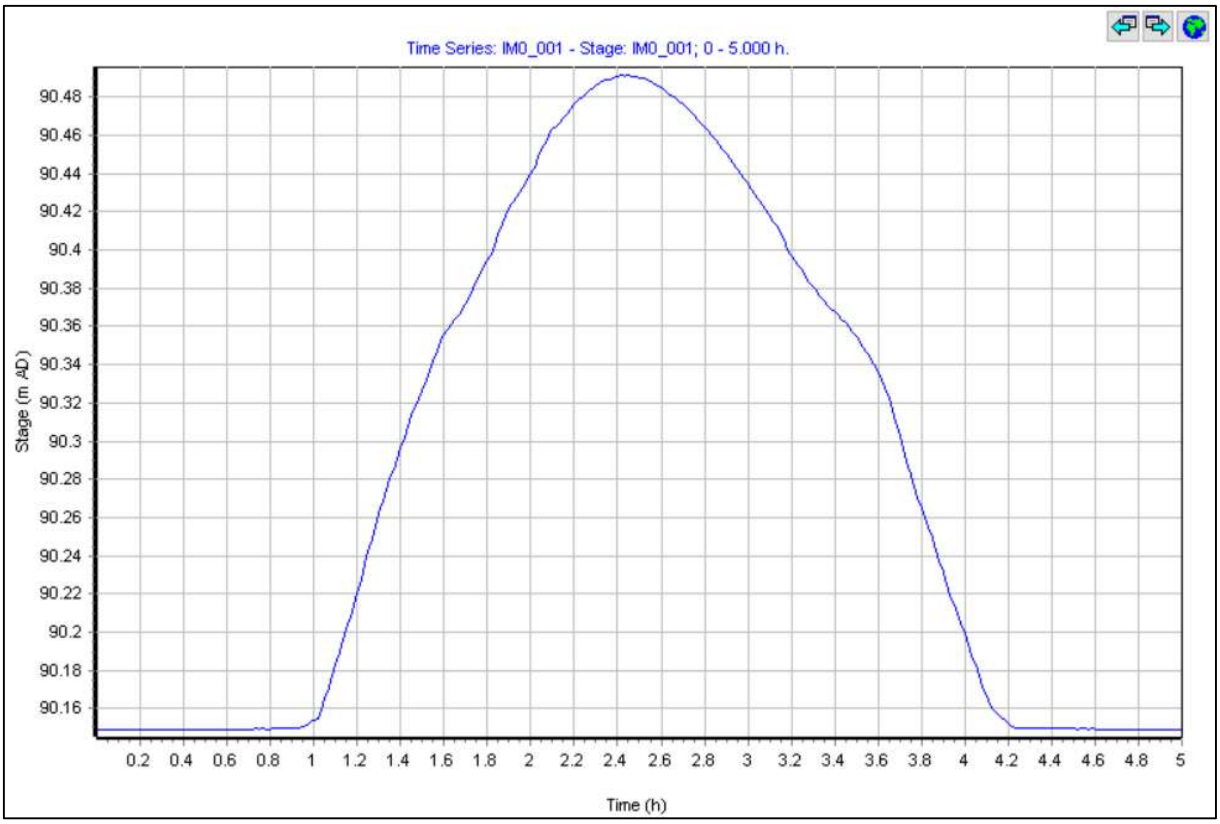
Scenario E

Label	Flow (m^3/s)	Stage (mAOD)	Froude Number	Velocity (m/s)
XS_01	4.537	94.619	1.257	2.996
XS_02	4.536	93.451	0.746	1.529
XS_03	4.536	93.246	1.505	2.366
XS_04	4.183	93.272	0.209	0.417
XS_05	3.470	91.701	1.092	3.218
IM0_000	3.729	90.965	1.811	3.049
IM0_001	3.742	90.492	1.332	2.848
IM0_002	4.157	90.062	1.394	2.371
IM0_003	4.193	89.572	2.092	3.112
IM0_004	4.205	89.130	1.300	2.256
IM0_005	4.204	88.879	1.549	2.974
IM0_006	4.201	88.737	2.735	3.028
IM0_007	4.200	88.765	1.092	1.847
IM0_008	4.198	88.770	1.859	2.245
XS_06	4.201	88.768	0.433	0.993
XS_07	4.244	87.033	0.047	0.203
XS_08	4.246	87.000	0.033	0.141
South_000	0.582	95.268	1.726	1.450
South_002	0.582	94.301	1.470	1.432
South_003	0.582	93.318	1.370	1.245
South_004	0.588	92.641	1.112	1.001
South_005	0.329	92.628	0.182	0.363
South_009	0.000	93.214	0.000	0.000
South_010	0.000	93.272	0.162	0.369
South_006	0.003	92.718	0.165	0.101
South_007	0.001	93.016	0.280	0.127
South_008	0.000	93.096	0.177	0.089

E TIME VARYING STAGE PREDICTIONS (SCENARIO B)



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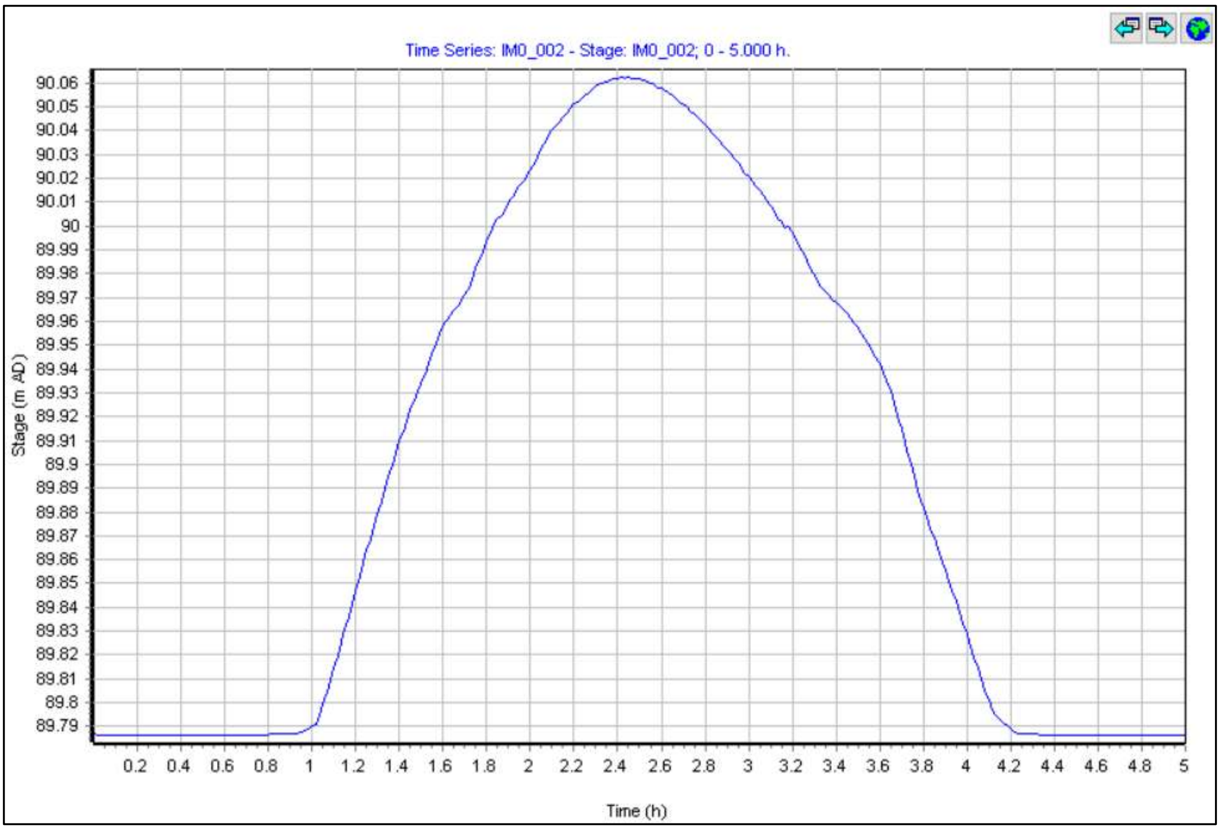
Stage (m AD)
Time (h)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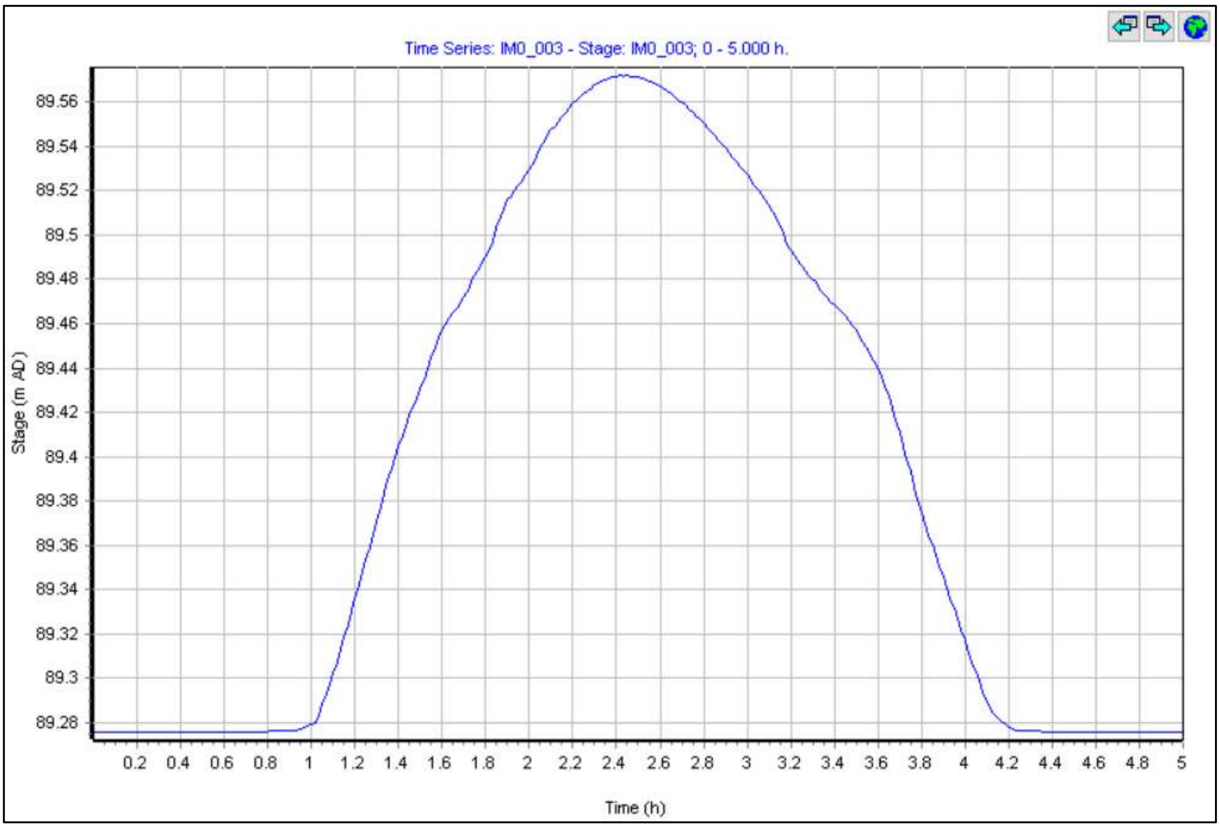
Time (h)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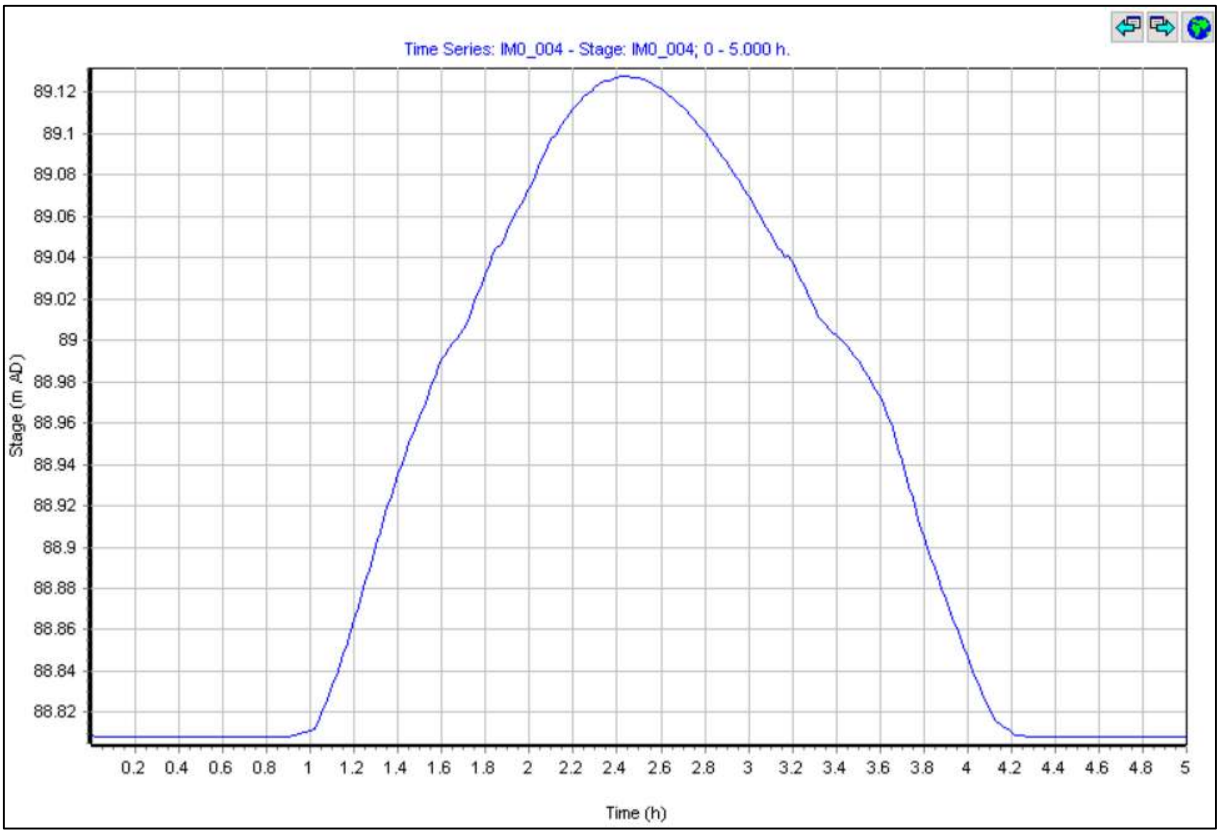
89.44
89.42
89.4
89.38
89.36
89.34
89.32
89.3
89.28
0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3 3.2 3.4 3.6 3.8 4 4.2 4.4 4.6 4.8 5
Time (h)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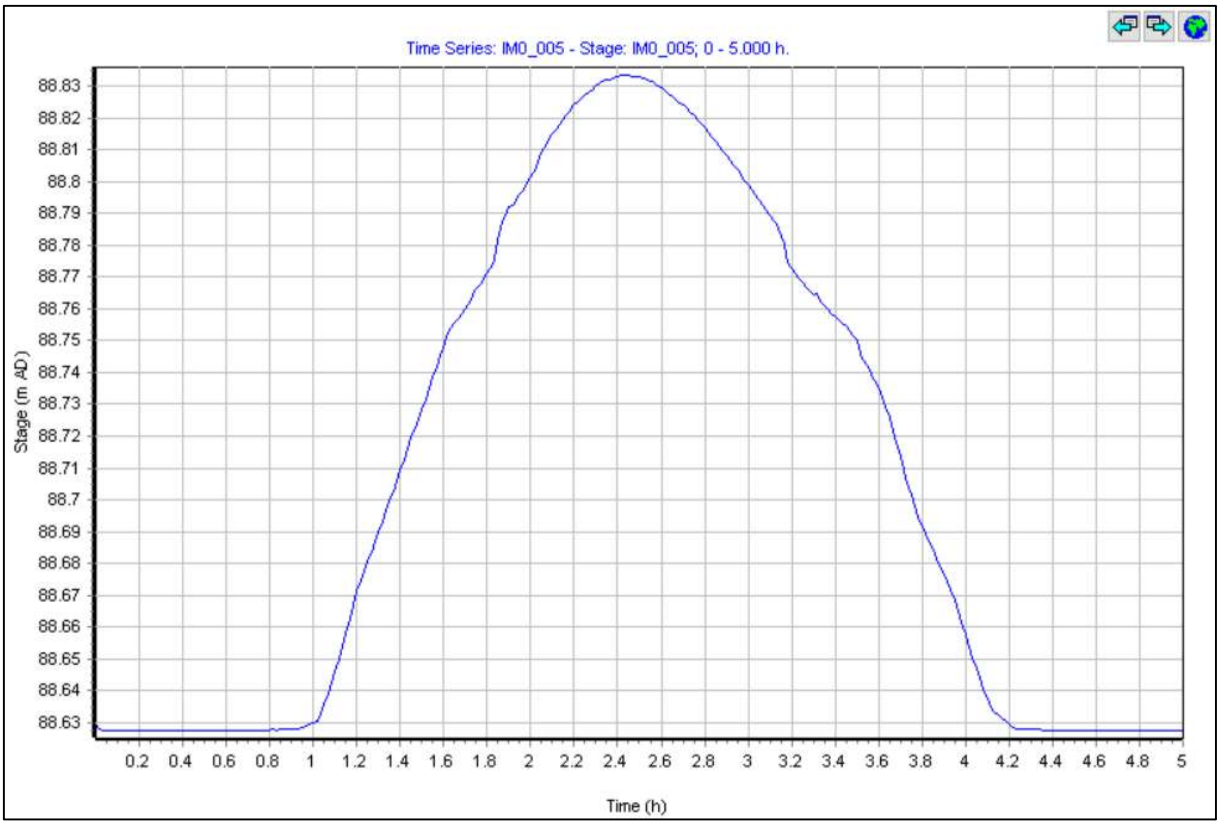
88.98
88.96
88.94
88.92
88.9
88.88
88.86
88.84
88.82
0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3 3.2 3.4 3.6 3.8 4 4.2 4.4 4.6 4.8 5
Time (h)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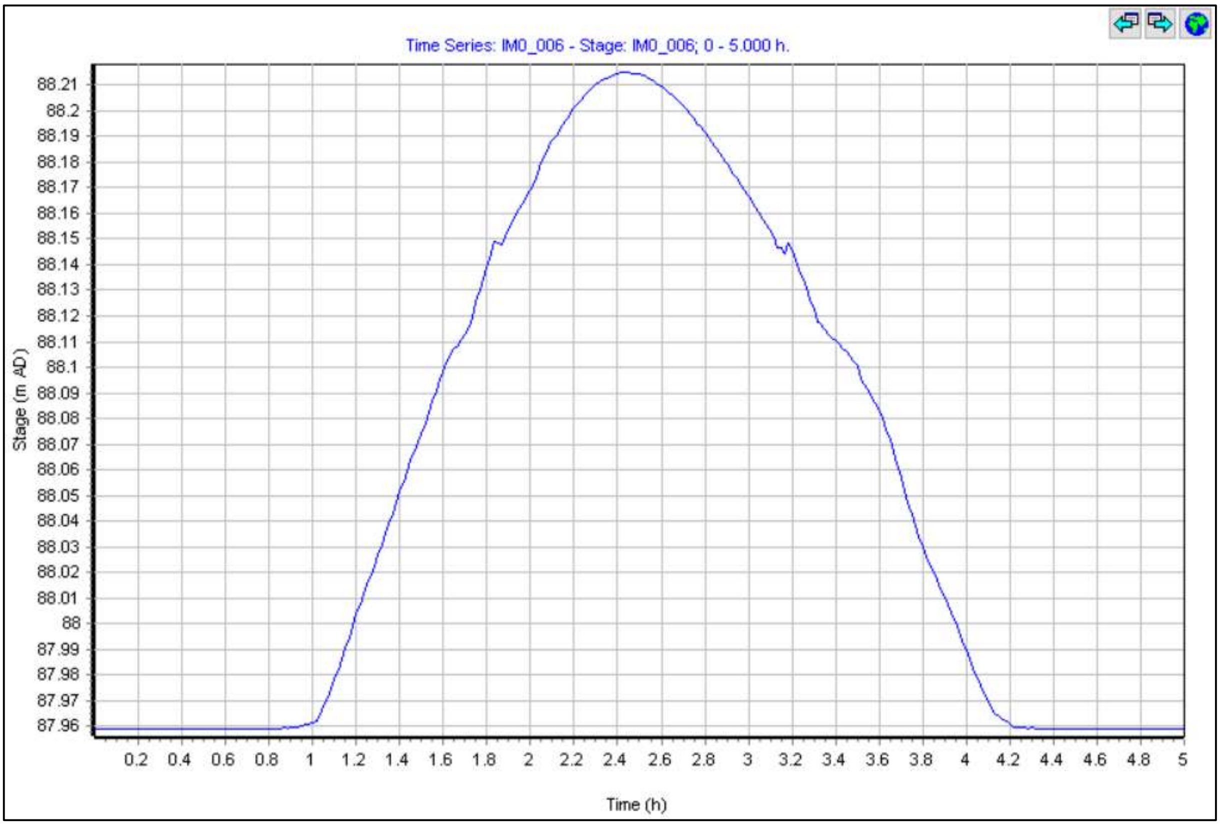
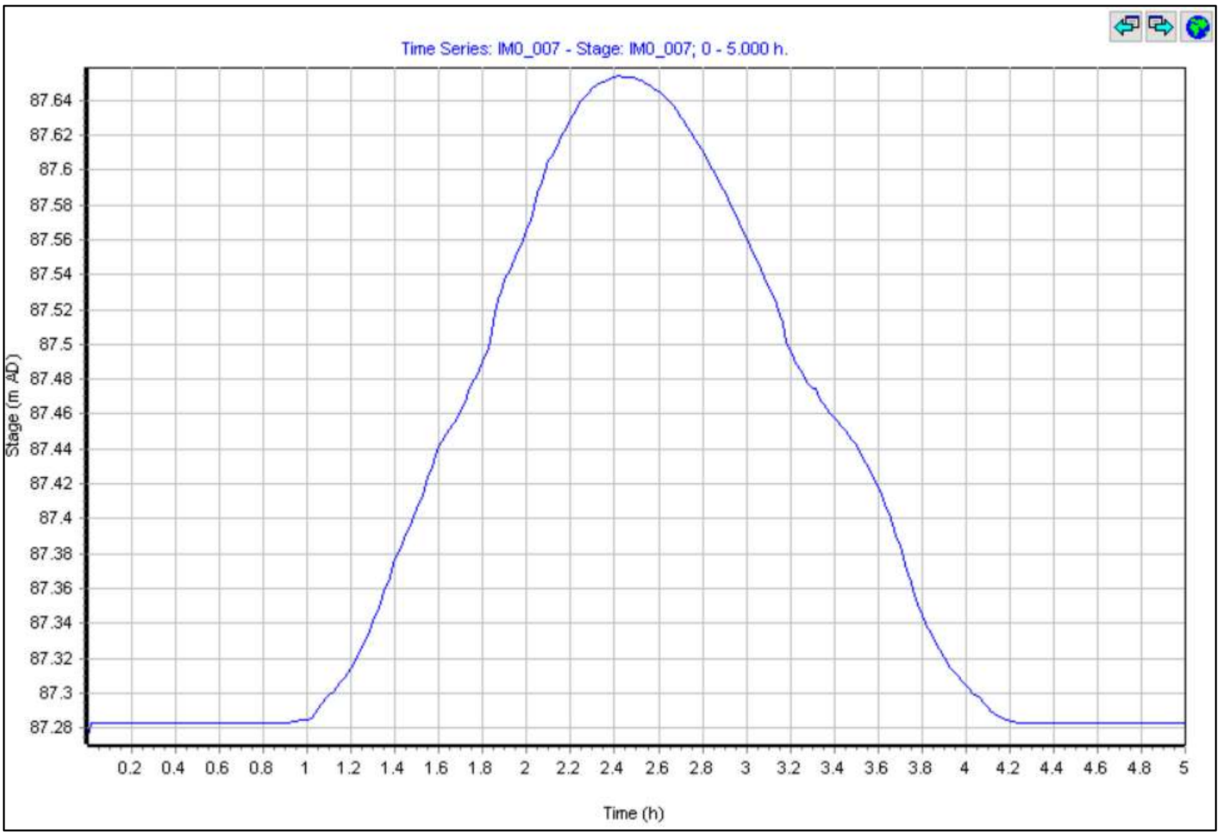
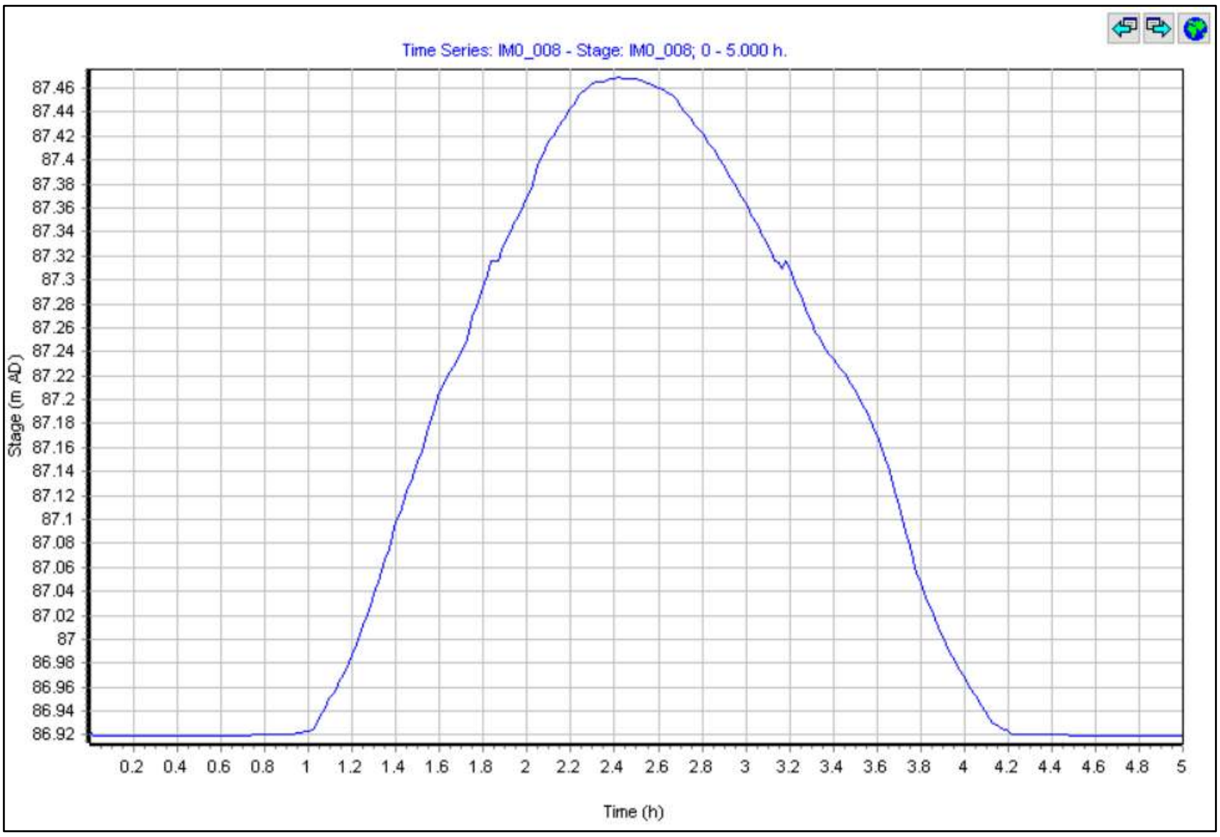
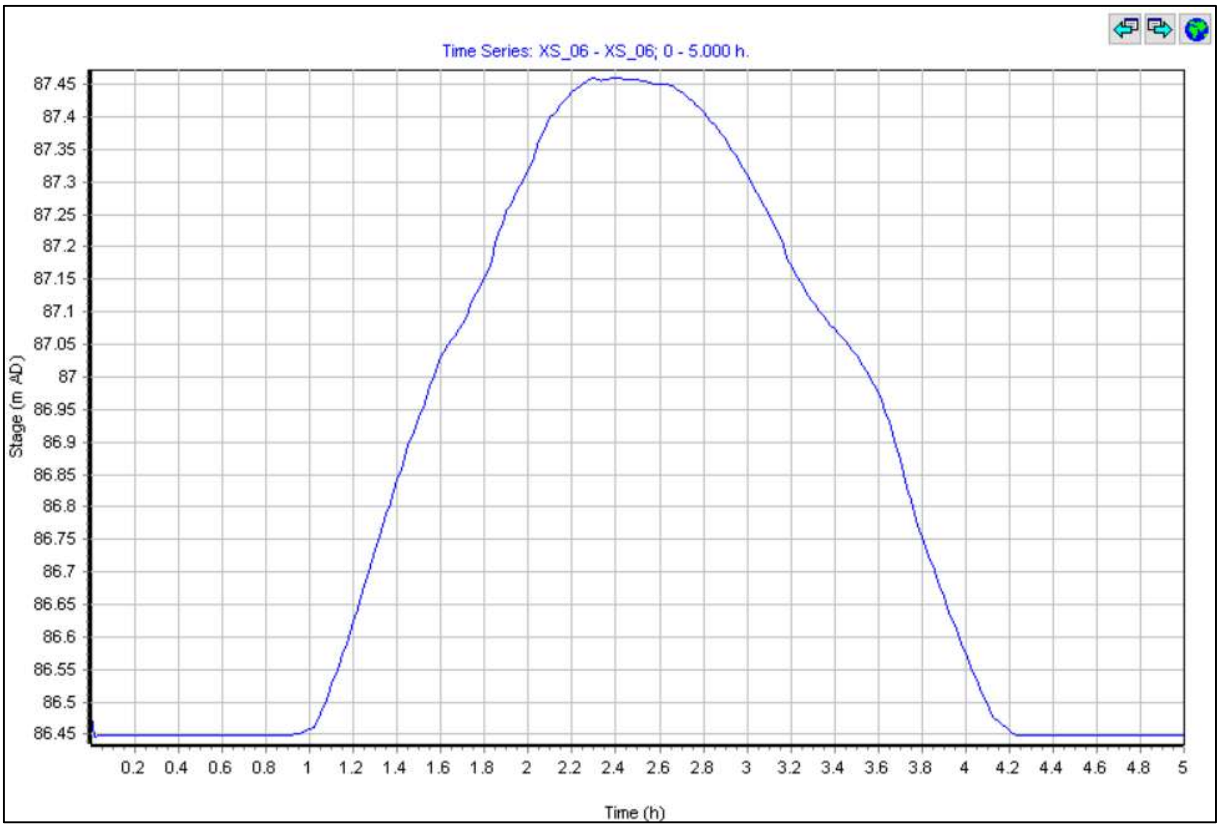
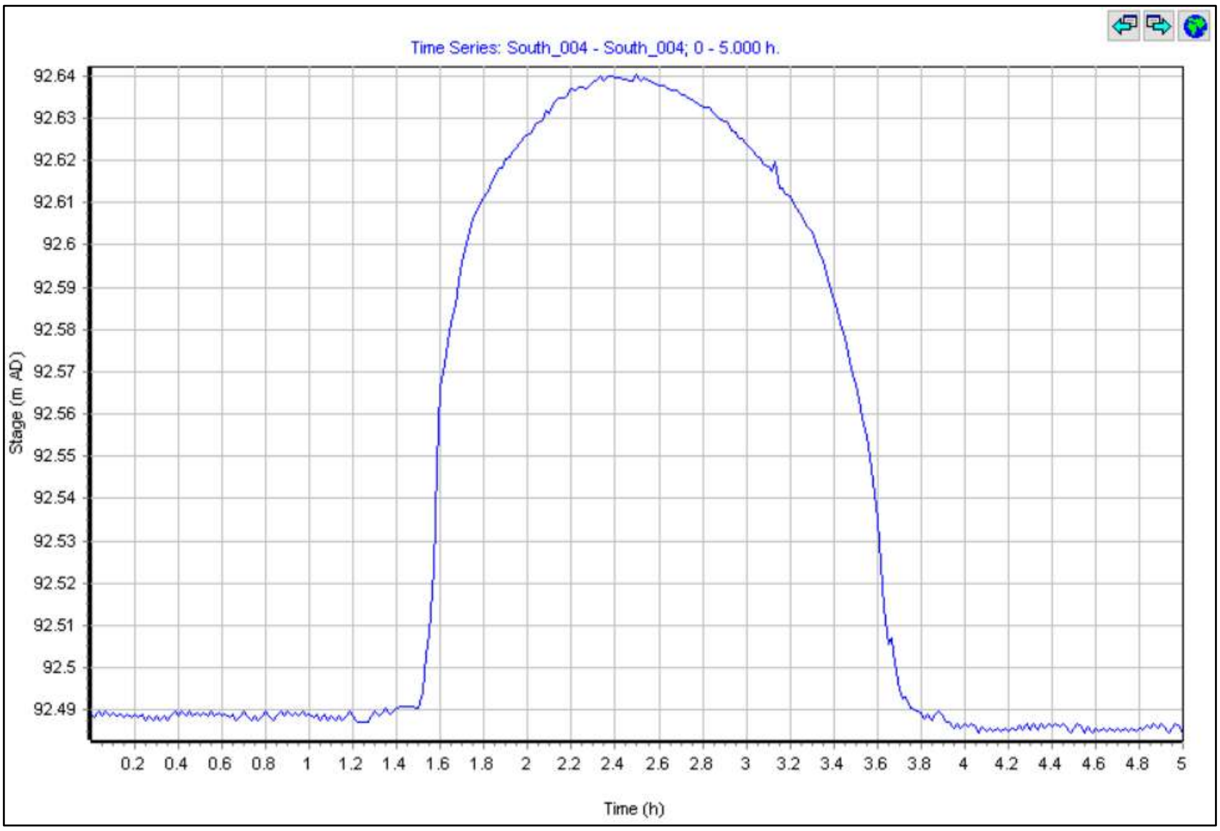
88.73
88.72
88.71
88.7
88.69
88.68
88.67
88.66
88.65
88.64
88.63
0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3 3.2 3.4 3.6 3.8 4 4.2 4.4 4.6 4.8 5
Time (h)

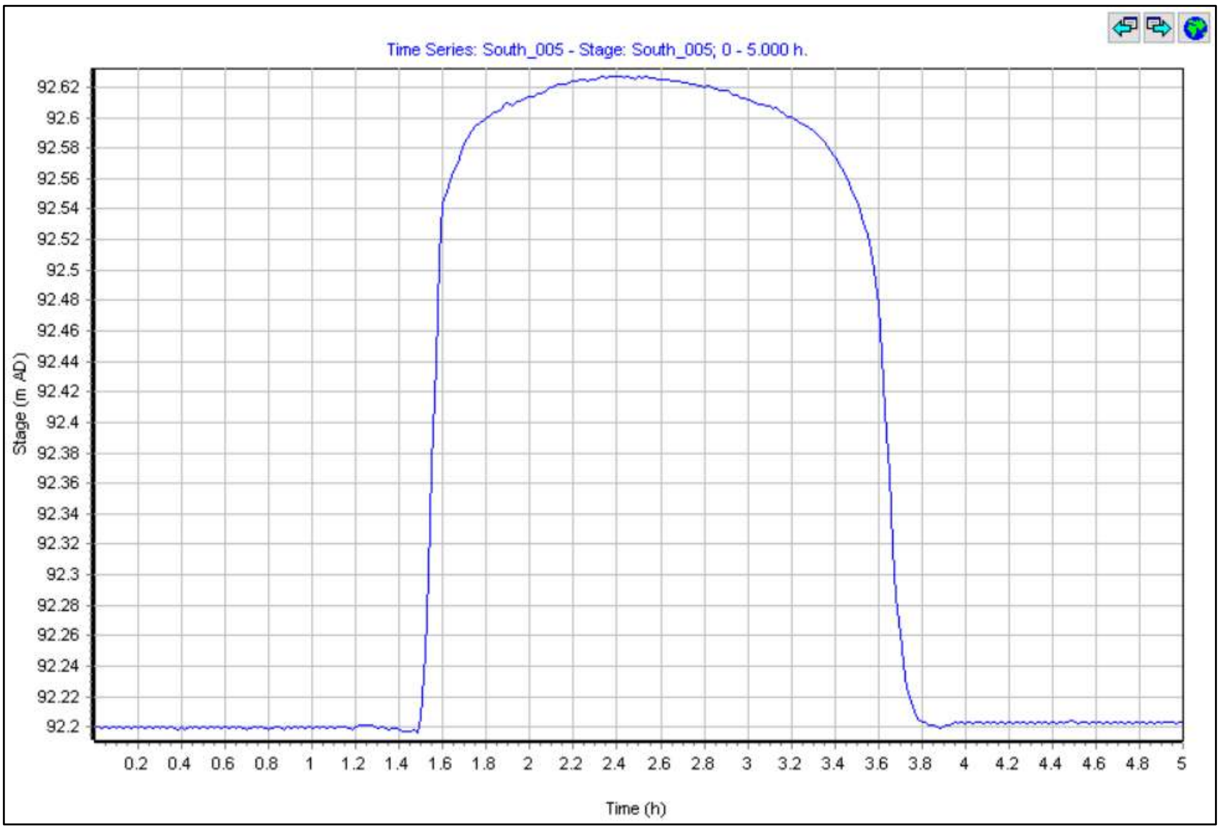

Time Series: IM0_006 - Stage: IM0_006; 0 - 5.000 h.
Stage (m AD)
88.21
88.2
88.19
88.18
88.17
88.16
88.15
88.14
88.13
88.12
88.11
88.1
88.09
88.08
88.07
88.06
88.05
88.04
88.03
88.02
88.01
88
87.99
87.98
87.97
87.96
0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3 3.2 3.4 3.6 3.8 4 4.2 4.4 4.6 4.8 5
Time (h)

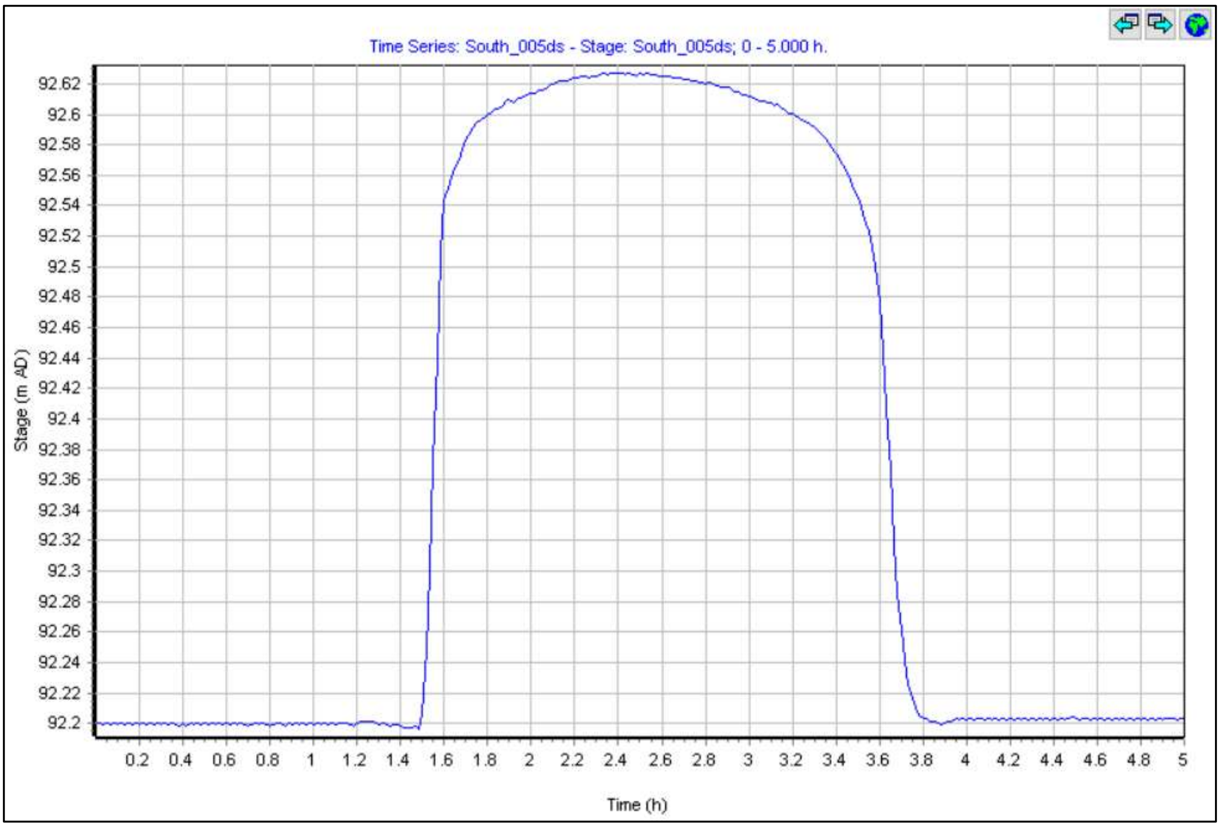

Time Series: IM0_007 - Stage: IM0_007; 0 - 5.000 h.
Stage (m AD)
Time (h)


Time Series: IM0_008 - Stage: IM0_008; 0 - 5.000 h.
Stage (m AD)
Time (h)


Time Series: XS_06 - XS_06; 0 - 5.000 h.
Stage (m AD)
87.45
87.4
87.35
87.3
87.25
87.2
87.15
87.1
87.05
87
86.95
86.9
86.85
86.8
86.75
86.7
86.65
86.6
86.55
86.5
86.45
0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3 3.2 3.4 3.6 3.8 4 4.2 4.4 4.6 4.8 5
Time (h)

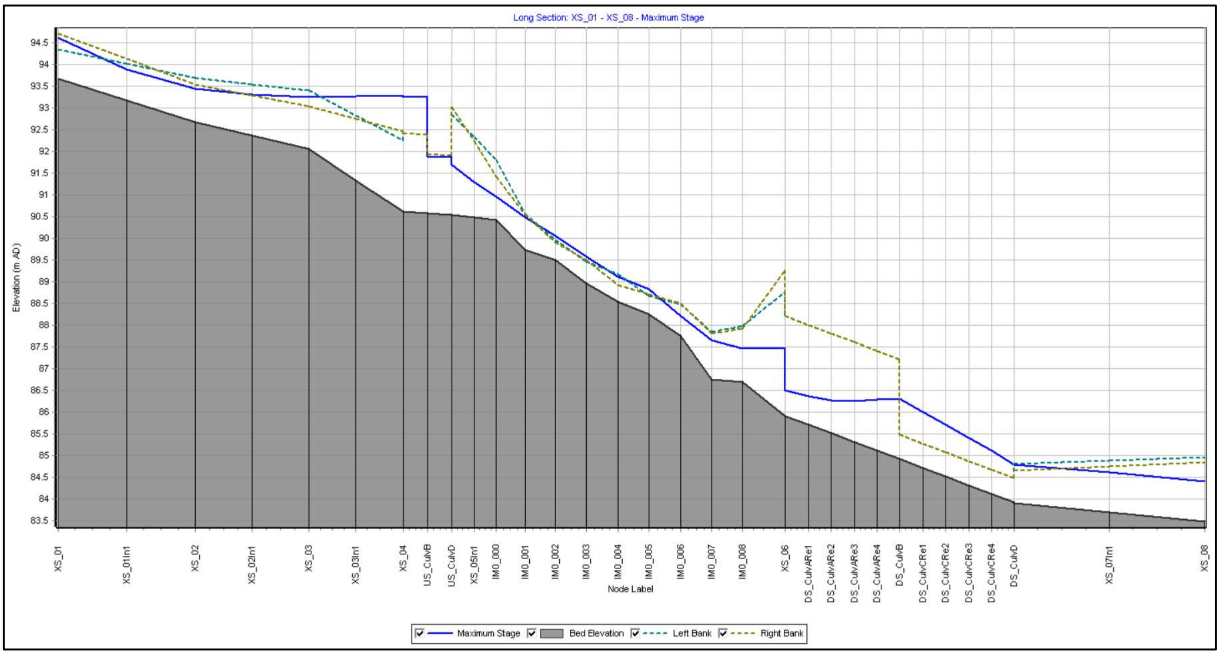

Time Series: South_004 - South_004; 0 - 5.000 h.
Stage (m AD)
92.64
92.63
92.62
92.61
92.6
92.59
92.58
92.57
92.56
92.55
92.54
92.53
92.52
92.51
92.5
92.49
0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3 3.2 3.4 3.6 3.8 4 4.2 4.4 4.6 4.8 5
Time (h)


Time Series: South_005 - Stage: South_005; 0 - 5.000 h.
Stage (m AD)
92.62
92.6
92.58
92.56
92.54
92.52
92.5
92.48
92.46
92.44
92.42
92.4
92.38
92.36
92.34
92.32
92.3
92.28
92.26
92.24
92.22
92.2
0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3 3.2 3.4 3.6 3.8 4 4.2 4.4 4.6 4.8 5
Time (h)


Time Series: South_005ds - Stage: South_005ds; 0 - 5.000 h.
Stage (m AD)
92.62
92.6
92.58
92.56
92.54
92.52
92.5
92.48
92.46
92.44
92.42
92.4
92.38
92.36
92.34
92.32
92.3
92.28
92.26
92.24
92.22
92.2
0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3 3.2 3.4 3.6 3.8 4 4.2 4.4 4.6 4.8 5
Time (h)

F LONG SECTION PREDICTIONS (SCENARIO B)

Tom Chulan Watercourse



Unmapped Channel