Annex B Topographic Survey

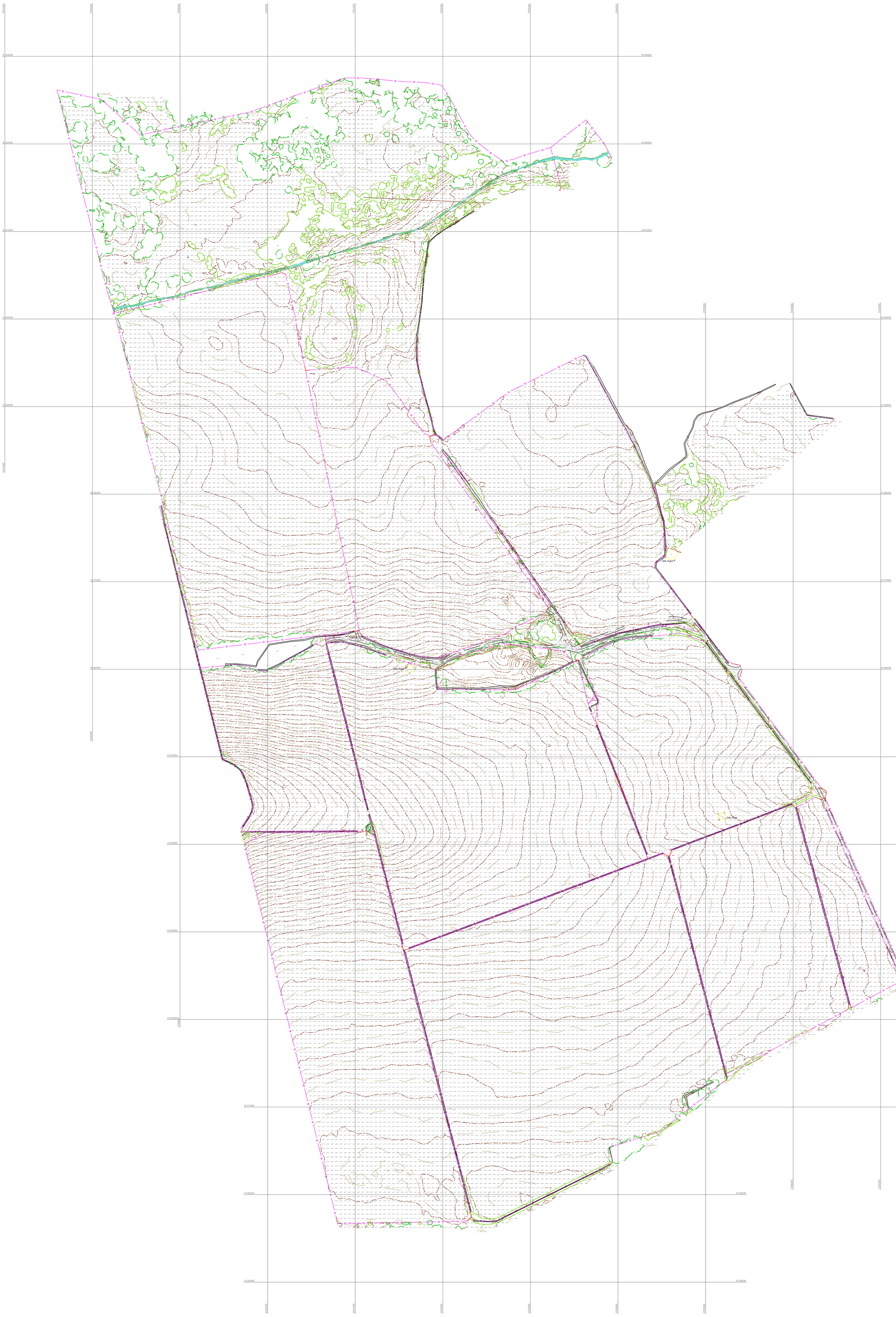
Kintore Hydrogen Facility

Appendix 13.2: Flood Risk Assessment

Kintore Hydrogen Ltd

SLR Project No.: 428.013099.00001

31 August 2024



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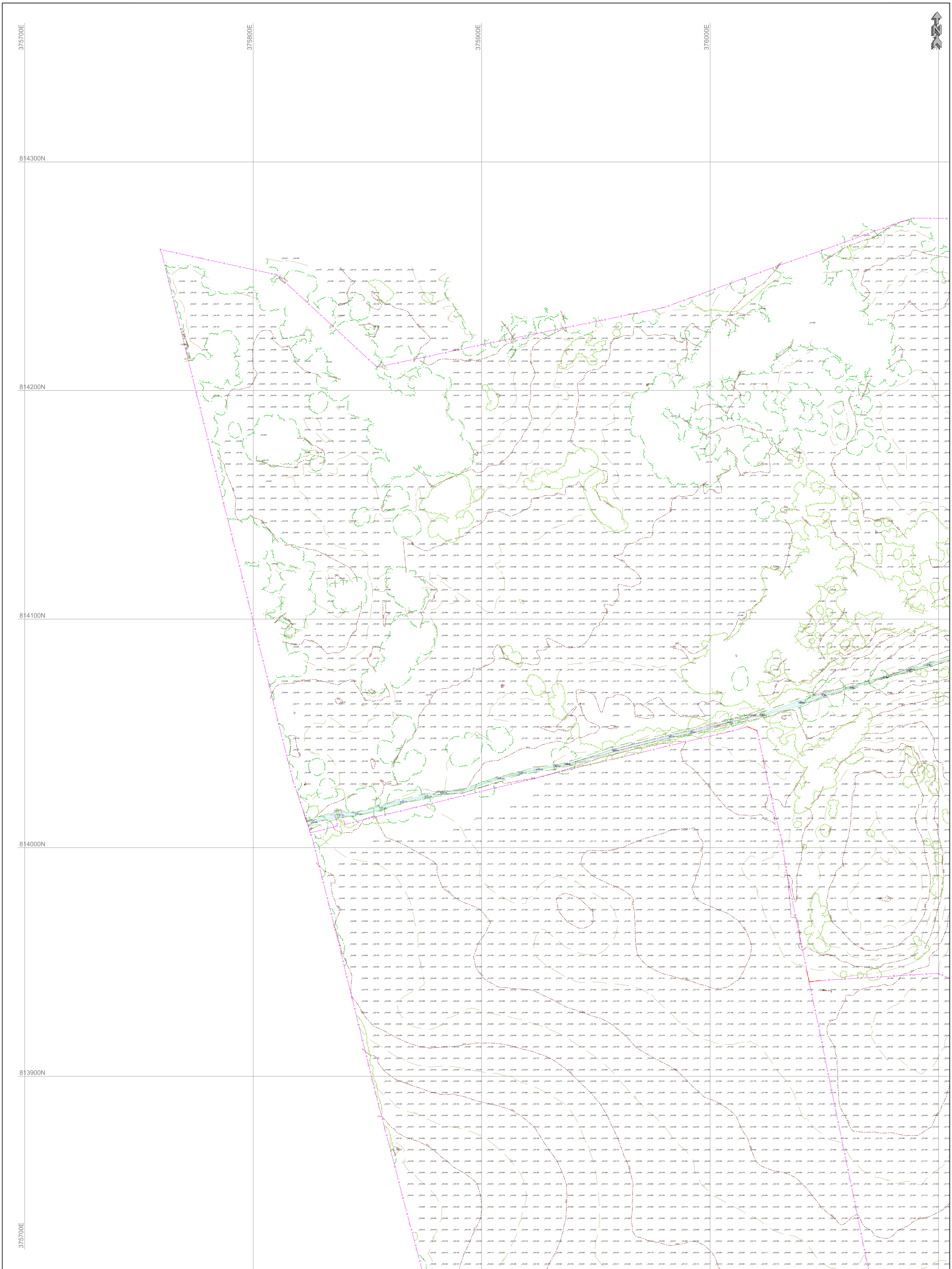

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376100E

376200E

376300E

376400E

814300N

814200N

814100N

N

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813800N

813700N

813600N

375800E

OHL Pylon

N

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376500E

376600E

376700E

814000N

813900N

813800N

813700N

813600N

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813300N

813200N

375900E

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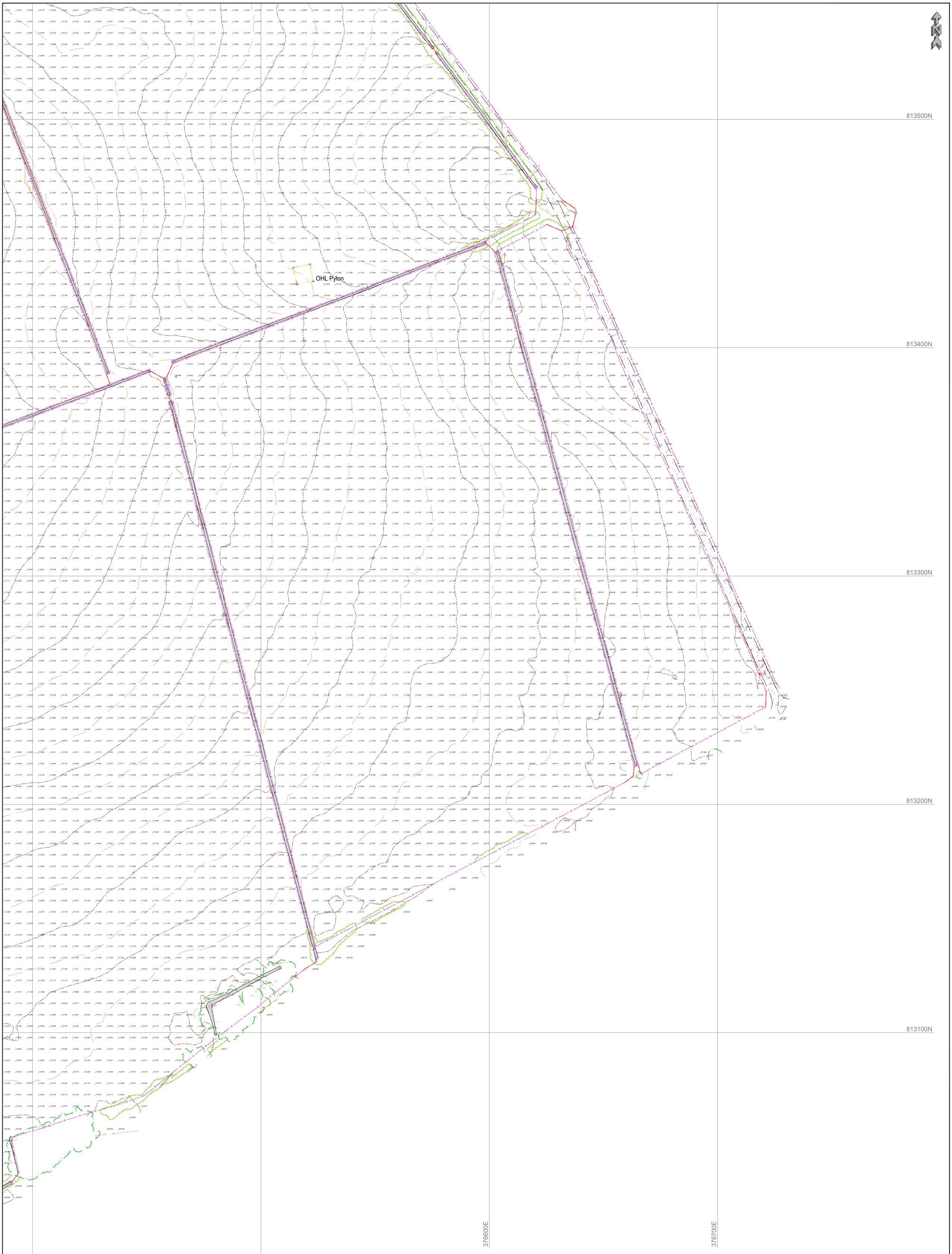

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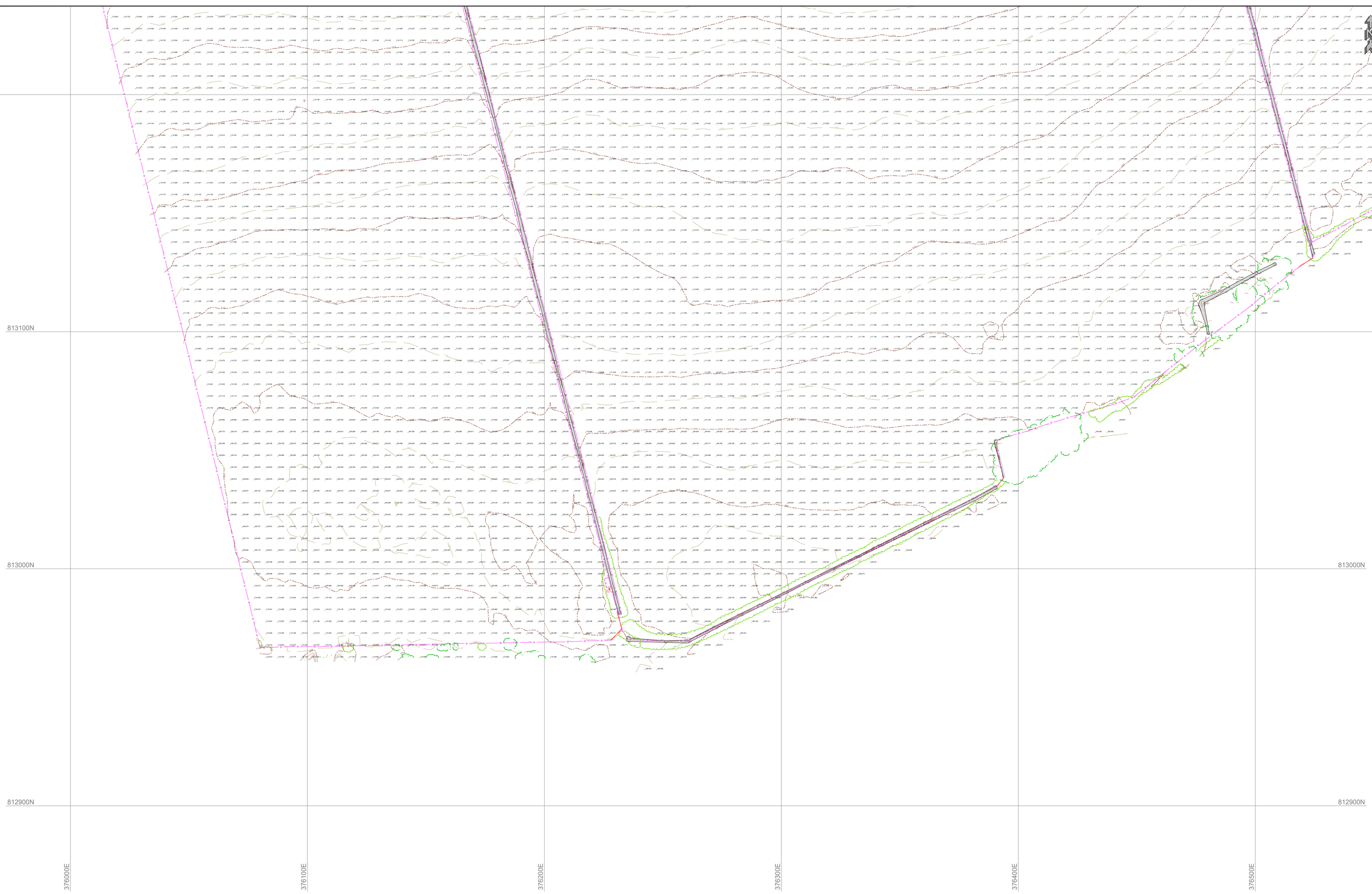

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Annex C SEPA Checklist

Kintore Hydrogen Facility

Appendix 13.2: Flood Risk Assessment

Kintore Hydrogen Ltd

SLR Project No.: 428.013099.00001

31 August 2024

Flood Risk Assessment (FRA) Checklist

(SS-NFR-F-001 - Version 13 - Last updated 15/04/2015

This document should 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						
Site Name		Kintore Hydrogen Facility				
Grid Reference	Easting:	375998	Northing:	813949		
Local Authority		Aberdeenshire Council				
Planning Reference number (if known)						
Nature of the development		Commercial	If residential, state type:			
Size of the development site		80	Ha			
Identified Flood Risk	Source:	Fluvial	Source name:			
Supporting Information						
Have clear maps / plans been provided within the FRA (including topographic and flood inundation plans)		Yes				
Has a historic flood search been undertaken?		Yes				
Is a formal flood prevention scheme present?		No	If known, state the standard of protection offered			
Current / historical site use		undeveloped				
Hydrology						
Area of catchment		2.05	km^2			
Qmed estimate		0.591	m^3/s	Method:	Gauged Record	
Estimate of 200 year design flood flow		2.29	m^3/s			
Estimation method(s) used *		Rainfall-runoff	If other (please specify methodology used):			
			If Pooled analysis have group details been included		Select from List	
Hydraulics						
Hydraulic modelling method		Linked 1D 2D	Software used:	TuFlow		
If other please specify						
Modelled reach length		c1000	m			
Any structures within the modelled length?		Select from List	Specify, if combination			
Brief summary of sensitivity tests, and range:						
variation on flow (%)		20	%			
variation on channel roughness		+/-40%				
blockage of structure (range of % blocked)			%	Reference CIRIA culvert design guide R168, section 8.4		
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	varies	m AOD	200 year plus climate change	varies	m AOD

Flood Risk Assessment (FRA) Checklist

(SS-NFR-F-001 - Version 13 - Last updated 15/04/2015

Coastal

Estimate of 200 year design flood level			m AOD			
Estimation method(s) used			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			
Development						
Is any of the site within the functional floodplain? (refer to SPP para 255)		Yes	If yes, what is the net loss of storage	98	m^3	
Is the site brownfield or greenfield		Greenfield				
Freeboard on design water level (m)			m			
Is the development for essential civil infrastructure or vulnerable groups?		No	If yes, has consideration been given to 1000 year design flood?			
Is safe / dry access and egress available?		Vehicular and Pedestrian	Min access/egress level		m AOD	
If there is no dry access, what return period is dry access available?			years			
If there is no dry access, what is the impact on the access routes?	Max Flood Depth @ 200 year event:		m	Max Flood Velocity:	0	m/s
Design levels	Ground level		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?		Yes				
Demonstration of compensatory storage on a "like for like" basis?		Yes				
Should water resistant materials and forms of construction be used?		No				
Comments						
Any additional comments:						

Approved by:	**R. Walker**
Organisation:	**SLR Consulting**
Date:	**20.05.2024**

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

**** ReFH2 is now accepted by SEPA for flow estimates in Scotland. Any use of this method should be compared with other accepted methods.***

Annex D Hydrology Report

Kintore Hydrogen Facility

Appendix 13.2: Flood Risk Assessment

Kintore Hydrogen Ltd

SLR Project No.: 428.013099.00001

31 August 2024

Kintore Hydrogen Facility

Flood Estimation Handbook Peak Flow Analysis

Kintore Hydrogen Ltd

Prepared by:

SLR Consulting Limited

Suite 223ab, 4 Redheughs Rigg Westpoint, South Gyle, Edinburgh EH12 9DQ

SLR Project No.: 428.013099.00001

Planning Application No: ENQ/2024/0415

31 August 2024

Revision: 02

Revision Record

Revision	Date	Prepared By	Checked By	Authorised By
1	13 May 2024	A. Hay	G. Frisby	R. Walker
2	31 August 2024	A. Hay	G. Frisby	R. Walker
	Click to enter a date.			
	Click to enter a date.			
	Click to enter a date.			

Basis of Report

This document has been prepared by SLR Consulting Limited (SLR) with reasonable skill, care and diligence, and taking account of the timescales and resources devoted to it by agreement with Kintore Hydrogen Ltd (the Client) as part or all of the services it has been appointed by the Client to carry out. It is subject to the terms and conditions of that appointment.

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Appendices

Appendix A WINFAP Outputs
Appendix B ReFH2 Outputs

1.0 Background

SLR Consulting Ltd (SLR) was appointed by Kintore Hydrogen Ltd (the “Client”) to undertake a Flood Risk Assessment for the proposed Kintore electrolysis plant, water abstraction and treatment plant and the gas injection location (the “Sites”).

Peak flow estimates and accompanying hydrographs are required for the 0.5%, 0.5% + climate change, 0.1% and 0.1% + climate change Annual Exceedance Probability (AEP) events. These are required for input into a bespoke hydraulic model constructed for the Dewsford Burn and it’s upstream tributaries around Bandshed Moss. As such, a single lumped flow estimate is required for the Dewsford burn at grid ref at E 377200, N 814550 (Catchment 3) and two sub catchment estimates (Catchments 1 and 2) on unnamed watercourses upstream of their confluence with the main reach of the Dewsford burn, approximately 1.25km upstream of Catchment 3 outlet.

2.0 Methodology

The flood estimates have been developed using the latest Flood Estimation Handbook[1] (FEH) Statistical and Rainfall Runoff methods. All catchments in this study are classed as small (<25km^2) and are ungauged.

The WINFAP v5.1 software[2] has been used to apply the Statistical method using the NRFA Peak Flow Dataset v12.1[3] to the lumped catchment. This method requires the estimation of the median annual flood (QMED) and a normalised flood frequency curve, termed flood growth curve.

The Rainfall Runoff methods are those first published by Kjeldsen[4], which were subsequently updated in 2015 and implemented within the ReFH2 software[5]. The latest ReFH2.3 model was released in 2023 and calibrated for the FEH22 depth duration frequency (DDF) rainfall model. This has been applied to all sub and lumped catchments. The 1999 re-statement of the FSR 'unit hydrograph' rainfall runoff method, as outlined in FEH Volume 4 has been applied to the catchments of this study due to advice outlined in Section 4.3 of SEPA technical flood risk guidance[6].

The FEH data and methods are the regulatory recommended methods for estimating river flood frequency and design rainfall in England, Scotland and Wales.

[1] Flood Estimation Handbook, Centre for Ecology and Hydrology. 1999

[2] https://www.hydrosolutions.co.uk/software/winfap-5/

[3] https://nrfa.ceh.ac.uk/peak-flow-dataset

[4] The revitalised FSR/FEH rainfall-runoff method. Supplementary Report No.1. Kjeldsen, T. R. Centre for Ecology and Hydrology. 2007.

[5] https://www.hydrosolutions.co.uk/software/refh-2/

[6] SEPA, May 2019,

3.0 Analysis

3.1 Catchment Boundary

The FEH Webservice[7] was used to define the catchment boundary at the single lumped and two sub catchment estimation points. The FEH catchment boundaries were reviewed against the Phase 2 LiDAR DTM data from the Scottish Remote Sensing Portal (tile NJ71) and OS 10 m interval contours. Upon review of the FEH Webservice derived catchment boundaries at the topographic dataset significant discrepancies were observed particularly in the upper sub catchments. This is likely due to the coarser scale 50m resolution Integrated Hydrological Digital Terrain Model[8] used in the FEH delineation. As such the catchment boundaries were manually defined based on the LiDAR and OS topographic datasets using engineering judgement.

To enable the adjustment of the FEH catchment descriptors, the FEH Webservice catchment boundary for the missing area was obtained so that the FEH catchment descriptors could be adjusted to account for the missing area. The National Grid References Eastings and Northings of the FEH Webservice derived catchment outlets are presented in Table 3-1. The FEH outlet locations and updated catchment delineations can be seen in Figure 3-1 to Figure 3-4.

Table 3-1: FEH Catchment Outlet NGRs

Name	Code	Grid Ref of Catchment Outlet	FEH Area (km2)	Updated Area (km2)
Northern Dewsford Burn upstream sub catchment 1	Catch_1	375750, 814200	0.51	0.34
Southern Dewsford Burn upstream sub catchment 2	Catch_2	375850, 814150	1.03	0.67
Dewsford Burn downstream lumped catchment 3	Catch_3	377200, 814550	2.21	2.05

[7] https://fehweb.ceh.ac.uk/

[8] https://www.ceh.ac.uk/data/integrated-hydrological-digital-terrain-model

Figure 3-1: FEH Delineated Catchment Outlet Locations

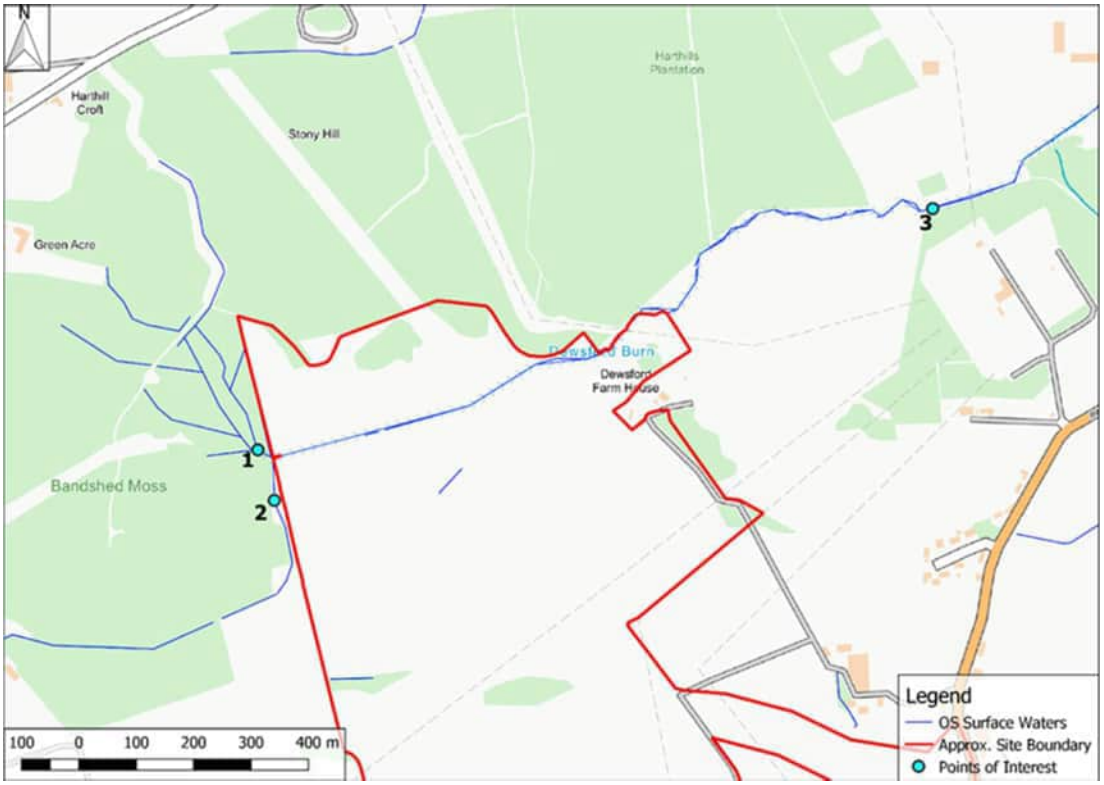


Figure 3-2: Updated Catchment Delineations – Catchment 1

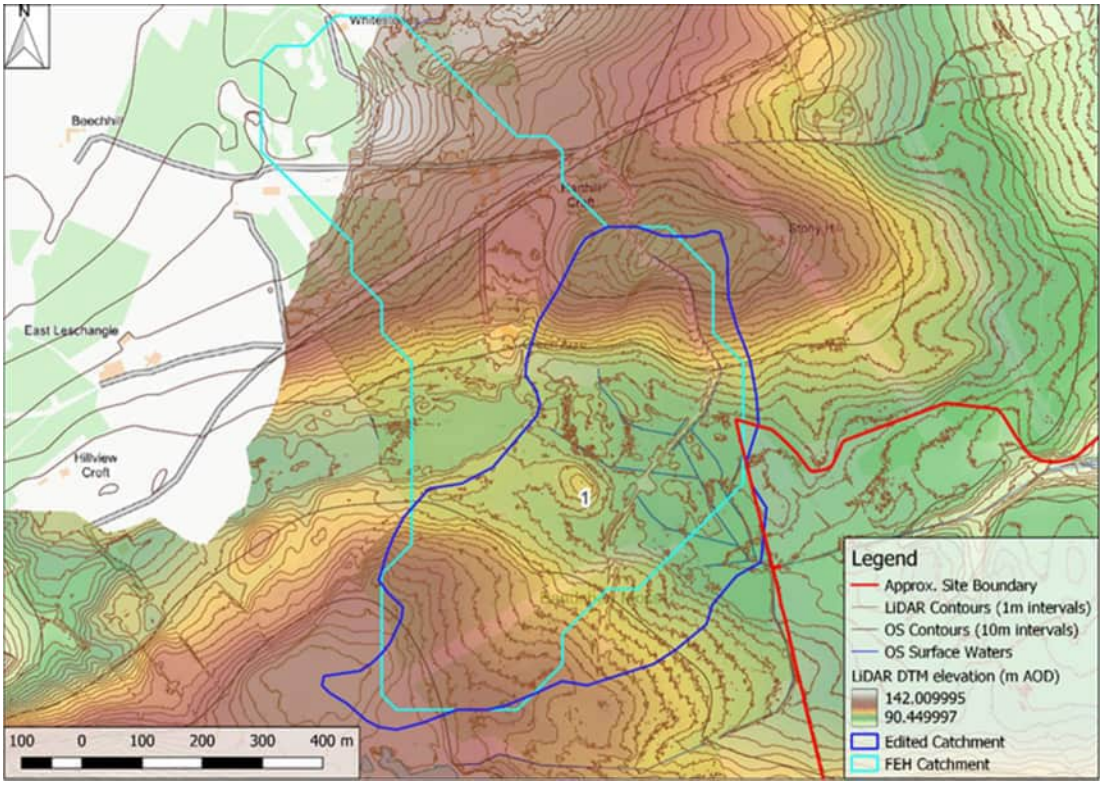


Figure 3-3: Updated Catchment Delineations – Catchment 2

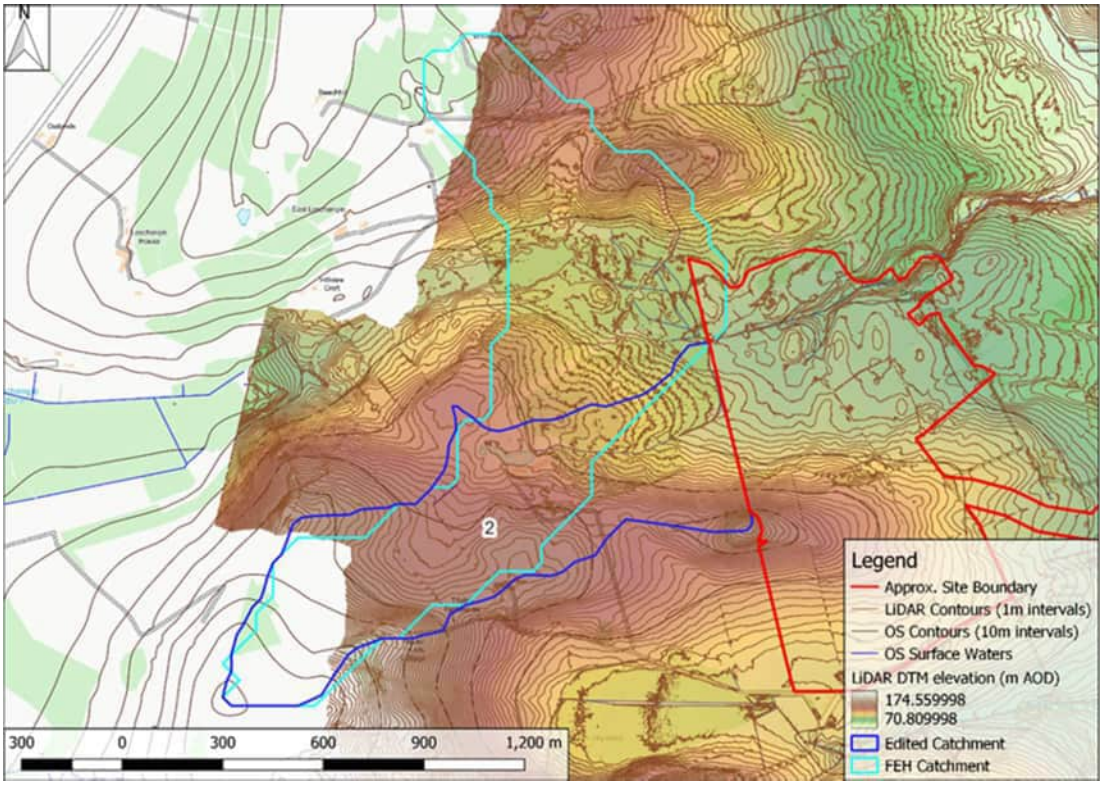
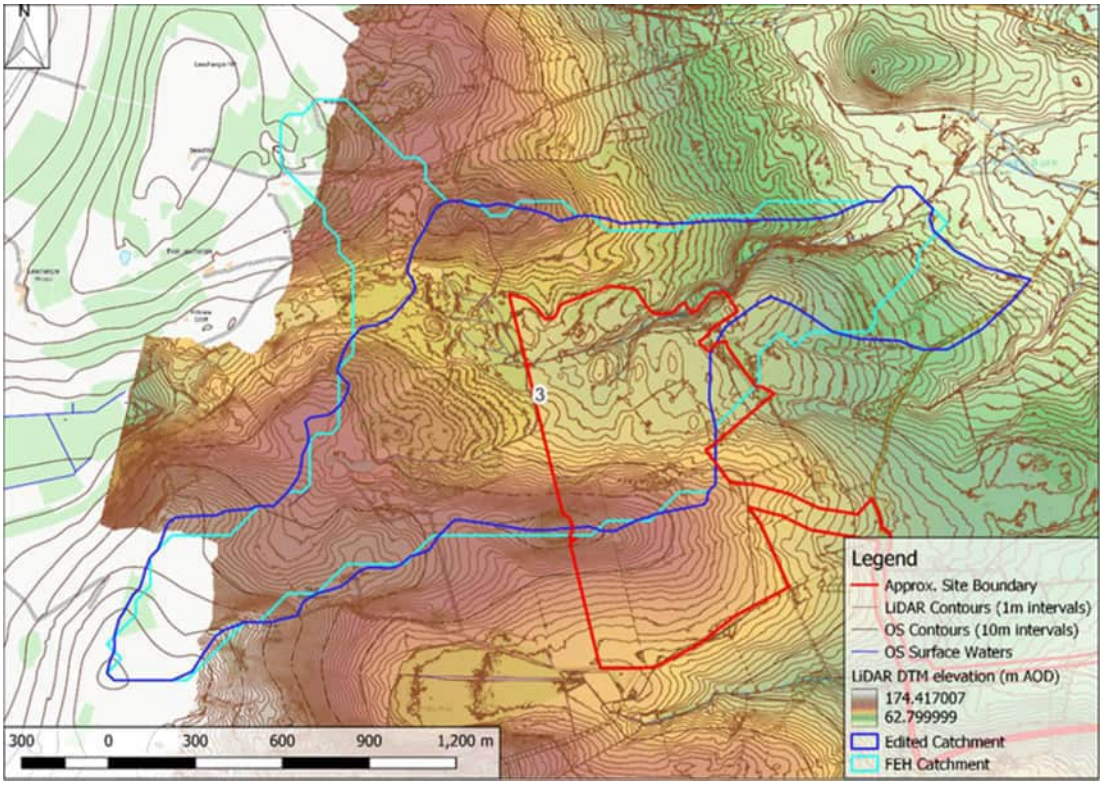


Figure 3-4: Updated Catchment Delineations – Catchment 3



3.2 Catchment Descriptors

3.2.1 FEH Catchment Descriptors

The catchment descriptors for the three catchments have been obtained from the FEH Webservice. The key FEH catchment descriptors for the three catchments are provided in Table 3-2..

The downstream catchment covers an area of approximately 2.05km^2 (updated delineation), with the Dewsford Burn flowing from west to east. The upper sub catchments drain agricultural and forested hillslopes to the west, with elevations reaching approximately 150m and 180m Above Ordnance Datum (mAOD) for Catchments 1 and 2 respectively. The lower catchment is characterised by moderate slopes and hills with the catchment outlet at approximately 75mAOD.

The catchment is predominantly underlain by a bedrock of Kemnay Pluton Granite. These are predominantly overlain by superficial deposits of the Banchory Till Formation and Glaciofluvial Sheet Deposits - Gravel, sand and silt in the lower parts of the catchment near the Dewsford Burn itself. This is reflected in the BFIHOST19 values of around 0.52 indicating that the catchment is 'moderately permeable'.

The catchment is not significantly influenced by lakes or reservoirs as indicated in the FARL value of 1.000.

The catchment is not significantly urbanised with the URBEXT2000 value of 0 classifying the catchment as 'essentially rural'.

Table 3-2: FEH Catchment Descriptors

Descriptor	Catch_1	Catch_2	Catch_3
FEH Area (km2)	0.51	1.03	2.21
SAAR6190 (mm)	786	785	785
DPLBAR (km)	0.68	0.98	2.02
BFIHOST19	0.514	0.521	0.517
FARL	1.000	1.000	1.000
FPEXT	0.0735	0.0823	0.0546
PROPWET	0.53	0.46	0.53
URBEXT2000	0.00	0.00	0.00

3.2.2 Adjusted Catchment Descriptors

As there are significant changes in catchment areas, key catchment descriptors for the updated catchment delineations have been updated using the area-weighting method, as detailed in FEH Chapter 5 Section 7.2[9]. As there are urban areas or reservoirs in the catchments, URBEXT and FARL remain unchanged. DPLBAR has been adjusted based on regression analysis of the relationship between DPLBAR and AREA for the FEH catchments. The key adjusted catchment descriptors are presented in Table 3-3.

[9] https://www.ceh.ac.uk/sites/default/files/2021-11/Flood-Estimation%20Handbook-5-Catchment-Descriptors_Adrian-Bayliss.pdf

Table 3-3: Adjusted Catchment Descriptors

Descriptor	Catch_1	Catch_2	Catch_3
Area (km^2)	0.34 [0.51]	0.67 [1.03]	2.05 [2.21]
DPLBAR (km)	0.54 [0.68]	1.31 [0.98]	1.89 [2.02]

3.3 Climate Change

The most recent advice on climate change is provided by the Scottish Environment Protection Agency (SEPA)[10]. The catchment is located within the North East Scotland region, as the catchment area is less than $30km^2$ the peak rainfall intensity allowance of 37% has been applied to the ReFH2 design rainfall to determine anticipated impact of climate change on peak flows. This analysis found the anticipated increase in peak flows as a result of climate change 45% for the 0.5% AEP event and between 47% and 48% for the 0.1% AEP event. As such the anticipated impact of climate change on peak flows has conservatively been estimated as 45% for 0.5% AEP event and 48% for the 0.1% AEP event.

3.4 Statistical Method

The FEH statistical method has been applied only to the downstream lumped catchment. This is as the lumped catchment (Catch_3) is the only catchment deemed large enough to be suitable for the application of the statistical method, and this method is being applied predominantly as a comparative method for peak flows.

3.4.1 Local Gauging Stations

There are no gauges on the Dewsford Burn or the Tauch Burn. The closest local river gauging station within the NRFA and SEPA hydrometric dataset[11] is the Don at Haughton (NRFA: 11002) located upstream of the confluence of the Tauch Burn and the River Don. The gauging station is considered as suitable for QMED and Pooling group. The gauge has 50 years of gauging station record and 1 ‘Non-flood year’ on record.

The Annual Maxima (AM) flood flow data for the Don at Haughton gauging station is shown in Figure 3-5, and a map of local gauging stations is shown in Figure 3-6.

[10] https://www.sepa.org.uk/media/gq3c2xyb/climate-change-allowances-guidance-v4-final_nov23.pdf

[11] https://timeseriesdoc.sepa.org.uk/

Figure 3-5: Don at Haughton AMAX data series

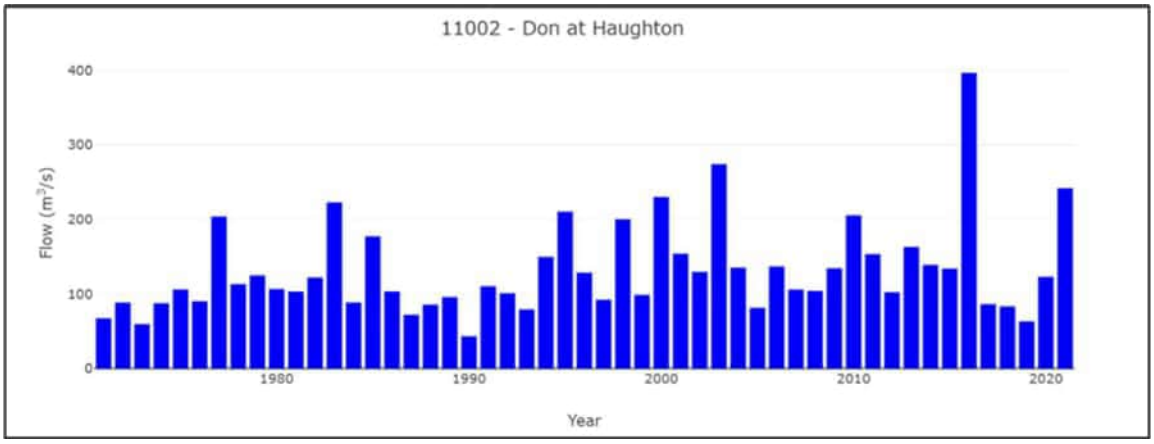
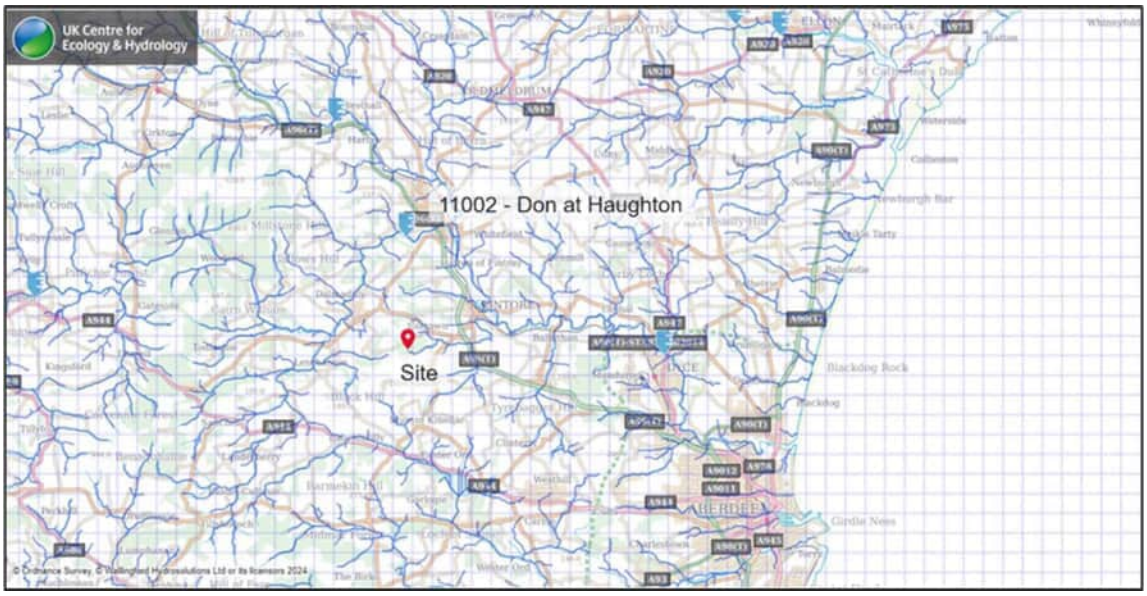


Figure 3-6: Local Gauging Stations



3.4.2 QMED Estimation

The rural QMED for the lumped catchment estimates were initially estimated from catchment descriptors ($QMED_{cds}$) which is presented in

Table 3-5. As the catchment is ungauged the estimates of QMED were refined using the Donor Adjustment method[12]

As the catchments are defined as small catchments (<25km^2) in line with the recommendations by Phase 2 of the small catchments research[13], the donor group was initially comprised of the geographically closest station suitable for QMED estimation.

The 10 closest stations suitable for QMED estimation and the selected donor station are provided in Table 3-4. It should be noted that the Don at Haugton gauge is the closest gauge in terms of catchment outlet.

The 4 closest stations show a trend of $QMED_{cds}$ overestimating observed QMED, indicating that catchment descriptors overestimate QMED in local area.

Table 3-4: Fithie Burn Downstream Lumped Catchment Donor Group Used

NRFA Number	Station Name	Centroid Distance (km)	QMED Deurbanised (m^3/s)	$QMED_{cds}$ Rural (m^3/s)	Adjustment Ratio[1]	Decision
11001	(Don @ Parkhill)	18.51	135.53	169.10	0.80	Reject
10003	(Ythan @ Ellon)	24.51	58.37	59.59	0.98	Reject
10001	(Ythan @ Ardlethen)	25.81	50.09	55.87	0.90	Reject
11002	**(Don @ Haughton)**	**27.23**	**108.18**	**126.18**	**0.86**	**Accept**
12008	(Feugh @ Heugh Head)	30.44	134.42	107.56	1.25	Reject
9004	(Bogie @ Redcraig)	31.58	31.57	44.42	0.71	Reject
13001	(Bervie @ Inverbervie)	35.09	35.51	30.62	1.16	Reject
9001	(Deveron @ Avochie)	36.13	127.33	114.80	1.11	Reject
11003	(Don @ Bridge of Alford)	36.39	93.18	101.10	0.92	Reject
9002	(Deveron @ Muiresk)	37.99	263.70	183.40	1.44	Reject

Note 1: Adjustment ratio is the ratio of de-urbanised QMED from flow data to $QMED_{cds}$.

The observed QMED values for each gauged catchment were deurbanised prior to being used for donor transfer. The Don at Haughton gauge has been selected as the donor station due to similarities in catchment descriptors such as catchment orientation and BFIHOST, geographic distance and being well gauged for high flows. The final rural QMED estimate following donor transfer are provided in

[12] Using multiple donor sites for enhanced flood estimation in ungauged catchments, Kjeldsen, T.R., Jones, D.A., and Morris, D.G. Water Resour. Res., 50, 6646-6657. 2014

[13] Estimating flood peaks and hydrographs for small catchments: Phase 2. Project: SC090031. Stewart, L., Faulkner, D., Formetta, F., Griffin, A., Haxton, T., Prosdocimi, I., Vesuviano, G., and Young. A. 2019

Table 3-5.

As all the catchments are classified as ‘essentially rural’ based on the FEH guidance with URBEXT2000 values of 0, the UAF for the catchments is 1 and therefore the urbanised QMED estimates are the same as the rural QMED estimates.

Table 3-5: Lumped Catchment QMED Estimates

Code	$QMED_{cds}$ (m^3/s)	Donor Adjusted QMED (m^3/s)
Catch_3	0.615	0.591

3.4.3 Growth Curve Derivation

In line with best practice guidance from the Environment Agency[14] and to promote spatial consistency between the multiple flood estimation points, a single pooling group has been applied to all the lumped catchments, with the pooling group selected based on the Fithie Burn downstream catchment.

Flood growth curves for the site have been estimated using the weighted average of the L-moments of the distributions of Annual Maxima (AM) flood flow data from a pooling group of hydrologically similar gauging stations, including a minimum of 500 years of AM data.

Similarity is defined using the FEH similarity distance measure (SDM), for small catchments it is assessed with regards to the catchment descriptors: AREA and SAAR.

Following a review of the default pooling group NRFA station 7011 Black Burn at Pluscarden Abbey was due to high skew (L-CV_{deurb} 0.494 and L-$SKEW_{deurb}$ 0.553) in the site growth curve for the higher return periods, as well as a lack of data with less than 9 years of data collection. Without this site the total years of data is still above 500yrs (525yrs).

The initial pooling group and details of any stations added or removed from the group are detailed in Table 3-6, full details of pooling group stations are provided in Appendix A.

Table 3-6: Pooling Group Selection

NRFA Number	Station Name	SDM	Decision
76011	(Coal Burn @ Coalburn)	0.973	Accept
27073	(Brompton Beck @ Snainton Ings)	1.114	Accept
27051	(Crimple @ Burn Bridge)	1.125	Accept
45816	(Haddeo @ Upton)	1.564	Accept
25019	(Leven @ Easby)	1.591	Accept
26016	(Gypsey Race @ Kirby Grindalythe)	1.625	Accept
49005	(Bolingey Stream @ Bolingey Cocks Bridge)	1.826	Accept
27010	(Hodge Beck @ Bransdale Weir)	1.876	Accept
28033	(Dove @ Hollinsclough)	1.881	Accept
44008	(South Winterbourne @ Winterbourne Steepleton)	1.953	Accept

[14] https://www.gov.uk/government/publications/flood-estimation-guidelines

NRFA Number	Station Name	SDM	Decision
26014	(Water Forlornes @ Driffield)	2.201	Accept
36010	(Bumpstead Brook @ Broad Green)	2.219	Accept
47022	(Tory Brook @ Newnham Park)	2.234	Accept
41020	(Bevern Stream @ Clappers Bridge)	2.286	Accept
7011	(Black Burn @ Pluscarden Abbey)	2.28	Reject

The standardised test value of H2 is 3.6, WINFAP categorises this as "*The pooling group is strongly heterogeneous and a review of the pooling group is essential*". It is noted that due to the small catchment size (2.05km^2) and lack of similar sized gauged catchments the pooling group is expected to be heterogeneous.

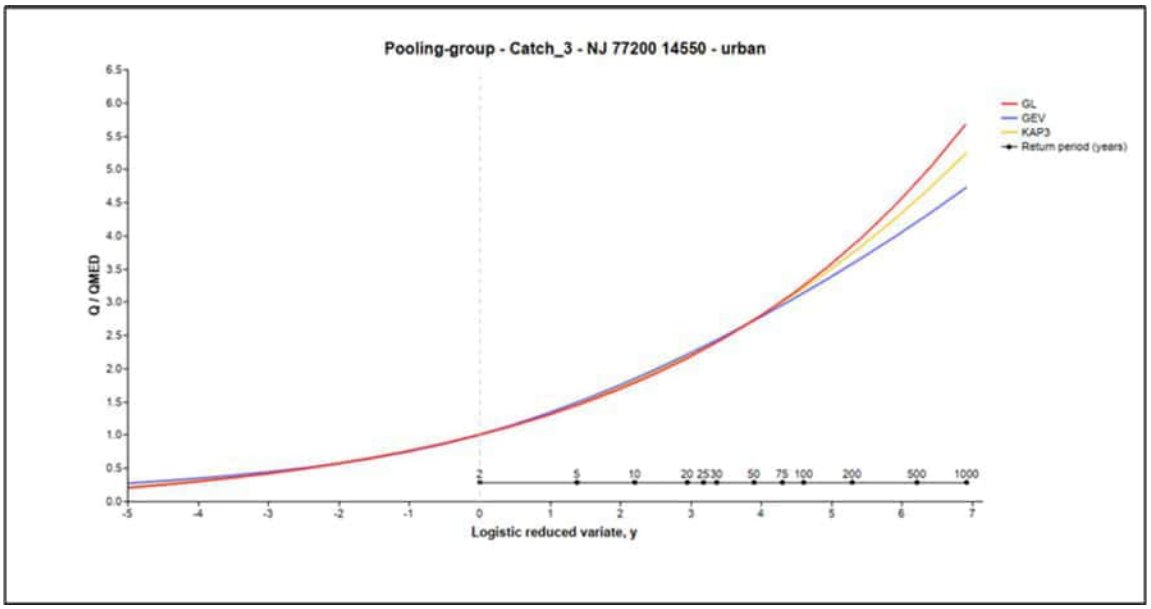
Due to the best fit (lowest absolute Z value of -0.0619), the General Extreme Value growth curve fitting has been selected. As the catchment is essentially rural the de-urbanised L-moments were used. The growth curve L-moments are L-CV 0.268 and L-Skew 0.234. The peak flow estimates for the downstream lumped catchment are presented in Table 3-7.

Table 3-7: Peak Flow Estimates

AEP (%)	0.5	0.5 + 45% CC	0.1	0.1 + 48% CC
Catch_3	2.11	3.0595	2.79	4.12

The final pooling group growth curve is presented in Figure 3-7.

Figure 3-7: Catch_3 Pooling Group Growth Curve



3.5 Rainfall Runoff Method

3.5.1 Revitalised Flood Hydrograph Method (ReFH2)

The FEH rainfall runoff method analysis has been undertaken using the ReFH2.3 model. As the catchments cover areas above 0.5km^2 and all contain clear watercourses, the catchment scale equations have been used. The Scotland specific algorithm for estimation of model parameters has also selected.

The default model parameters have been retained. As this is a rural catchment the default winter storm seasonality has been used. The default urbanisations parameters have also been retained, as the catchment is 'essentially rural' the flow estimates are not sensitive to urbanisation.

The default recommended duration and timesteps for the Catch_1 and Catch_2 catchments have been assessed, to enable critical duration testing to be undertaken. The aerial reduction factor (ARF) and seasonal correction factor (SCF) have been based on the default ARF and SCF for the FB_DS catchment for the respective event duration. The duration and timesteps assessed along with their respective ARF and SCF values are presented in Table 3-8.

The FEH22 design-depth-frequency (DDF) model derived from the FEH Webservice for the FB_DS catchment has been used for all catchment assessed.

Table 3-8: ARF and SCF Factors for assessed events

Duration (hh:mm:ss)	Timestep (hh:mm:ss)	ARF	SCF
03:30:00	00:30:00	0.968	0.681

The ReFH2 summary reports for the Catch_2 3 hour 15 minute 0.1% AEP + 37% climate change (CC) (peak rainfall intensity) event is provided in Appendix B.

The final peak flow estimates from the Rainfall Runoff method are provided in Table 3-9, with the recommended storm duration event shown for each catchment to show the largest peak flows.

Table 3-9: Final ReFH2 Rainfall Runoff Method Peak Flow Estimates

Catchment	Event Duration	AEP %			
		0.5	0.5 + CC	0.1	0.1 + CC
Catch_1 Peak Flow (m^3/s)	2.75hr	0.50	0.72	0.72	1.06
Catch_2 Peak Flow (m^3/s)	3.25hr	0.81	1.17	1.16	1.72
Catch_3 Peak Flow (m^3/s)	3.5hr	2.29	3.33	3.29	4.86

3.5.2 Re-statement of the FSR 'unit hydrograph' Rainfall-Runoff Method

The 1999 FEH rainfall runoff method as Outlined in Chapter 4 of the Flood Estimation Handbook has been applied to all catchments in this study to provide a peak flow estimate comparison to the updated ReFH2 method. See Table 3-10.

Table 3-10: Final 1999 Rainfall Runoff Method Peak Flow Estimates

Catchment	Event Duration	AEP %			
		0.5	0.5 + CC	0.1	0.1 + CC
Catch_1 Peak Flow (m^3/s)	2.75hr	0.51	0.74	0.8	1.18
Catch_2 Peak Flow (m^3/s)	3.25hr	0.76	1.10	1.18	1.75
Catch_3 Peak Flow (m^3/s)	3.5hr	1.94	2.81	3.02	4.47

4.0 Results and Discussion

4.1 Peak Flows

A comparison of peak flow for the downstream lumped catchment is shown below in Table 4-1.

Table 4-1: Peak Flow Estimate Method Comparison – Catch_3

AEP (%)	0.5	0.5 + 45% CC	0.1	0.1 + 48% CC
FEH Statistical Method	2.11	3.0595	2.79	4.12
ReFH2	2.29	3.33	3.29	4.86
1999 Rainfall Runoff	1.94	2.81	3.02	4.47

Peak flow estimates derived from the statistical method are lower than the peak flows derived using the rainfall runoff method. 1999 Re-Statement of the rainfall runoff method also shows lower peak flow estimates than the ReFH2 rainfall runoff method.

Due to the small size of the catchments (<2.5.km^2), rainfall runoff methods are considered more appropriate as the statistical method struggles to represent the catchment through the pooling group of similar gauging stations, leading to highly heterogenous pooling groups as in this study. There also tends to be greater confidence in rainfall frequency growth curves compared to flood frequency growth curves for large events (200yr and 1000yr return period) due to the greater availability of long rainfall records and the spatial consistency of extreme rainfall[15].

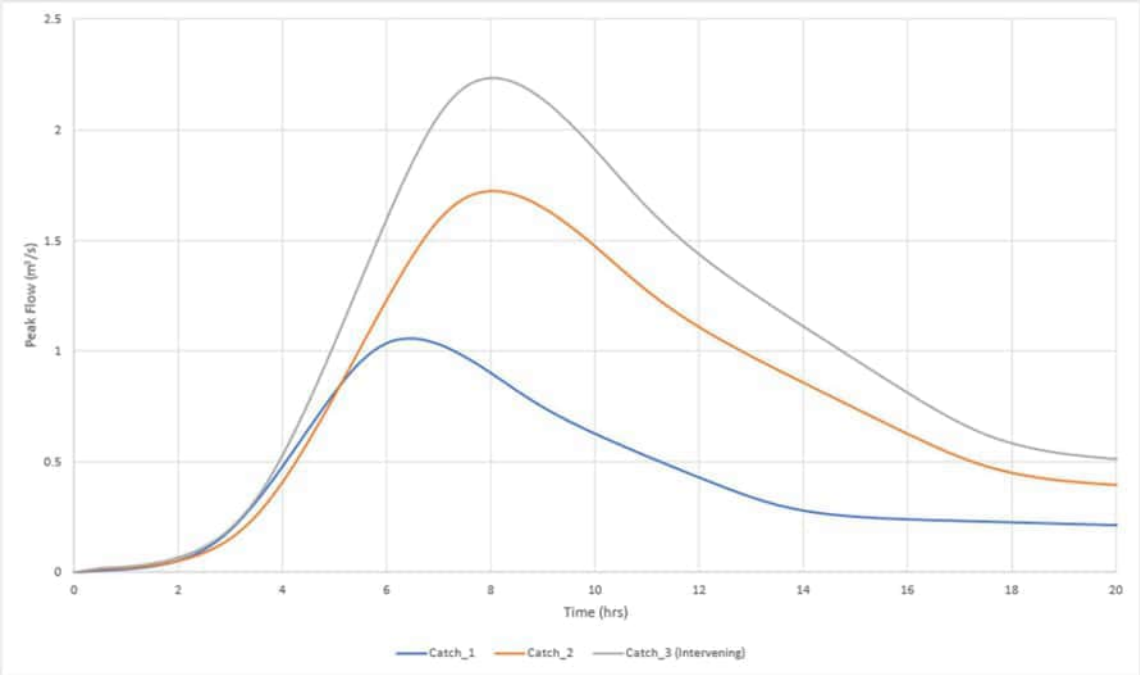
The inclusion of more modern rainfall data (FEH22 DDF) and calibration specifically to Scottish catchments means the ReFH2 method is deemed the most suitable method for peak flow and hydrograph estimation.

4.2 Hydrographs

Final hydrographs for Catch_1 and Catch_2 are the raw ReFH2 hydrographs, with Catch_3 hydrograph being added as an intervening catchment. The difference in peak flow between the lumped downstream Catch_3 and combined sub catchments Catch1 and Catch 2 is applied as a peak flow for the intervening catchment. The Catch_3 intervening peak flow has been used to scale the Catch_2 hydrograph, as this is the dominant sub catchment and therefore allows matching of the peak flows. The final peak flow hydrographs to be adopted in the hydraulic model are shown below event can be seen in Figure 4-1 for the largest event.

[15] Environment Agency, Flood Estimation Guidelines LIT 11832 – Section 6.6: Estimating long return period floods (200 – 1000 years), Published 07/07/2022

Figure 4-1: 0.1% AEP + 48% CC Design Hydrographs



4.3 Discussion

4.3.1 Assumptions and limitations

The main assumptions made during this hydrology study are as follows:

- There is higher confidence in the growth curves for rainfall than for river flows for events with a higher than 0.5% AEP.
- There is negligible difference in the peak flow estimates at the outlet of the upstream lumped catchments assessed and the upstream boundaries of the model.
- As the catchment is small and has no large attenuating water bodies, flooding at the site is conveyance driven and not volumetrically driven.
- The rainfall runoff method derived hydrograph shapes are representative of the runoff response of the catchment.

4.3.2 Suitability of results for future studies

The flow estimates derived are suitable for the site only as the hydrology has been targeted towards flows at the site, and not location upstream or downstream.

Appendix A WINFAP Outputs

Kintore Hydrogen Facility

Flood Estimation Handbook Peak Flow Analysis

Kintore Hydrogen Ltd

SLR Project No.: 428.013099.00001

31 August 2024

UK Design Flood Estimation

Summary of ESS/Pooled Estimation Analysis using the Flood Estimation Handbook Statistical Method

Date of creation:	15-05-2024 21:59:16
Software:	WINFAP Version: 5.1.8682 (15044)
Peak Flow dataset:	Peak Flow Dataset 12.1.1
Supplementary data used:	No

Site details

Site number:	2330272216
Site name:	FEH_Catchment_Descriptors_377200_814550_v5_0_1_C3
Site location:	NJ 77200 14550
Easting:	377200
Northing:	814550
Catchment area:	2.04 km²
SAAR:	785 mm
BFIHOST19:	0.517
FPEXT:	0.055
FARL:	1.000
URBEXT2000:	0.0000

Site data

At-site data

At-site data present: No

UK Design Flood Estimation

Summary of ESS/Pooled Estimation Analysis using the Flood Estimation Handbook Statistical Method

Analysis settings

Urbanisation settings

User defined:	No
Urban area:	0.00 km²
PRimp:	70.00%
Impervious Factor:	0.300
UAF:	1.00000

Growth curve settings

Distance Measure Method:	Small catchment
Pooling group URBEXT2000 Threshold:	0.030
Deurbanise Pooling Group L-moments:	Yes

QMED settings

Use at-site data:	No
Method:	Donor Station(s)

Growth curve data and results

Pooling group AM data

Station	Distance	Years of data	QMED AM	L-CV Observed	L-CV Deurbanised	L-SKEW Observed	L-SKEW Deurbanised
76011 (Coal Burn @ Coalburn)	0.973	45	1.840	0.171	**0.171**	0.292	**0.292**
27073 (Brompton Beck @ Snainton Ings)	1.114	42	0.816	0.212	**0.213**	0.020	**0.018**
27051 (Crimple @ Burn Bridge)	1.125	50	4.641	0.218	**0.218**	0.133	**0.133**
45816 (Haddeo @ Upton)	1.564	29	3.248	0.289	**0.290**	0.432	**0.431**
25019 (Leven @ Easby)	1.591	44	5.384	0.340	**0.341**	0.367	**0.366**
26016 (Gypsey Race @ Kirby Grindalythe)	1.625	25	0.101	0.309	**0.309**	0.249	**0.249**
49005 (Bolingey Stream @ Bolingey Cocks Bridge)	1.826	12	4.924	0.266	**0.267**	0.268	**0.267**
27010 (Hodge Beck @ Bransdale Weir)	1.876	41	9.420	0.224	**0.224**	0.293	**0.293**
28033 (Dove @ Hollinsclough)	1.881	47	4.150	0.231	**0.231**	0.381	**0.381**
44008 (South Winterbourne @ Winterbourne Steepleton)	1.953	31	0.544	0.413	**0.414**	0.268	**0.267**
26014 (Water Forlornes @ Driffield)	2.201	24	0.431	0.318	**0.319**	0.185	**0.184**
36010 (Bumpstead Brook @ Broad Green)	2.219	55	7.590	0.352	**0.354**	0.109	**0.108**
47022 (Tory Brook @ Newnham Park)	2.234	27	6.176	0.246	**0.248**	0.151	**0.149**
41020 (Bevern Stream @ Clappers Bridge)	2.286	53	13.660	0.201	**0.202**	0.172	**0.170**
Total		**525**					

UK Design Flood Estimation

Summary of ESS/Pooled Estimation Analysis using the Flood Estimation Handbook Statistical Method

Pooling group suitability

Station	Suitability for QMED	Suitability for pooling	Years	Non-flood years	Percentage non-flood years	Mann Kendall (MK)	MK significance (%)	Discordancy	Comments
76011 (Coal Burn @ Coalburn)	Yes	Yes	45	0	0.00			0.981	
27073 (Brompton Beck @ Snainton Ings)	Yes	Yes	42	2	4.76	1.17	None	1.398	
27051 (Crimple @ Burn Bridge)	Yes	Yes	50	4	8.00	1.51	None	0.469	
45816 (Haddeo @ Upton)	Yes	Yes	29	0	0.00	-0.83	None	1.033	
25019 (Leven @ Easby)	Yes	Yes	44	3	6.82			0.815	
26016 (Gypsey Race @ Kirby Grindalythe)	Yes	Yes	25	3	12.00			0.267	
49005 (Bolingey Stream @ Bolingey Cocks Bridge)	Yes	Yes	12	0	0.00			3.198	
27010 (Hodge Beck @ Bransdale Weir)	Yes	Yes	41	1	2.44	-2.10	5	0.338	
28033 (Dove @ Hollinsclough)	Yes	Yes	47	1	2.13			0.861	
44008 (South Winterbourne @ Winterbourne Steepleton)	Yes	Yes	31	8	25.81	1.07	None	1.589	
26014 (Water Forlornes @ Driffield)	Yes	Yes	24	3	12.50			0.307	
36010 (Bumpstead Brook @ Broad Green)	Yes	Yes	55	12	21.82	0.09	None	1.580	
47022 (Tory Brook @ Newnham Park)	Yes	Yes	27	1	3.70			0.415	
41020 (Bevern Stream @ Clappers Bridge)	Yes	Yes	53	2	3.77	1.06	None	0.749	

Pooling group catchment descriptors

Station	Area	SAAR	FPEXT	FARL	URBEXT2000	BFIHOST19
76011 (Coal Burn @ Coalburn)	1.630	1096	0.074	1.000	0.000	0.274
27073 (Brompton Beck @ Snainton Ings)	8.060	721	0.237	1.000	0.008	0.811
27051 (Crimple @ Burn Bridge)	8.172	855	0.013	1.000	0.006	0.329
45816 (Haddeo @ Upton)	6.808	1210	0.011	1.000	0.005	0.535
25019 (Leven @ Easby)	15.088	830	0.019	1.000	0.004	0.495
26016 (Gypsey Race @ Kirby Grindalythe)	15.850	757	0.030	1.000	0.000	0.927
49005 (Bolingey Stream @ Bolingey Cocks Bridge)	16.080	1044	0.023	0.991	0.006	0.562
27010 (Hodge Beck @ Bransdale Weir)	18.820	987	0.009	1.000	0.001	0.303
28033 (Dove @ Hollinsclough)	7.915	1346	0.007	1.000	0.000	0.347
44008 (South Winterbourne @ Winterbourne Steepleton)	20.183	1012	0.015	1.000	0.004	0.848
26014 (Water Forlornes @ Driffield)	32.415	721	0.016	1.000	0.007	0.924
36010 (Bumpstead Brook @ Broad Green)	27.547	588	0.045	0.999	0.007	0.367
47022 (Tory Brook @ Newnham Park)	13.432	1403	0.023	0.942	0.014	0.353
41020 (Bevern Stream @ Clappers Bridge)	35.480	886	0.076	0.993	0.013	0.362

Pooling Group Rejected Stations

Station	Distance	Years of data	QMED AM	L-CV Observed	L-CV Deurbanised	L-SKEW Observed	L-SKEW Deurbanised	Comments
7011 (Black Burn @ Pluscarden Abbey)	2.280	10	4.752	0.494	0.494	0.554	0.553	

UK Design Flood Estimation

Summary of ESS/Pooled Estimation Analysis using the Flood Estimation Handbook Statistical Method

Growth curve L-moments

Rural L-CV:	0.268	Urban L-CV:	0.268
Rural L-Skewness:	0.234	Urban L-Skewness:	0.234

Rural fitted parameters

Distribution	Location	Scale	Shape	H	Bound
GL	1.000	0.271	-0.234		-0.160
GEV	0.854	0.392	-0.097		-3.184
KAP3	0.926	0.325	-0.172	-0.400	-0.957

Urban fitted parameters

Distribution	Location	Scale	Shape	H	Bound
GL	1.000	0.271	-0.234		-0.160
GEV	0.854	0.392	-0.097		-3.184
KAP3	0.926	0.325	-0.172	-0.400	-0.957

Goodness of fit

GL:	1.5570 *
GEV:	-0.0460 *
P3:	-1.7111
GP:	-3.8768
KAP3:	1.0019 *

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

Heterogeneity

Standardised test value H2: 3.5788

The pooling group is heterogeneous and a review of the pooling group is desirable.

Standardised growth curves

Rural

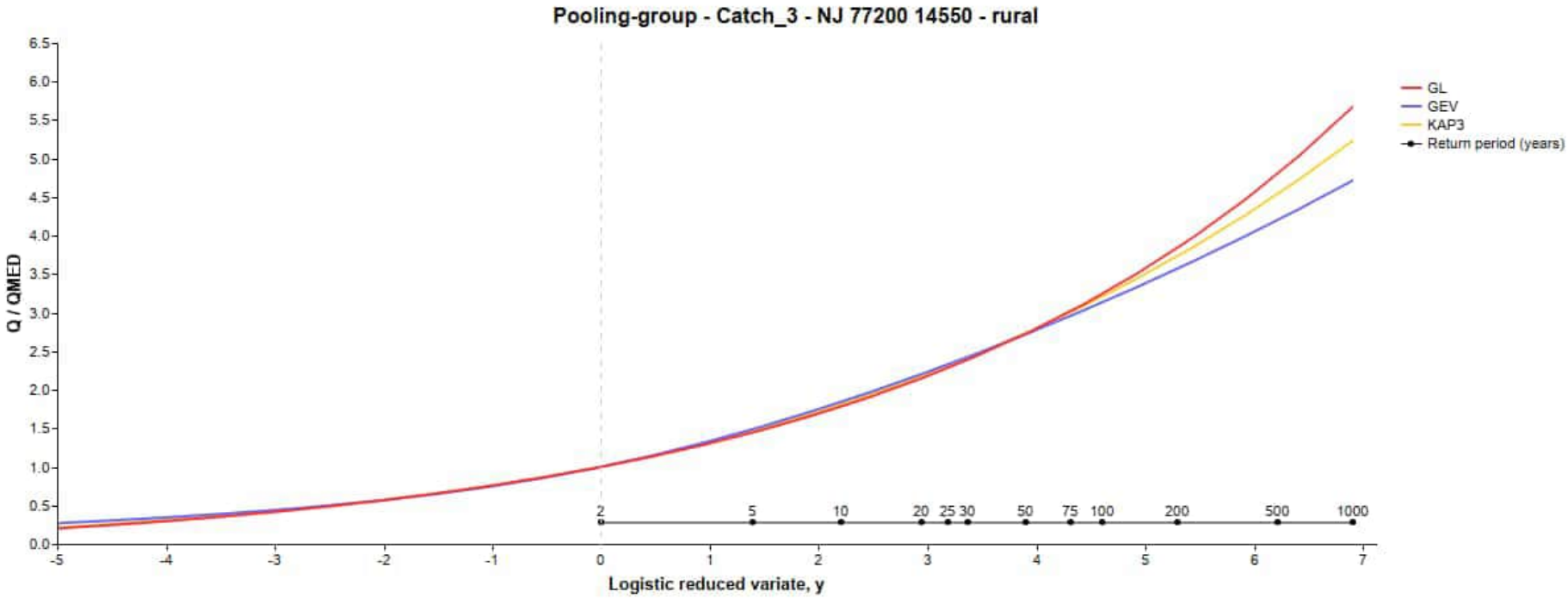
Return period	GL	GEV	KAP3
2	1.000	1.000	1.000
5	1.444	1.487	1.462
10	1.779	1.841	1.808
20	2.150	2.205	2.179
25	2.280	2.326	2.306
30	2.390	2.426	2.413
50	2.723	2.716	2.730
75	3.015	2.955	3.000
100	3.238	3.130	3.203
200	3.841	3.572	3.734
500	4.801	4.203	4.539
1000	5.676	4.718	5.237

Urban

Return period	GL	GEV	KAP3
2	1.000	1.000	1.000
5	1.444	1.487	1.462
10	1.779	1.841	1.808
20	2.150	2.205	2.179
25	2.280	2.326	2.306
30	2.390	2.426	2.413
50	2.723	2.716	2.730
75	3.015	2.955	3.000
100	3.238	3.130	3.203
200	3.841	3.572	3.734
500	4.801	4.203	4.539
1000	5.676	4.718	5.237

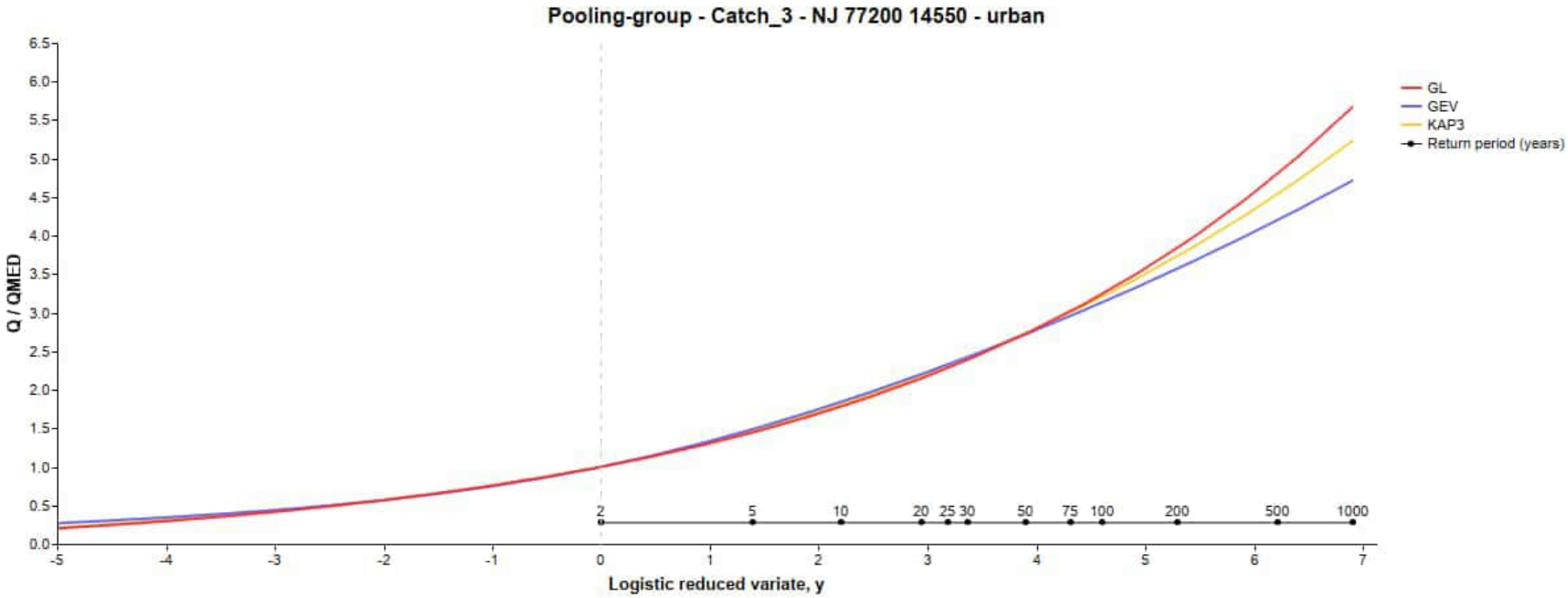
UK Design Flood Estimation

Summary of ESS/Pooled Estimation Analysis using the Flood Estimation Handbook Statistical Method



UK Design Flood Estimation

Summary of ESS/Pooled Estimation Analysis using the Flood Estimation Handbook Statistical Method



UK Design Flood Estimation

Summary of ESS/Pooled Estimation Analysis using the Flood Estimation Handbook Statistical Method

QMED data and results

Donor selection criteria

Only sites suitable for QMED:	Yes
URBEXT2000:	<0.030
Donor adjusted FSE:	1.413
No. of donors:	1

Donor stations

Station	Distance	Use QMED obs deurbanised	QMED obs	QMED deurbanised	QMED CDs urban	QMED CDs rural
11002 (Don @ Haughton)	27.23	Yes	108.393	**108.175**	126.178	126.178

Donor suitability

Station	Suitability for QMED	Suitability for pooling	Years	Non-flood years	Percentage non-flood years	Mann Kendall (MKZ)	MKZ significance (%)	Comments
11002 (Don @ Haughton)	Yes	Yes	50	1	2.00	2.13	5	

Donor catchment descriptors

Station	Area	Centroid X	Centroid Y	SAAR	FPEXT	FARL	URBEXT2000	BFIHOST19
*FEH_Catchment_Descriptors_377200_814550_v5_0_1_C3 @ NJ 77200 14550)	2.041	375781	813983	785	0.055	1.000	0.000	0.517
11002 (Don @ Haughton)	792.673	348554	814054	916	0.051	0.997	0.002	0.542

Unused Donor stations

Station	Distance	URBEXT	Use QMED obs deurbanised	QMED obs	QMED deurbanised	QMED CDs urban	QMED CDs rural	Centroid X	Centroid Y	Area	SAAR	BFIHOST19	FARL	Years of data	QMED suitability	Pooling suitability
11001 (Don @ Parkhill)	18.51	0.004	Yes	136.246	**135.533**	169.096	169.096	357665	817763	1269.145	884	0.551	0.996	37	Yes	Yes
10003 (Ythan @ Ellon)	24.51	0.002	Yes	58.564	**58.368**	59.592	59.592	382301	837609	532.288	826	0.592	0.993	39	Yes	Yes
10001 (Ythan @ Ardlethen)	25.81	0.001	Yes	50.180	**50.092**	55.866	55.866	381355	839183	457.115	830	0.576	0.992	46	Yes	Yes
12008 (Feugh @ Heugh Head)	30.44	0.000	Yes	134.446	**134.421**	107.557	107.557	360827	787475	232.843	1130	0.366	0.998	37	Yes	Yes
9004 (Bogie @ Redcraig)	31.58	0.001	Yes	31.622	**31.571**	44.424	44.424	348531	829935	182.425	955	0.505	0.998	26	Yes	Yes
13001 (Bervie @ Inverbervie)	35.09	0.002	Yes	35.577	**35.510**	30.617	30.617	376480	778903	124.470	890	0.473	0.998	27	Yes	Yes
9001 (Deveron @ Avochie)	36.13	0.002	Yes	127.625	**127.334**	114.798	114.798	344246	831611	444.913	988	0.463	0.998	63	Yes	Yes
11003 (Don @ Bridge of Alford)	36.39	0.000	Yes	93.211	**93.177**	101.097	101.097	339410	812896	509.938	967	0.527	0.996	49	Yes	Yes
9002 (Deveron @ Muiresk)	37.99	0.002	Yes	264.411	**263.697**	183.395	183.395	348676	840600	961.450	928	0.484	0.997	63	Yes	No

QMED

Rural:	0.591 m³/s
Urban:	0.591 m³/s

UK Design Flood Estimation

Summary of ESS/Pooled Estimation Analysis using the Flood Estimation Handbook Statistical Method

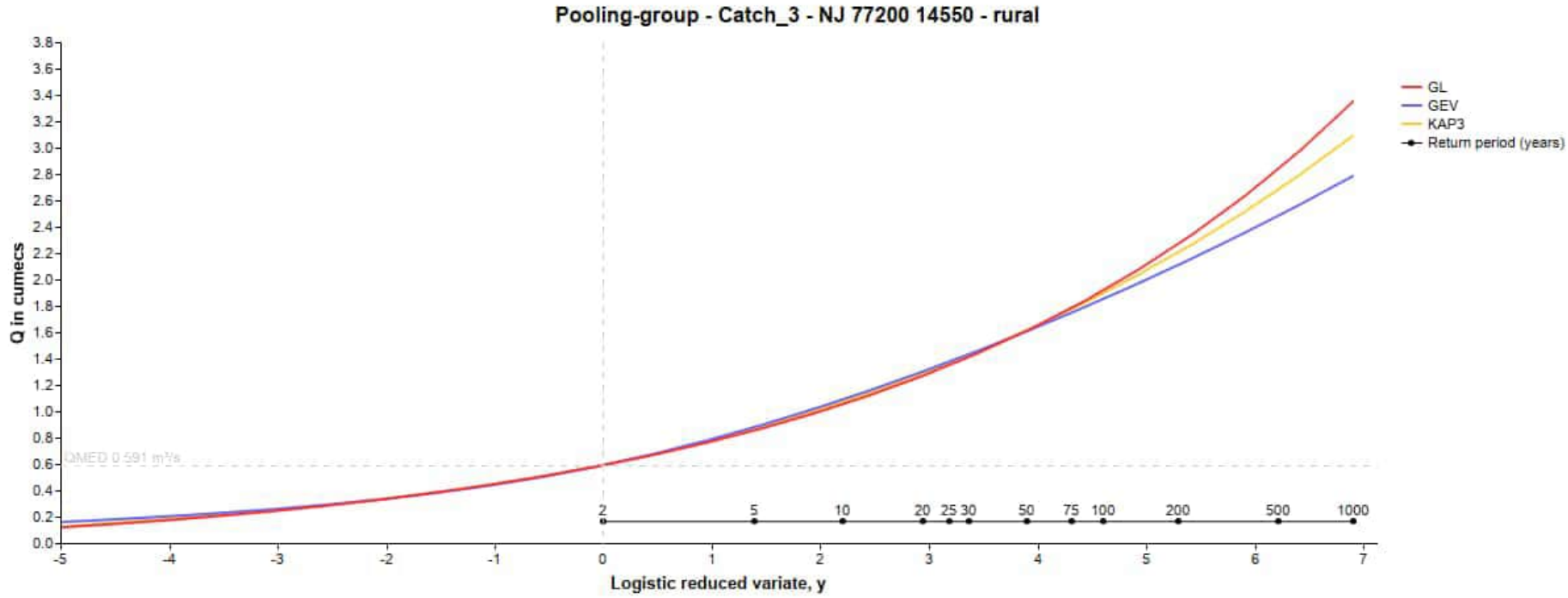
Flood Frequency Curve

Rural Flood Frequency Curve

Return period	GL (m³/s)	GEV (m³/s)	KAP3 (m³/s)
2	0.591	0.591	0.591
5	0.853	0.879	0.864
10	1.051	1.087	1.068
20	1.270	1.303	1.287
25	1.346	1.374	1.362
30	1.412	1.433	1.426
50	1.608	1.604	1.612
75	1.781	1.746	1.772
100	1.913	1.849	1.892
200	2.269	2.110	2.206
500	2.836	2.482	2.681
1000	3.353	2.787	3.093

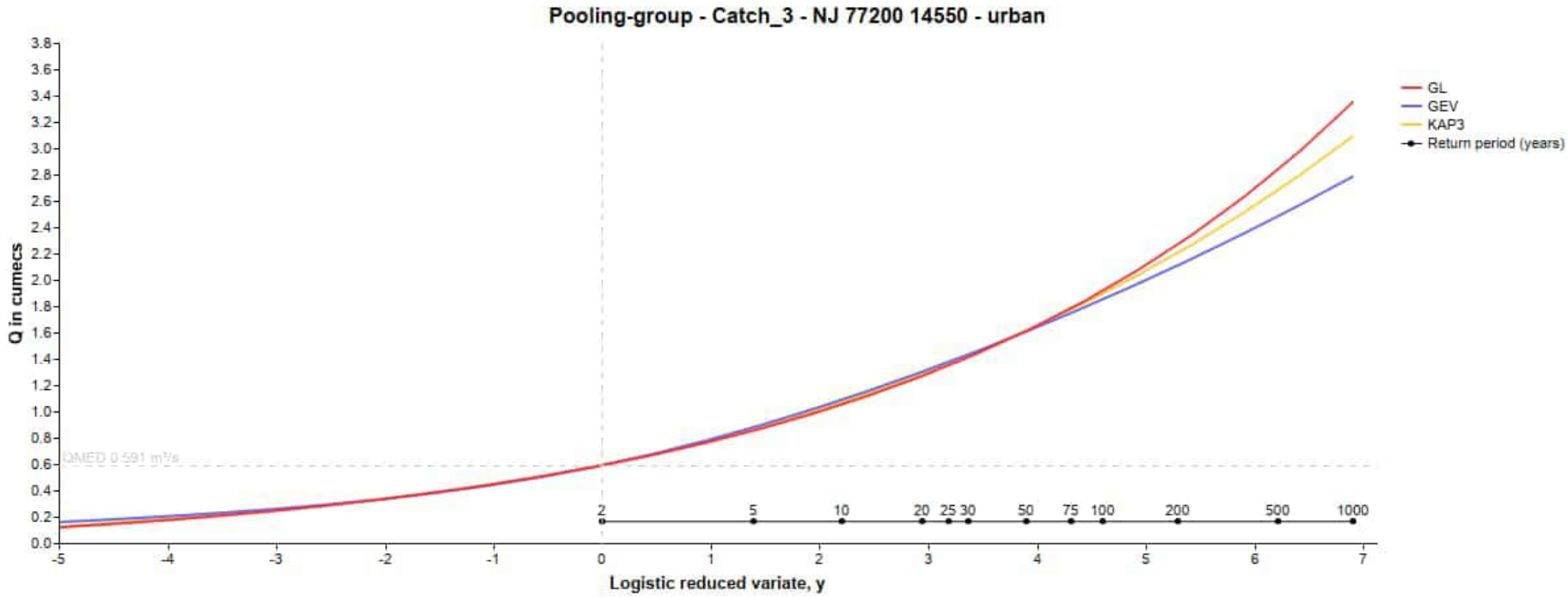
Urban Flood Frequency Curve

Return period	GL (m³/s)	GEV (m³/s)	KAP3 (m³/s)
2	0.591	0.591	0.591
5	0.853	0.879	0.864
10	1.051	1.087	1.068
20	1.270	1.303	1.287
25	1.346	1.374	1.362
30	1.412	1.433	1.426
50	1.608	1.604	1.612
75	1.781	1.746	1.772
100	1.913	1.849	1.892
200	2.269	2.110	2.206
500	2.836	2.482	2.681
1000	3.353	2.787	3.093



UK Design Flood Estimation

Summary of ESS/Pooled Estimation Analysis using the Flood Estimation Handbook Statistical Method

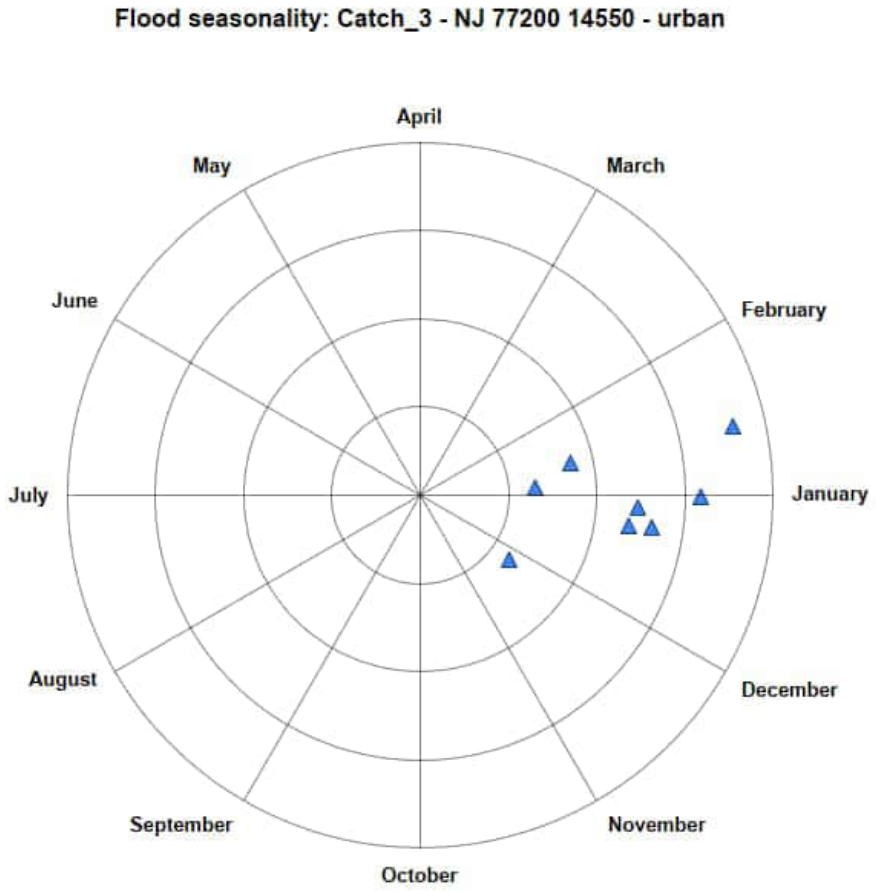


UK Design Flood Estimation

Summary of ESS/Pooled Estimation Analysis using the Flood Estimation Handbook Statistical Method

Appendix

Station record parameters

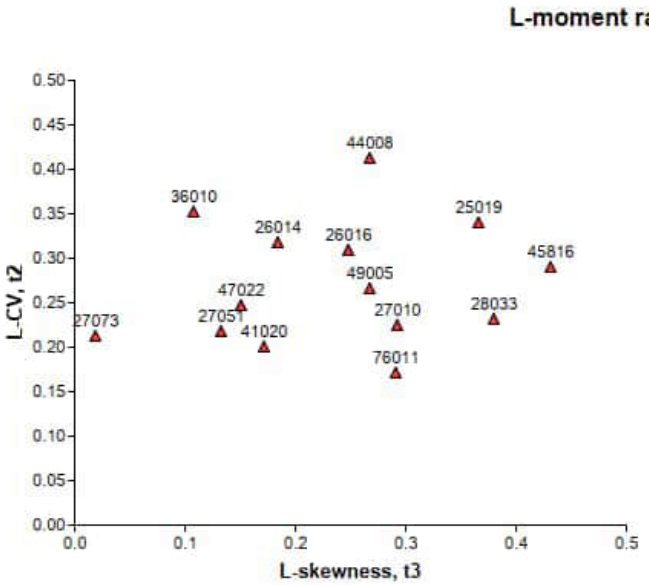


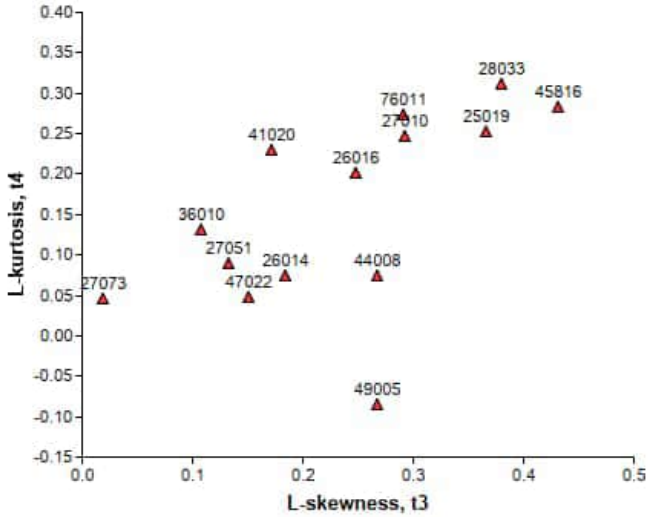
UK Design Flood Estimation

Summary of ESS/Pooled Estimation Analysis using the Flood Estimation Handbook Statistical Method

UK Design Flood Estimation

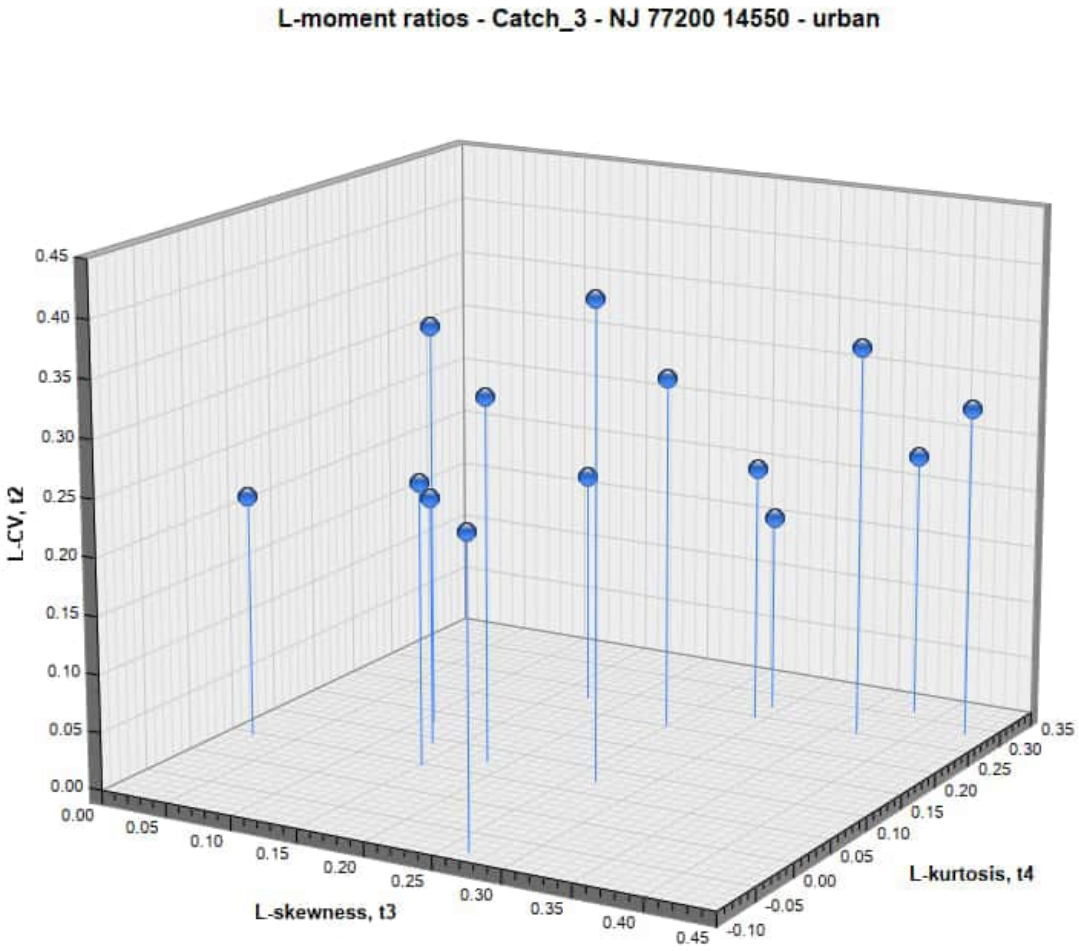
Summary of ESS/Pooled Estimation Analysis using the Flood Estimation Handbook Statistical Method





UK Design Flood Estimation

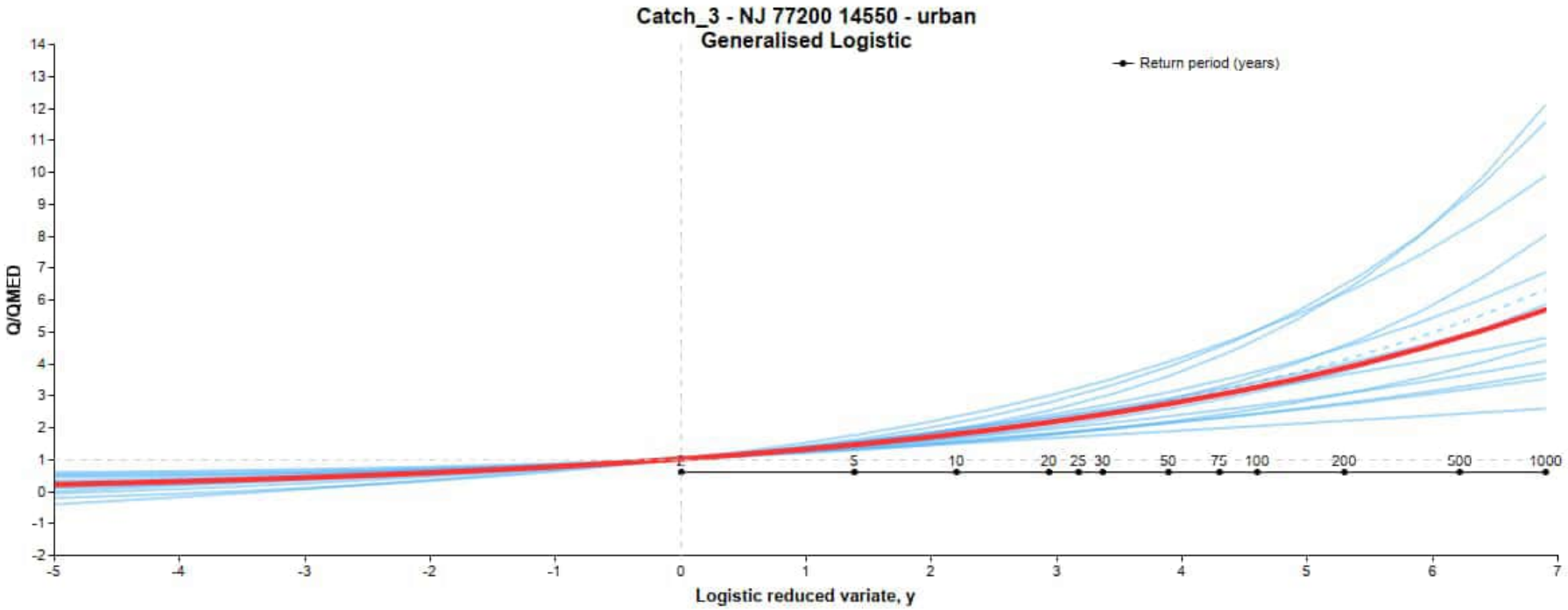
Summary of ESS/Pooled Estimation Analysis using the Flood Estimation Handbook Statistical Method



UK Design Flood Estimation

Summary of ESS/Pooled Estimation Analysis using the Flood Estimation Handbook Statistical Method

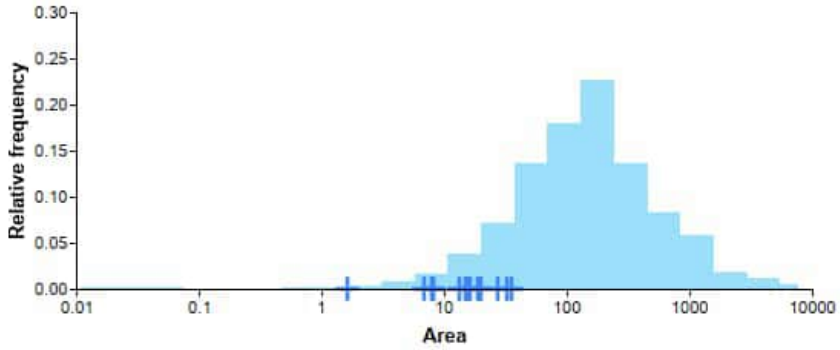
Pooling group growth curves

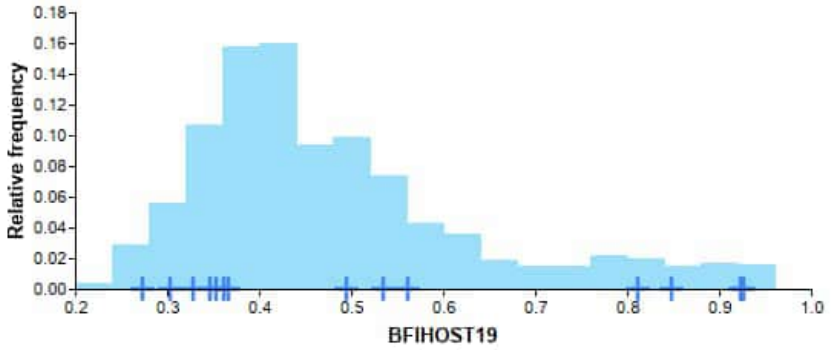


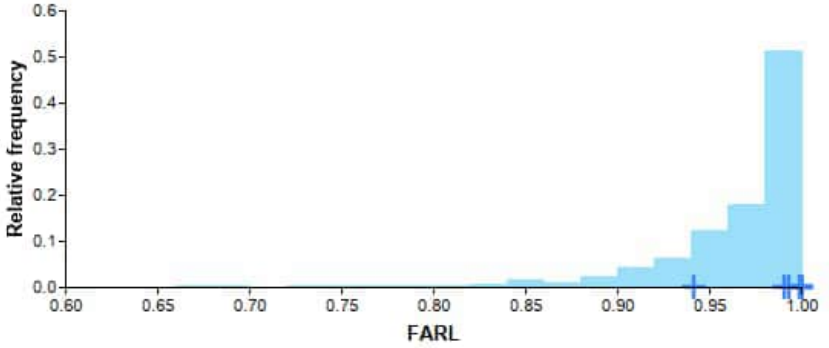
UK Design Flood Estimation

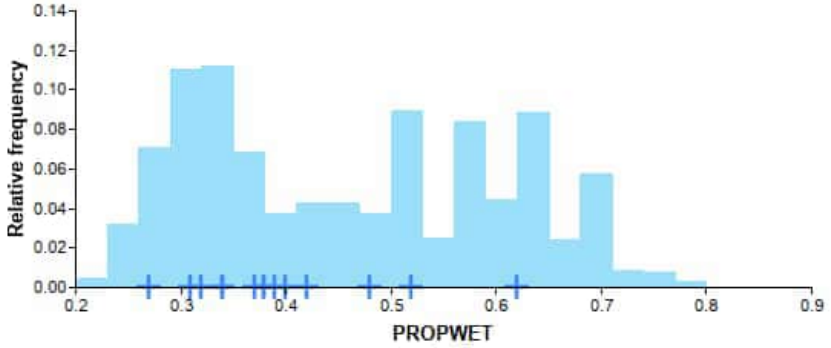
Summary of ESS/Pooled Estimation Analysis using the Flood Estimation Handbook Statistical Method

Catchment descriptors



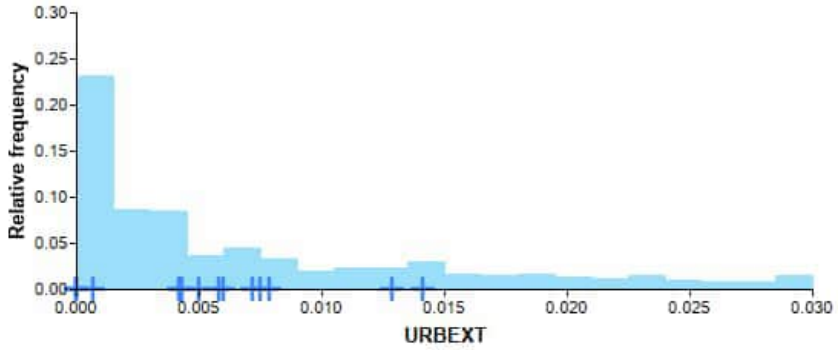


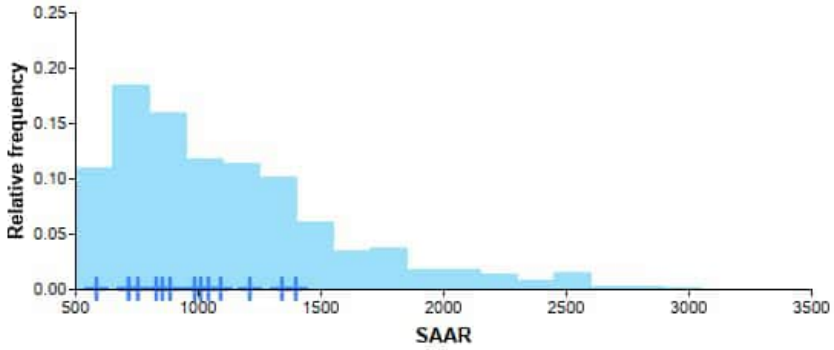


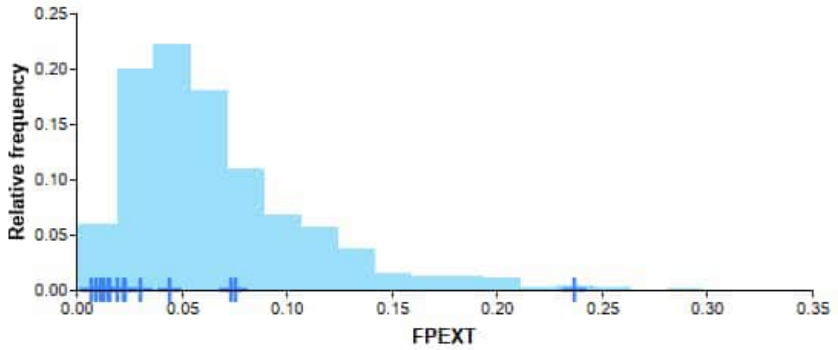


UK Design Flood Estimation

Summary of ESS/Pooled Estimation Analysis using the Flood Estimation Handbook Statistical Method







Appendix B ReFH2 Outputs

Kintore Hydrogen Facility

Flood Estimation Handbook Peak Flow Analysis

Kintore Hydrogen Ltd

SLR Project No.: 428.013099.00001

31 August 2024

UK Design Flood Estimation

Generated on 17 May 2024 06:33:21 by gfrisby
Printed from the ReFH2 Flood Modelling software package, version 4.1.8720.30241

Summary of estimate using the Flood Estimation Handbook revitalised flood hydrograph method (ReFH2)

Site details Checksum: D1BE-720C

Site name: FEH_Catchment_Descriptors_375850_814150_v5_0_1

Easting: 375850

Northing: 814150

Country: Scotland

Catchment Area (km^2): 0.67 [1.03]*

Using plot scale calculations: No

Model: 2.3

Site description: None

Model run: 1000 year 1.37 CC

Summary of results

Rainfall - FEH22 (mm):	141.73	Total runoff (ML):	20.36
Total Rainfall (mm):	93.61	Total flow (ML):	59.09
Peak Rainfall (mm):	18.25	Peak flow (m^3/s):	1.72

Parameters

Where the user has overriden a system-generated value, this original value is shown in square brackets after the value used.
** Indicates that the user locked the duration/timestep*

Rainfall parameters (Rainfall - FEH22)

Name	Value	User-defined?
Duration (hh:mm:ss)	03:15:00	No
Timestep (hh:mm:ss)	00:15:00	No
SCF (Seasonal correction factor)	0.68	No
ARF (Areal reduction factor)	0.98	No
Seasonality	Winter	No
Climate change factor	1.37	Yes

Loss model parameters

Name	Value	User-defined?
Cini (mm)	98.15	No
Cmax (mm)	446.5	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	1.96	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	0.01	No
BL (hr)	21.68	No
BR	1.9	No

Urbanisation parameters

Name	Value	User-defined?
Sewer capacity (m^3/s)	0	No
Exporting drained area (km^2)	0	No
Urban area (km^2)	0	No
Effective URBEXT2000	0	n/a
Impervious runoff factor	0.7	No
Imperviousness factor	0.4	No
Tp scaling factor	0.75	No
Depression storage depth (mm)	0.5	No

Time series data

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
00:00:00	1.666	0.000	0.369	0.000	0.013	0.013
00:15:00	2.580	0.000	0.584	0.001	0.013	0.015
00:30:00	3.981	0.000	0.931	0.007	0.013	0.020
00:45:00	6.114	0.000	1.499	0.018	0.013	0.031
01:00:00	9.325	0.000	2.447	0.039	0.014	0.052
01:15:00	14.013	0.000	4.043	0.075	0.015	0.089
01:30:00	18.251	0.000	5.925	0.137	0.017	0.153
01:45:00	14.013	0.000	5.056	0.238	0.021	0.258
02:00:00	9.325	0.000	3.608	0.382	0.027	0.409
02:15:00	6.114	0.000	2.471	0.557	0.037	0.594
02:30:00	3.981	0.000	1.654	0.750	0.051	0.801
02:45:00	2.580	0.000	1.091	0.949	0.069	1.018
03:00:00	1.666	0.000	0.712	1.142	0.091	1.233
03:15:00	0.000	0.000	0.000	1.316	0.117	1.433
03:30:00	0.000	0.000	0.000	1.449	0.145	1.594
03:45:00	0.000	0.000	0.000	1.516	0.176	1.692
04:00:00	0.000	0.000	0.000	1.517	0.207	1.724
04:15:00	0.000	0.000	0.000	1.467	0.237	1.705
04:30:00	0.000	0.000	0.000	1.383	0.266	1.649
04:45:00	0.000	0.000	0.000	1.277	0.292	1.569
05:00:00	0.000	0.000	0.000	1.159	0.315	1.474
05:15:00	0.000	0.000	0.000	1.036	0.335	1.371
05:30:00	0.000	0.000	0.000	0.920	0.353	1.273
05:45:00	0.000	0.000	0.000	0.817	0.368	1.185
06:00:00	0.000	0.000	0.000	0.728	0.380	1.109
06:15:00	0.000	0.000	0.000	0.649	0.391	1.040
06:30:00	0.000	0.000	0.000	0.577	0.400	0.977
06:45:00	0.000	0.000	0.000	0.509	0.407	0.916
07:00:00	0.000	0.000	0.000	0.445	0.413	0.857
07:15:00	0.000	0.000	0.000	0.382	0.417	0.799
07:30:00	0.000	0.000	0.000	0.321	0.420	0.741
07:45:00	0.000	0.000	0.000	0.262	0.421	0.683
08:00:00	0.000	0.000	0.000	0.204	0.422	0.626
08:15:00	0.000	0.000	0.000	0.151	0.421	0.571

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
08:30:00	0.000	0.000	0.000	0.103	0.419	0.522
08:45:00	0.000	0.000	0.000	0.065	0.416	0.481
09:00:00	0.000	0.000	0.000	0.038	0.412	0.450
09:15:00	0.000	0.000	0.000	0.021	0.408	0.429
09:30:00	0.000	0.000	0.000	0.010	0.404	0.414
09:45:00	0.000	0.000	0.000	0.004	0.399	0.403
10:00:00	0.000	0.000	0.000	0.001	0.395	0.396
10:15:00	0.000	0.000	0.000	0.000	0.390	0.390
10:30:00	0.000	0.000	0.000	0.000	0.386	0.386
10:45:00	0.000	0.000	0.000	0.000	0.381	0.381
11:00:00	0.000	0.000	0.000	0.000	0.377	0.377
11:15:00	0.000	0.000	0.000	0.000	0.373	0.373
11:30:00	0.000	0.000	0.000	0.000	0.368	0.368
11:45:00	0.000	0.000	0.000	0.000	0.364	0.364
12:00:00	0.000	0.000	0.000	0.000	0.360	0.360
12:15:00	0.000	0.000	0.000	0.000	0.356	0.356
12:30:00	0.000	0.000	0.000	0.000	0.352	0.352
12:45:00	0.000	0.000	0.000	0.000	0.348	0.348
13:00:00	0.000	0.000	0.000	0.000	0.344	0.344
13:15:00	0.000	0.000	0.000	0.000	0.340	0.340
13:30:00	0.000	0.000	0.000	0.000	0.336	0.336
13:45:00	0.000	0.000	0.000	0.000	0.332	0.332
14:00:00	0.000	0.000	0.000	0.000	0.328	0.328
14:15:00	0.000	0.000	0.000	0.000	0.324	0.324
14:30:00	0.000	0.000	0.000	0.000	0.321	0.321
14:45:00	0.000	0.000	0.000	0.000	0.317	0.317
15:00:00	0.000	0.000	0.000	0.000	0.313	0.313
15:15:00	0.000	0.000	0.000	0.000	0.310	0.310
15:30:00	0.000	0.000	0.000	0.000	0.306	0.306
15:45:00	0.000	0.000	0.000	0.000	0.303	0.303
16:00:00	0.000	0.000	0.000	0.000	0.299	0.299
16:15:00	0.000	0.000	0.000	0.000	0.296	0.296
16:30:00	0.000	0.000	0.000	0.000	0.292	0.292
16:45:00	0.000	0.000	0.000	0.000	0.289	0.289
17:00:00	0.000	0.000	0.000	0.000	0.286	0.286

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
17:15:00	0.000	0.000	0.000	0.000	0.282	0.282
17:30:00	0.000	0.000	0.000	0.000	0.279	0.279
17:45:00	0.000	0.000	0.000	0.000	0.276	0.276
18:00:00	0.000	0.000	0.000	0.000	0.273	0.273
18:15:00	0.000	0.000	0.000	0.000	0.270	0.270
18:30:00	0.000	0.000	0.000	0.000	0.267	0.267
18:45:00	0.000	0.000	0.000	0.000	0.264	0.264
19:00:00	0.000	0.000	0.000	0.000	0.261	0.261
19:15:00	0.000	0.000	0.000	0.000	0.258	0.258
19:30:00	0.000	0.000	0.000	0.000	0.255	0.255
19:45:00	0.000	0.000	0.000	0.000	0.252	0.252
20:00:00	0.000	0.000	0.000	0.000	0.249	0.249
20:15:00	0.000	0.000	0.000	0.000	0.246	0.246
20:30:00	0.000	0.000	0.000	0.000	0.243	0.243
20:45:00	0.000	0.000	0.000	0.000	0.240	0.240
21:00:00	0.000	0.000	0.000	0.000	0.238	0.238
21:15:00	0.000	0.000	0.000	0.000	0.235	0.235
21:30:00	0.000	0.000	0.000	0.000	0.232	0.232
21:45:00	0.000	0.000	0.000	0.000	0.230	0.230
22:00:00	0.000	0.000	0.000	0.000	0.227	0.227
22:15:00	0.000	0.000	0.000	0.000	0.224	0.224
22:30:00	0.000	0.000	0.000	0.000	0.222	0.222
22:45:00	0.000	0.000	0.000	0.000	0.219	0.219
23:00:00	0.000	0.000	0.000	0.000	0.217	0.217
23:15:00	0.000	0.000	0.000	0.000	0.214	0.214
23:30:00	0.000	0.000	0.000	0.000	0.212	0.212
23:45:00	0.000	0.000	0.000	0.000	0.209	0.209
24:00:00	0.000	0.000	0.000	0.000	0.207	0.207
24:15:00	0.000	0.000	0.000	0.000	0.205	0.205
24:30:00	0.000	0.000	0.000	0.000	0.202	0.202
24:45:00	0.000	0.000	0.000	0.000	0.200	0.200
25:00:00	0.000	0.000	0.000	0.000	0.198	0.198
25:15:00	0.000	0.000	0.000	0.000	0.195	0.195
25:30:00	0.000	0.000	0.000	0.000	0.193	0.193
25:45:00	0.000	0.000	0.000	0.000	0.191	0.191

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
26:00:00	0.000	0.000	0.000	0.000	0.189	0.189
26:15:00	0.000	0.000	0.000	0.000	0.187	0.187
26:30:00	0.000	0.000	0.000	0.000	0.184	0.184
26:45:00	0.000	0.000	0.000	0.000	0.182	0.182
27:00:00	0.000	0.000	0.000	0.000	0.180	0.180
27:15:00	0.000	0.000	0.000	0.000	0.178	0.178
27:30:00	0.000	0.000	0.000	0.000	0.176	0.176
27:45:00	0.000	0.000	0.000	0.000	0.174	0.174
28:00:00	0.000	0.000	0.000	0.000	0.172	0.172
28:15:00	0.000	0.000	0.000	0.000	0.170	0.170
28:30:00	0.000	0.000	0.000	0.000	0.168	0.168
28:45:00	0.000	0.000	0.000	0.000	0.166	0.166
29:00:00	0.000	0.000	0.000	0.000	0.164	0.164
29:15:00	0.000	0.000	0.000	0.000	0.162	0.162
29:30:00	0.000	0.000	0.000	0.000	0.161	0.161
29:45:00	0.000	0.000	0.000	0.000	0.159	0.159
30:00:00	0.000	0.000	0.000	0.000	0.157	0.157
30:15:00	0.000	0.000	0.000	0.000	0.155	0.155
30:30:00	0.000	0.000	0.000	0.000	0.153	0.153
30:45:00	0.000	0.000	0.000	0.000	0.152	0.152
31:00:00	0.000	0.000	0.000	0.000	0.150	0.150
31:15:00	0.000	0.000	0.000	0.000	0.148	0.148
31:30:00	0.000	0.000	0.000	0.000	0.146	0.146
31:45:00	0.000	0.000	0.000	0.000	0.145	0.145
32:00:00	0.000	0.000	0.000	0.000	0.143	0.143
32:15:00	0.000	0.000	0.000	0.000	0.141	0.141
32:30:00	0.000	0.000	0.000	0.000	0.140	0.140
32:45:00	0.000	0.000	0.000	0.000	0.138	0.138
33:00:00	0.000	0.000	0.000	0.000	0.137	0.137
33:15:00	0.000	0.000	0.000	0.000	0.135	0.135
33:30:00	0.000	0.000	0.000	0.000	0.133	0.133
33:45:00	0.000	0.000	0.000	0.000	0.132	0.132
34:00:00	0.000	0.000	0.000	0.000	0.130	0.130
34:15:00	0.000	0.000	0.000	0.000	0.129	0.129
34:30:00	0.000	0.000	0.000	0.000	0.127	0.127

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
34:45:00	0.000	0.000	0.000	0.000	0.126	0.126
35:00:00	0.000	0.000	0.000	0.000	0.125	0.125
35:15:00	0.000	0.000	0.000	0.000	0.123	0.123
35:30:00	0.000	0.000	0.000	0.000	0.122	0.122
35:45:00	0.000	0.000	0.000	0.000	0.120	0.120
36:00:00	0.000	0.000	0.000	0.000	0.119	0.119
36:15:00	0.000	0.000	0.000	0.000	0.118	0.118
36:30:00	0.000	0.000	0.000	0.000	0.116	0.116
36:45:00	0.000	0.000	0.000	0.000	0.115	0.115
37:00:00	0.000	0.000	0.000	0.000	0.114	0.114
37:15:00	0.000	0.000	0.000	0.000	0.112	0.112
37:30:00	0.000	0.000	0.000	0.000	0.111	0.111
37:45:00	0.000	0.000	0.000	0.000	0.110	0.110
38:00:00	0.000	0.000	0.000	0.000	0.108	0.108
38:15:00	0.000	0.000	0.000	0.000	0.107	0.107
38:30:00	0.000	0.000	0.000	0.000	0.106	0.106
38:45:00	0.000	0.000	0.000	0.000	0.105	0.105
39:00:00	0.000	0.000	0.000	0.000	0.104	0.104
39:15:00	0.000	0.000	0.000	0.000	0.102	0.102
39:30:00	0.000	0.000	0.000	0.000	0.101	0.101
39:45:00	0.000	0.000	0.000	0.000	0.100	0.100
40:00:00	0.000	0.000	0.000	0.000	0.099	0.099
40:15:00	0.000	0.000	0.000	0.000	0.098	0.098
40:30:00	0.000	0.000	0.000	0.000	0.097	0.097
40:45:00	0.000	0.000	0.000	0.000	0.096	0.096
41:00:00	0.000	0.000	0.000	0.000	0.094	0.094
41:15:00	0.000	0.000	0.000	0.000	0.093	0.093
41:30:00	0.000	0.000	0.000	0.000	0.092	0.092
41:45:00	0.000	0.000	0.000	0.000	0.091	0.091
42:00:00	0.000	0.000	0.000	0.000	0.090	0.090
42:15:00	0.000	0.000	0.000	0.000	0.089	0.089
42:30:00	0.000	0.000	0.000	0.000	0.088	0.088
42:45:00	0.000	0.000	0.000	0.000	0.087	0.087
43:00:00	0.000	0.000	0.000	0.000	0.086	0.086
43:15:00	0.000	0.000	0.000	0.000	0.085	0.085

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
43:30:00	0.000	0.000	0.000	0.000	0.084	0.084
43:45:00	0.000	0.000	0.000	0.000	0.083	0.083
44:00:00	0.000	0.000	0.000	0.000	0.082	0.082
44:15:00	0.000	0.000	0.000	0.000	0.081	0.081
44:30:00	0.000	0.000	0.000	0.000	0.080	0.080
44:45:00	0.000	0.000	0.000	0.000	0.079	0.079
45:00:00	0.000	0.000	0.000	0.000	0.079	0.079
45:15:00	0.000	0.000	0.000	0.000	0.078	0.078
45:30:00	0.000	0.000	0.000	0.000	0.077	0.077
45:45:00	0.000	0.000	0.000	0.000	0.076	0.076
46:00:00	0.000	0.000	0.000	0.000	0.075	0.075
46:15:00	0.000	0.000	0.000	0.000	0.074	0.074
46:30:00	0.000	0.000	0.000	0.000	0.073	0.073
46:45:00	0.000	0.000	0.000	0.000	0.072	0.072
47:00:00	0.000	0.000	0.000	0.000	0.072	0.072
47:15:00	0.000	0.000	0.000	0.000	0.071	0.071
47:30:00	0.000	0.000	0.000	0.000	0.070	0.070
47:45:00	0.000	0.000	0.000	0.000	0.069	0.069
48:00:00	0.000	0.000	0.000	0.000	0.068	0.068
48:15:00	0.000	0.000	0.000	0.000	0.068	0.068
48:30:00	0.000	0.000	0.000	0.000	0.067	0.067
48:45:00	0.000	0.000	0.000	0.000	0.066	0.066
49:00:00	0.000	0.000	0.000	0.000	0.065	0.065
49:15:00	0.000	0.000	0.000	0.000	0.065	0.065
49:30:00	0.000	0.000	0.000	0.000	0.064	0.064
49:45:00	0.000	0.000	0.000	0.000	0.063	0.063
50:00:00	0.000	0.000	0.000	0.000	0.062	0.062
50:15:00	0.000	0.000	0.000	0.000	0.062	0.062
50:30:00	0.000	0.000	0.000	0.000	0.061	0.061
50:45:00	0.000	0.000	0.000	0.000	0.060	0.060
51:00:00	0.000	0.000	0.000	0.000	0.060	0.060
51:15:00	0.000	0.000	0.000	0.000	0.059	0.059
51:30:00	0.000	0.000	0.000	0.000	0.058	0.058
51:45:00	0.000	0.000	0.000	0.000	0.058	0.058
52:00:00	0.000	0.000	0.000	0.000	0.057	0.057

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
52:15:00	0.000	0.000	0.000	0.000	0.056	0.056
52:30:00	0.000	0.000	0.000	0.000	0.056	0.056
52:45:00	0.000	0.000	0.000	0.000	0.055	0.055
53:00:00	0.000	0.000	0.000	0.000	0.054	0.054
53:15:00	0.000	0.000	0.000	0.000	0.054	0.054
53:30:00	0.000	0.000	0.000	0.000	0.053	0.053
53:45:00	0.000	0.000	0.000	0.000	0.052	0.052
54:00:00	0.000	0.000	0.000	0.000	0.052	0.052
54:15:00	0.000	0.000	0.000	0.000	0.051	0.051
54:30:00	0.000	0.000	0.000	0.000	0.051	0.051
54:45:00	0.000	0.000	0.000	0.000	0.050	0.050
55:00:00	0.000	0.000	0.000	0.000	0.050	0.050
55:15:00	0.000	0.000	0.000	0.000	0.049	0.049
55:30:00	0.000	0.000	0.000	0.000	0.048	0.048
55:45:00	0.000	0.000	0.000	0.000	0.048	0.048
56:00:00	0.000	0.000	0.000	0.000	0.047	0.047
56:15:00	0.000	0.000	0.000	0.000	0.047	0.047
56:30:00	0.000	0.000	0.000	0.000	0.046	0.046
56:45:00	0.000	0.000	0.000	0.000	0.046	0.046
57:00:00	0.000	0.000	0.000	0.000	0.045	0.045
57:15:00	0.000	0.000	0.000	0.000	0.045	0.045
57:30:00	0.000	0.000	0.000	0.000	0.044	0.044
57:45:00	0.000	0.000	0.000	0.000	0.044	0.044
58:00:00	0.000	0.000	0.000	0.000	0.043	0.043
58:15:00	0.000	0.000	0.000	0.000	0.043	0.043
58:30:00	0.000	0.000	0.000	0.000	0.042	0.042
58:45:00	0.000	0.000	0.000	0.000	0.042	0.042
59:00:00	0.000	0.000	0.000	0.000	0.041	0.041
59:15:00	0.000	0.000	0.000	0.000	0.041	0.041
59:30:00	0.000	0.000	0.000	0.000	0.040	0.040
59:45:00	0.000	0.000	0.000	0.000	0.040	0.040
60:00:00	0.000	0.000	0.000	0.000	0.039	0.039
60:15:00	0.000	0.000	0.000	0.000	0.039	0.039
60:30:00	0.000	0.000	0.000	0.000	0.038	0.038
60:45:00	0.000	0.000	0.000	0.000	0.038	0.038

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
61:00:00	0.000	0.000	0.000	0.000	0.038	0.038
61:15:00	0.000	0.000	0.000	0.000	0.037	0.037
61:30:00	0.000	0.000	0.000	0.000	0.037	0.037
61:45:00	0.000	0.000	0.000	0.000	0.036	0.036
62:00:00	0.000	0.000	0.000	0.000	0.036	0.036
62:15:00	0.000	0.000	0.000	0.000	0.035	0.035
62:30:00	0.000	0.000	0.000	0.000	0.035	0.035
62:45:00	0.000	0.000	0.000	0.000	0.035	0.035
63:00:00	0.000	0.000	0.000	0.000	0.034	0.034
63:15:00	0.000	0.000	0.000	0.000	0.034	0.034
63:30:00	0.000	0.000	0.000	0.000	0.033	0.033
63:45:00	0.000	0.000	0.000	0.000	0.033	0.033
64:00:00	0.000	0.000	0.000	0.000	0.033	0.033
64:15:00	0.000	0.000	0.000	0.000	0.032	0.032
64:30:00	0.000	0.000	0.000	0.000	0.032	0.032
64:45:00	0.000	0.000	0.000	0.000	0.032	0.032
65:00:00	0.000	0.000	0.000	0.000	0.031	0.031
65:15:00	0.000	0.000	0.000	0.000	0.031	0.031
65:30:00	0.000	0.000	0.000	0.000	0.031	0.031
65:45:00	0.000	0.000	0.000	0.000	0.030	0.030
66:00:00	0.000	0.000	0.000	0.000	0.030	0.030
66:15:00	0.000	0.000	0.000	0.000	0.029	0.029
66:30:00	0.000	0.000	0.000	0.000	0.029	0.029
66:45:00	0.000	0.000	0.000	0.000	0.029	0.029
67:00:00	0.000	0.000	0.000	0.000	0.028	0.028
67:15:00	0.000	0.000	0.000	0.000	0.028	0.028
67:30:00	0.000	0.000	0.000	0.000	0.028	0.028
67:45:00	0.000	0.000	0.000	0.000	0.028	0.028
68:00:00	0.000	0.000	0.000	0.000	0.027	0.027
68:15:00	0.000	0.000	0.000	0.000	0.027	0.027
68:30:00	0.000	0.000	0.000	0.000	0.027	0.027
68:45:00	0.000	0.000	0.000	0.000	0.026	0.026
69:00:00	0.000	0.000	0.000	0.000	0.026	0.026
69:15:00	0.000	0.000	0.000	0.000	0.026	0.026
69:30:00	0.000	0.000	0.000	0.000	0.025	0.025

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
69:45:00	0.000	0.000	0.000	0.000	0.025	0.025
70:00:00	0.000	0.000	0.000	0.000	0.025	0.025
70:15:00	0.000	0.000	0.000	0.000	0.025	0.025
70:30:00	0.000	0.000	0.000	0.000	0.024	0.024
70:45:00	0.000	0.000	0.000	0.000	0.024	0.024
71:00:00	0.000	0.000	0.000	0.000	0.024	0.024
71:15:00	0.000	0.000	0.000	0.000	0.023	0.023
71:30:00	0.000	0.000	0.000	0.000	0.023	0.023
71:45:00	0.000	0.000	0.000	0.000	0.023	0.023
72:00:00	0.000	0.000	0.000	0.000	0.023	0.023
72:15:00	0.000	0.000	0.000	0.000	0.022	0.022
72:30:00	0.000	0.000	0.000	0.000	0.022	0.022
72:45:00	0.000	0.000	0.000	0.000	0.022	0.022
73:00:00	0.000	0.000	0.000	0.000	0.022	0.022
73:15:00	0.000	0.000	0.000	0.000	0.021	0.021
73:30:00	0.000	0.000	0.000	0.000	0.021	0.021
73:45:00	0.000	0.000	0.000	0.000	0.021	0.021
74:00:00	0.000	0.000	0.000	0.000	0.021	0.021
74:15:00	0.000	0.000	0.000	0.000	0.020	0.020
74:30:00	0.000	0.000	0.000	0.000	0.020	0.020
74:45:00	0.000	0.000	0.000	0.000	0.020	0.020
75:00:00	0.000	0.000	0.000	0.000	0.020	0.020
75:15:00	0.000	0.000	0.000	0.000	0.019	0.019
75:30:00	0.000	0.000	0.000	0.000	0.019	0.019
75:45:00	0.000	0.000	0.000	0.000	0.019	0.019
76:00:00	0.000	0.000	0.000	0.000	0.019	0.019
76:15:00	0.000	0.000	0.000	0.000	0.019	0.019
76:30:00	0.000	0.000	0.000	0.000	0.018	0.018
76:45:00	0.000	0.000	0.000	0.000	0.018	0.018
77:00:00	0.000	0.000	0.000	0.000	0.018	0.018
77:15:00	0.000	0.000	0.000	0.000	0.018	0.018
77:30:00	0.000	0.000	0.000	0.000	0.018	0.018
77:45:00	0.000	0.000	0.000	0.000	0.017	0.017
78:00:00	0.000	0.000	0.000	0.000	0.017	0.017
78:15:00	0.000	0.000	0.000	0.000	0.017	0.017

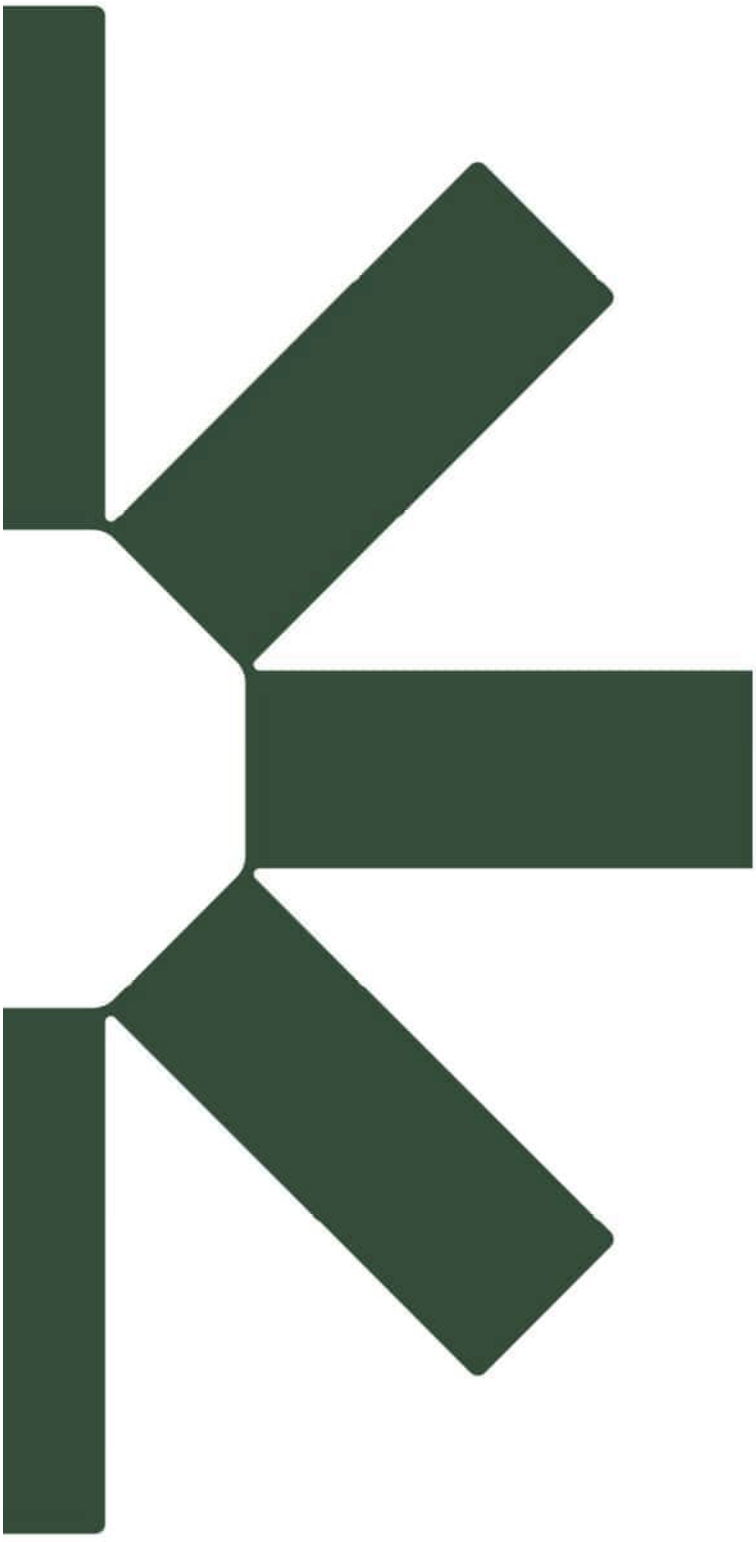
Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
78:30:00	0.000	0.000	0.000	0.000	0.017	0.017
78:45:00	0.000	0.000	0.000	0.000	0.017	0.017
79:00:00	0.000	0.000	0.000	0.000	0.016	0.016
79:15:00	0.000	0.000	0.000	0.000	0.016	0.016
79:30:00	0.000	0.000	0.000	0.000	0.016	0.016
79:45:00	0.000	0.000	0.000	0.000	0.016	0.016
80:00:00	0.000	0.000	0.000	0.000	0.016	0.016
80:15:00	0.000	0.000	0.000	0.000	0.015	0.015
80:30:00	0.000	0.000	0.000	0.000	0.015	0.015
80:45:00	0.000	0.000	0.000	0.000	0.015	0.015
81:00:00	0.000	0.000	0.000	0.000	0.015	0.015
81:15:00	0.000	0.000	0.000	0.000	0.015	0.015
81:30:00	0.000	0.000	0.000	0.000	0.015	0.015
81:45:00	0.000	0.000	0.000	0.000	0.014	0.014
82:00:00	0.000	0.000	0.000	0.000	0.014	0.014
82:15:00	0.000	0.000	0.000	0.000	0.014	0.014
82:30:00	0.000	0.000	0.000	0.000	0.014	0.014
82:45:00	0.000	0.000	0.000	0.000	0.014	0.014
83:00:00	0.000	0.000	0.000	0.000	0.014	0.014
83:15:00	0.000	0.000	0.000	0.000	0.013	0.013
83:30:00	0.000	0.000	0.000	0.000	0.013	0.013

Appendix

Catchment descriptors *

Name	Value	User-defined value used?
Area (km^2)	0.67 [1.03]	**Yes**
ALTBAR	126	No
ASPBAR	63	No
ASPVAR	0.42	No
BFIHOST	0.6	No
BFIHOST19	0.52	No
DPLBAR (km)	1.31 [0.98]	**Yes**
DPSBAR (mkm^{-1})	48.9	No
FARL	1	No
LDP	2.12	No
PROPWET	0.53	No
RMED1H	8.1	No
RMED1D	32.4	No
RMED2D	44.8	No
SAAR (mm)	785	No
SAAR4170 (mm)	867	No
SPRHOST	29.05	No
URBEXT2000	0	No
URBEXT1990	0	No
URBCONC	0	No
URBLOC	0	No
DDF parameter C	-0.01	No
DDF parameter D1	0.45	No
DDF parameter D2	0.44	No
DDF parameter D3	0.28	No
DDF parameter E	0.24	No
DDF parameter F	2.2	No
DDF parameter C (1km grid value)	-0.01	No
DDF parameter D1 (1km grid value)	0.45	No
DDF parameter D2 (1km grid value)	0.44	No
DDF parameter D3 (1km grid value)	0.28	No
DDF parameter E (1km grid value)	0.24	No
DDF parameter F (1km grid value)	2.21	No

Values in square brackets are the original values loaded from the FEH Web Service or FEH CD-ROM



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