Insch FPS Study Information Review Report

Final Report

April 2019

Aberdeenshire Council

JBA Project Manager

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Revision History

Revision Ref / Date Issued	Amendments	Issued to
P01 / January 2018	-	Alistair Scotland and Lee Watson, Aberdeenshire Council
P03 / April 2018	Aberdeenshire Council comments addressed. Minor corrections.	Alistair Scotland and Lee Watson, Aberdeenshire Council
C01 / April 2019	Figure 1-4 amended. Published.	Alistair Scotland and Lee Watson, Aberdeenshire Council

Contract

This report describes work commissioned Gavin Penman, on behalf of Aberdeenshire Council on 10 October 2017, by Purchase Order Number 1095192. Dougall Ballie's representative for the contract was Scott Macphail and Aberdeenshire Council's Representative for the contract was Alistair Scotland. Caroline Anderton, Alice Gent and Grace Thompson of JBA Consulting carried out this work.

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Purpose

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Acknowledgements

JBA would like to thank SEPA for the provision of flood mapping and Aberdeenshire Council for the supply of data.

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Abbreviations

ARF	Areal Reduction Factor
BGS	British Geological Survey
CCTV	Closed Circuit Television
CEH	Centre for Ecology and Hydrology
CS	Cross Section
DDF	Depth Duration Frequency
DTM	Digital Terrain Model
FEH	Flood Estimation Handbook
FPS	Flood Protection Scheme
FRA	Flood Risk Assessment
GIS	Geographical Information System
ID	Identifier
LiDAR	Light Detection And Ranging
mAOD	metres Above Ordnance Datum
OS	Ordnance Survey
QMED	Median Annual Flood (with return period 2 years)
RBMP	River Basin Management Plan
ReFH	Revitalised Flood Hydrograph method
SEPA	Scottish Environment Protection Agency
TBR	Tipping Bucket Raingauge

1 Introduction

1.1 Study extent

Insch, a small town approximately 50 km north west of Aberdeen, is located in the valley of the Shevock Burn. The catchment topography is relatively flat with hills to the north, south and east. Catchment elevations range from approximately 420 metres above Ordnance Datum (mAOD) at Gartly Moor to 100 mAOD downstream of Insch. The key watercourses are: the Shevock Burn, which runs through the centre of the town; the Valentine Burn, a left bank tributary that flows to the north and east of the town; and two unnamed burns to the south of Insch. The catchment bedrock, as described by the British Geological Survey (BGS)[1], is an igneous intrusion of silica-poor magma overlain by boulder clay and morainic drift. The catchment bedrock is therefore relatively impermeable but overlain by moderately permeable superficial deposits. Thus, the catchment is likely to have a relatively rapid response hydrograph.

Insch is part of the North East Local Plan District (LPD). The proposals for the management of flood risk for this LPD are contained in the North-East Flood Risk Management Strategy (FRMS)[2] and the North-East Flood Risk Management Plan (LFRMP)[3].

Insch is categorised as a Potentially Vulnerable Area (PVA) (06/11) in the North East LPD; the PVA has an area of approximately 40 km^2. The village of Oldtown is also included within the PVA (see Figure 1-1). The Insch flood protection study is ranked 61 of 168 nationally and 3 of 12 at local authority level. Key infrastructure within this PVA includes the Aberdeen to Inverness railway line and the B9002, B992 and A96 roads. The latter road lies to the east of Insch near the Shevock-Urie confluence. The majority of flooding is caused by fluvial flooding (89%) with additional flooding originating from surface water sources (11%). The Shevock Burn is the primary source of fluvial flooding and the key flood receptors are properties along Mill Road, the south end of Commerce Street, Commercial Road, the south side of Insch War Memorial Hospital, Old Mart Avenue, the east end of Rannes Street and the High Street. The Valentine Burn also contributes to flooding at Drumrossie Street, Largie Road and the east side of Market Street. There are 80 residential properties and 30 non-residential properties at risk of flooding across the PVA as well as a hospital and nursing home. Average annual damages are estimated to be £250,000, the majority of which are caused by fluvial flooding. The most recent flood event in January 2016 caused damage to 26 properties in the area. However, the largest impact event occurred in November 2002; during this event, the Insch nursing home and a number of residential properties had to be evacuated (similar to flooding in 1995).

The LFRMP identifies that actions to reduce flood risk in Insch from the Valentine Burn and the Shevock Burn would avoid potential flood damages up to £6.3 million, reduce flood risk to 141 people in the community (52 residential properties and 20 non-residential) and enhance the natural environment to create opportunities for local wildlife, recreation and tourism.

There are no international or national landscape designations in Insch. There are, however, five Category C and four Category B Listed Buildings within the Insch catchment as listed by Historic Environment Scotland[4], of which 3 fall within the 0.5% AP (200 year) flood outline on the SEPA flood map.

The Shevock Burn (ID 23291) is part of the River Basin Management Plan (RBMP) and was ranked as being of 'Poor' overall condition in 2016[5]. The reason for the downgrade was the 'Poor' overall ecological condition, in particular due to biological elements and access for fish migration being classified as 'Poor'. All other categories against which reaches are assessed (water flows and levels, physical condition, freedom from invasive species and water quality) are ranked as 'Good' or 'High'.

The Shevock Burn is ungauged, with the nearest SEPA gauge (Urie at Old Rayne) located on the River Urie, approximately 300 m downstream of the Shevock-Urie confluence.

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1 British Geological Society http://mapapps.bgs.ac.uk/geologyofbritain/home.html [Accessed: November 2017]

2 North-East Flood Risk Management Strategy http://apps.sepa.org.uk/FRMStrategies/pdf/lpd/LPD_06_Full.pdf [Accessed: 10 November 2017]

3 North East Flood Risk Management Plan http://www.aberdeenshire.gov.uk/media/17174/north-east-local-flood-risk-management-plan-2016-2022-web-version.pdf [Accessed: 10 November 2017]

4 http://historicscotland.maps.arcgis.com/apps/Viewer/index.html?appid=18d2608ac1284066ba3927312710d16d [Accessed: 23 November 2017]

5 SEPA RBMP Water Environment Hub https://www.sepa.org.uk/data-visualisation/water-environment-hub/ [Accessed: December 2017]

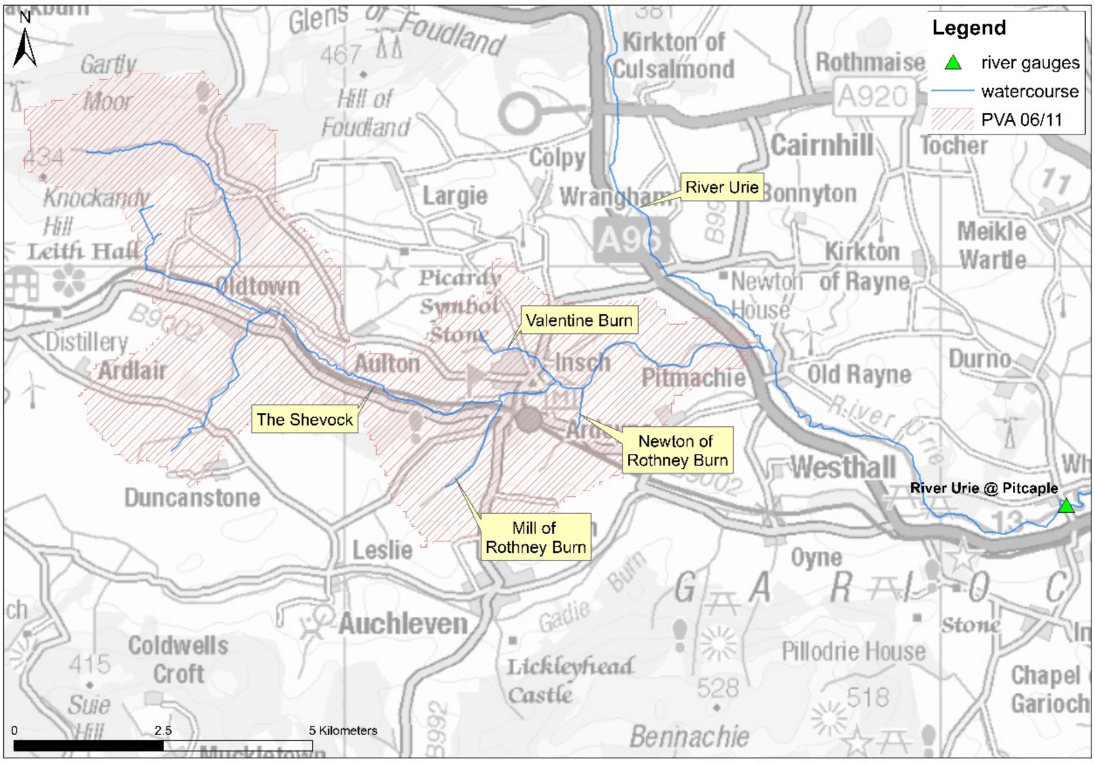


Figure 1-1: Location of PVA 06/11

1.2 Insch model extent

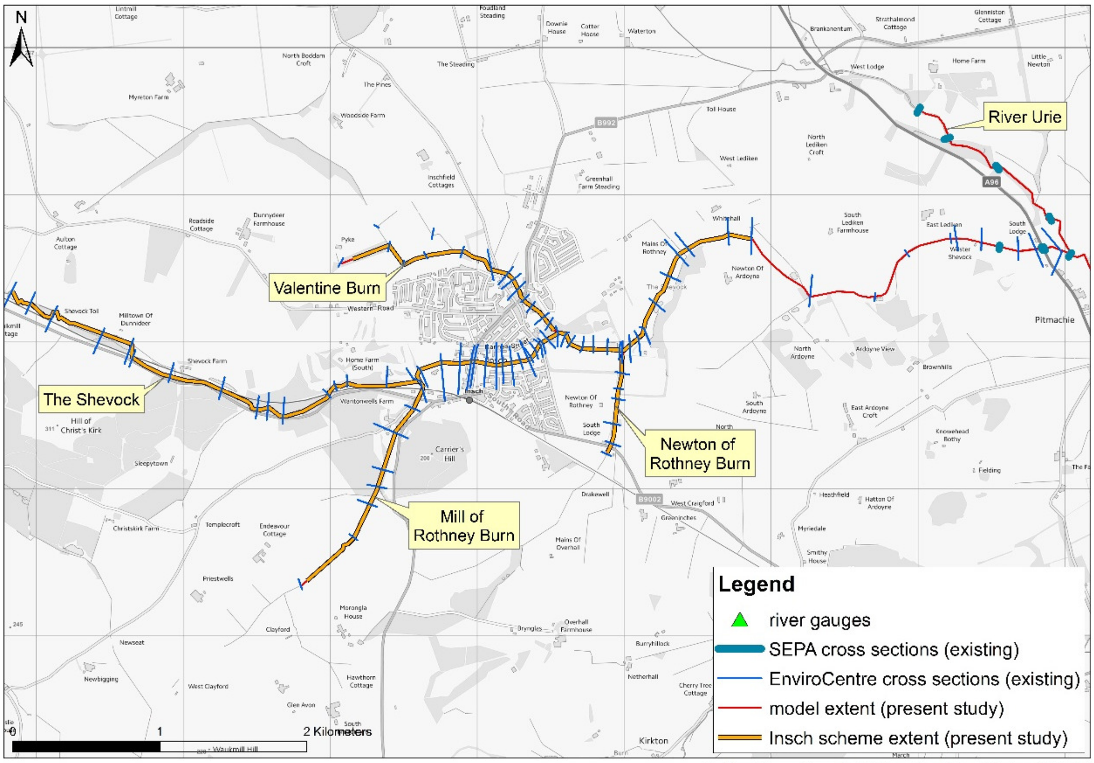


Figure 1-2: Model survey extent requested by Aberdeenshire Council based on existing EnviroCentre survey data from 2005 and other available survey data

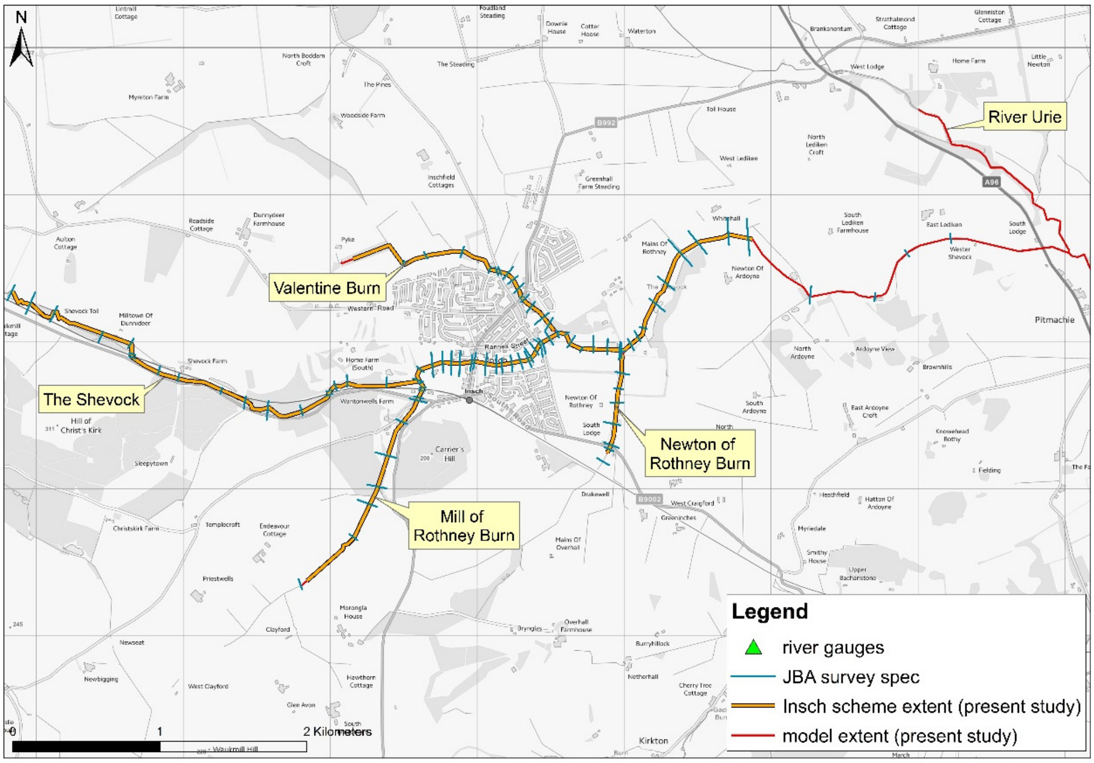


Figure 1-3: Cross section survey requested by JBA Consulting for present study

1.3 Historical flooding

A review of historic flooding was carried out using data collected from the following: Aberdeenshire Council, the Scottish Environmental Protection Agency (SEPA), the Chronology of British Hydrological Events (CBHE) and readily available internet sources. The historical flood record for Insch is documented in the table below.

Table 1-1: Historical flooding events in Insch

Date	Description	Source
1864	Overtopping of Shevock Burn resulting in flooding	SEPA FRM Strategy [6]
1865	1865 January: "The Shirach Burn [Urie tributary] at Insch, which, like the dangerous Rothes burn, rises rapidly, was sweeping down on the fields below on Thursday, and must be worse now (Friday morning), as the wind is blowing very strong." - Edinburgh Courant. [R. Don]	CBHE[7] (assumed to refer to Shevock Burn)
1879	Railway line flooded from a burn in Insch	SEPA FRM Strategy[6]
1903	Overtopping of Shevock Burn resulting in minor damage	SEPA FRM Strategy
1930	Overtopping of Shevock Burn resulting in minor damage	SEPA FRM Strategy[6]
1995	Colloquial evidence of flooding to a nursing home in Insch, although no SEPA evidence to confirm this event	SEPA FRM Strategy[6]
2002	Highest impact flood on record occurred in November 2002, when a nursing home had to be evacuated due to flooding by the Shevock Burn;	SEPA FRM Strategy[6]

6 North-East Flood Risk Management Strategy http://apps.sepa.org.uk/FRMStrategies/pdf/lpd/LPD_06_Full.pdf [Accessed: 10 November 2017]

7 British Chronology of Hydrological Events http://cbhe.hydrology.org.uk/results.php [Accessed: December 2017]

	residential properties were also affected.	
	"Flooding has closed a number of roads and a large part of the Aberdeen to Inverness railway line…Heavy rain in the area has made conditions hazardous. Railtrack said the rail line had been closed between Forres and Insch due to four separate instances of flooding."	BBC News http://news.bbc.co.uk/1/hi/scotland/2481223.stm? [Accessed: 16.11.17]
	"At Insch in Aberdeenshire, 41 elderly residents of a nursing home had to be carried to safety by firefighters after the Shevock Burn, a tributary of the River Urie, bust its banks, leaving 3ft of water surrounding the single-storey building."	The Scotsman https://www.scotsman.com/news/worst-flooding-in-30-years-1-629853 [Accessed: December 2017]
	Drumdaroch House and Willow Bank, Insch Flood photos	Supplied by SEPA
2004	June 2004 - Shevock Burn overtopped affecting properties in southwest Insch. Floods were exacerbated by drainage systems being unable to cope with the heavy rain.	SEPA FRM Strategy[6]
	August 2004 - Valentine Burn overtopped affecting property in north west Insch. Floods were exacerbated by drainage systems being unable to cope with the heavy rain.	SEPA FRM Strategy[6]
2007	"…firefighters had to pump away flood water threatening a nursing home, which has 39 residents, at Insch in Aberdeenshire."	BBC News, found online at: < http://news.bbc.co.uk/1/hi/scotland/north_east/7107078.stm> [Accessed:16.11.17]
2008	B9002 flooded due to surface water flooding	SEPA FRM Strategy[6]
2015	26 properties damaged as a result of flooding events in December 2015	SEPA FRM Strategy[6]
2016	"later flooding near Insch again disrupted rail travel" in January 2016	BBC News < http://www.bbc.co.uk/news/uk-scotland-north-east-orkney-shetland-35254350> [Accessed: 16.11.17]
	Photographs of flooding at Insch Airfield	Grampian Microlight and Flying Club < https://www.gmfc-insch.co.uk/index.php/news/50-flooding-january-2016> [Assessed: 16.11.17]

In summary, Insch has experienced flooding in 1864, 1865, 1879, 1903, 1930, 1995, 2002, 2004, 2007, 2008, 2015 and 2016. Key events are summarised below in Figure 1-4.

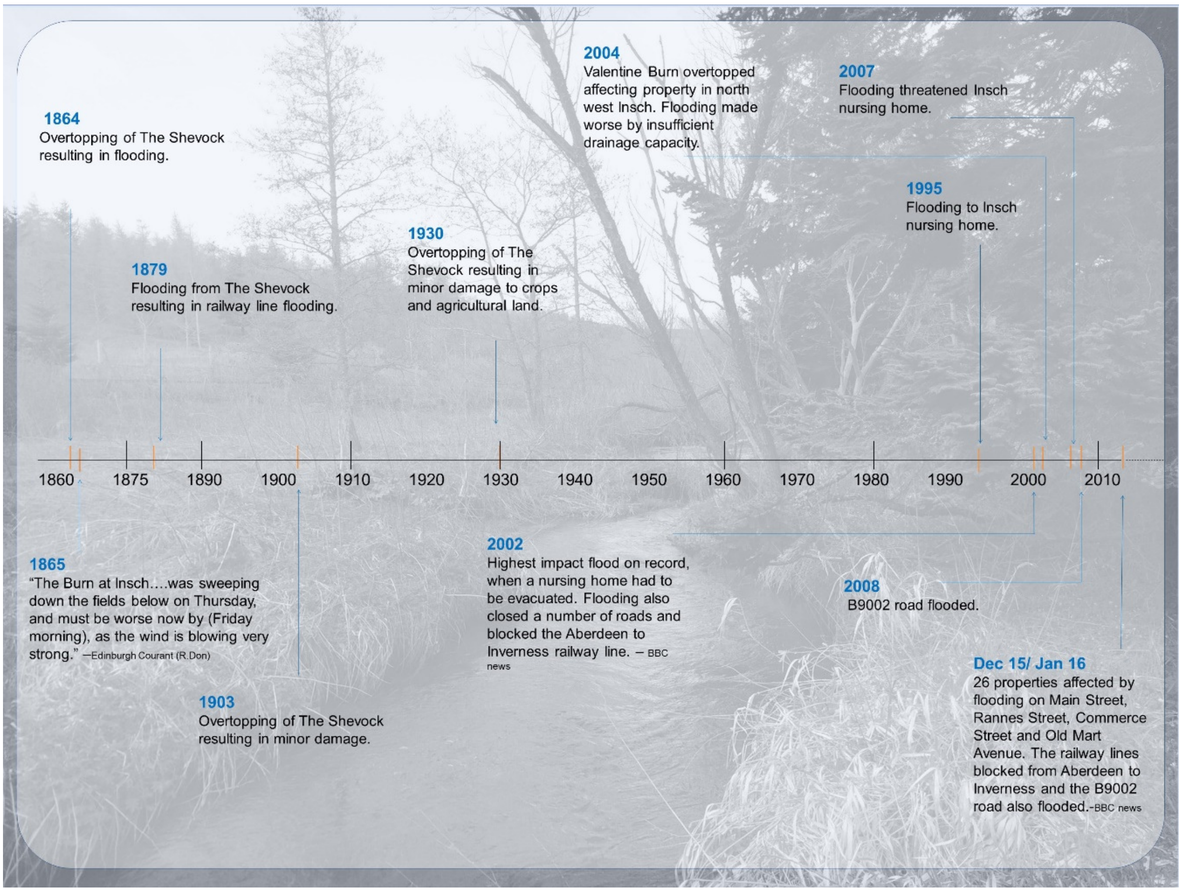


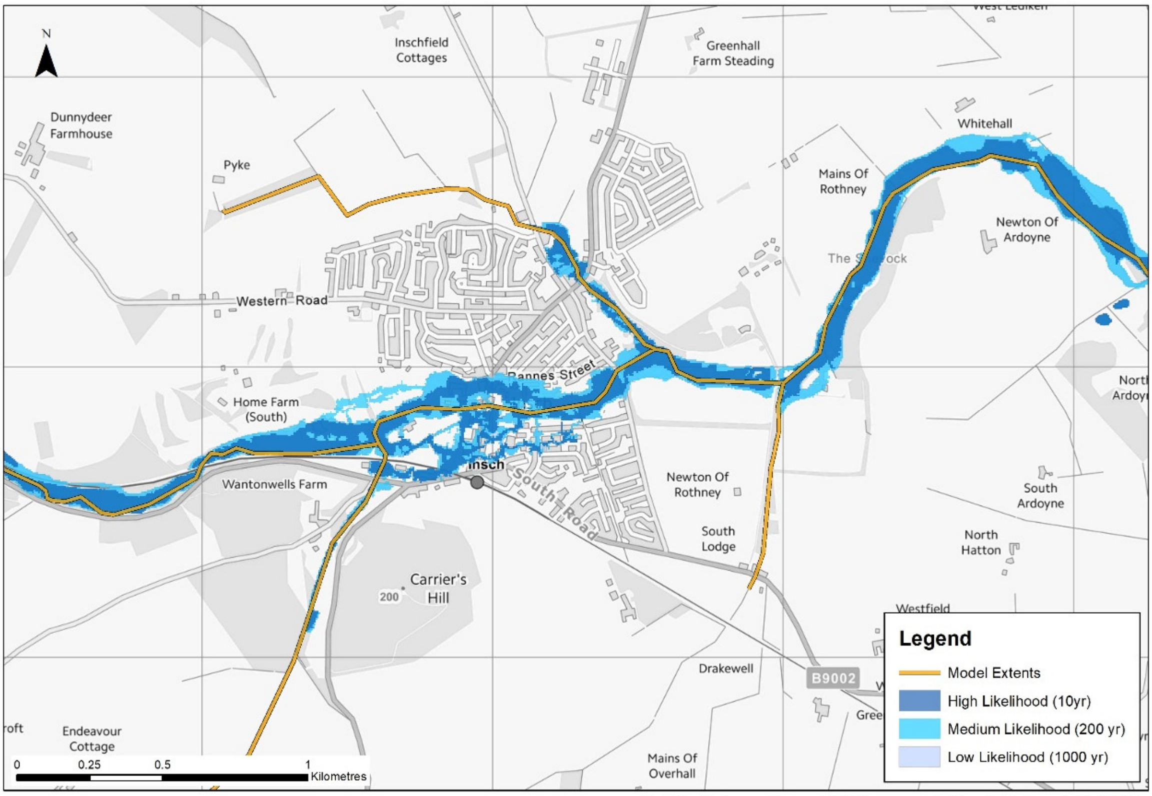
Figure 1-4: Key flood events in Insch (see Table 1-1 for sources).

1.4 Flood mechanisms

1.4.1 Shevock Burn flood mechanisms

Flooding from the Shevock Burn results from high flows that are restricted by a number of bridges and railway embankments[8] and cause overbank flows on to Mill Road, the south end of Commerce Street, Commercial Road, the south side of Insch War Memorial Hospital grounds, the back of properties on Old Mart Avenue, the east end of Rannes Street and the High Street. These flows also cause flooding of the Aberdeen - Inverness trainline and the B9002 road.

8 EnviroCentre. Report No 1948. Insch Drainage Study. December 2005.



Contains Ordnance Survey (OS) Crown copyright and database rights (2017)

Figure 1-5: SEPA fluvial flood map extents for Insch

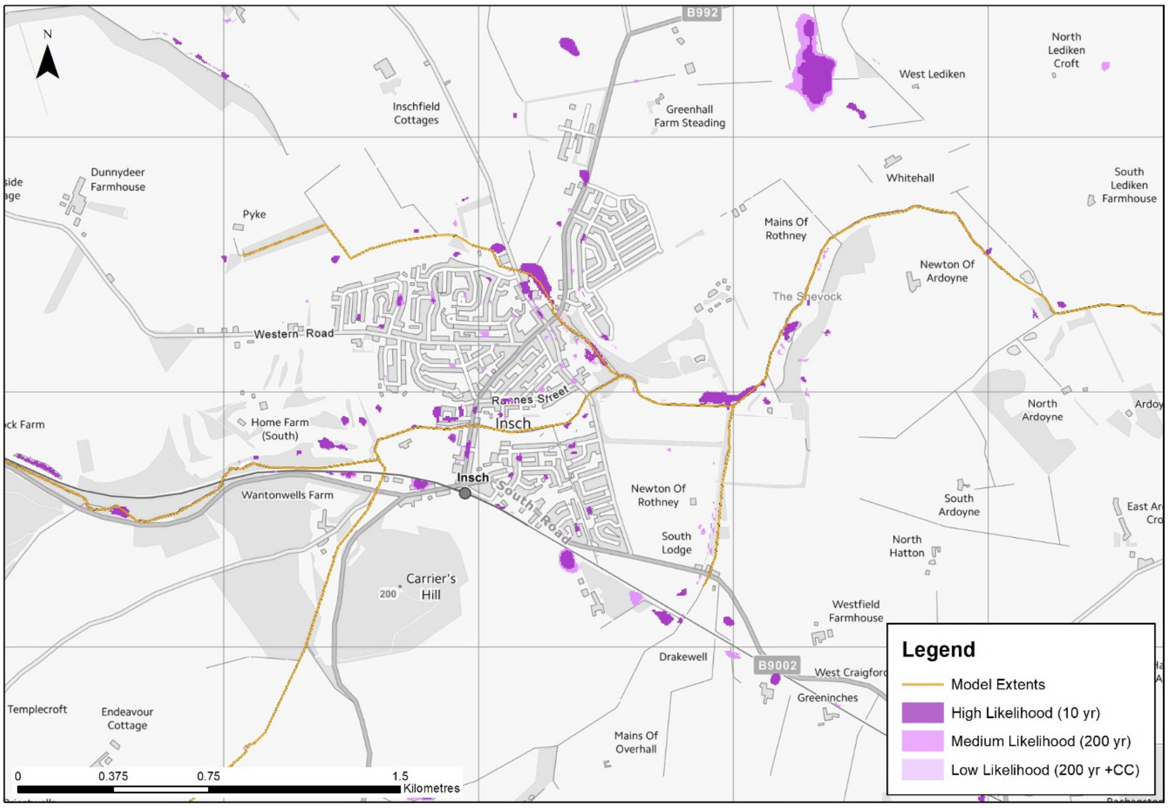


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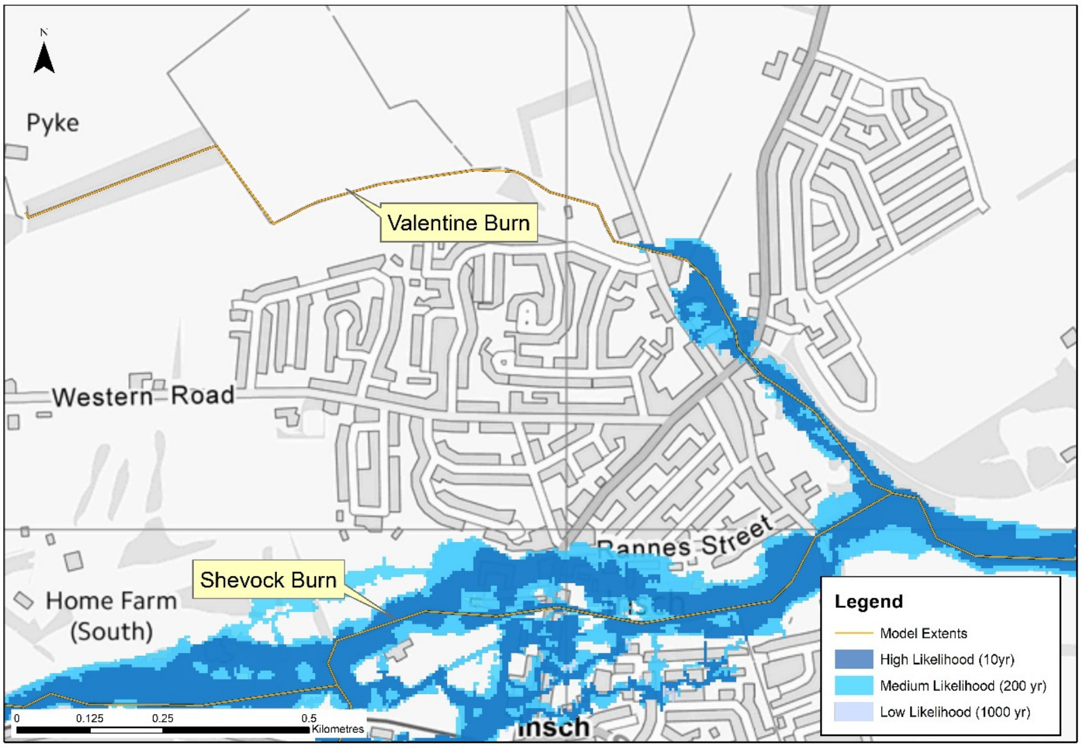
Figure 1-6: SEPA pluvial flood map extents for Insch

1.4.2 Flood mechanisms for Valentine Burn

The key flooding mechanisms from the Valentine Burn are water backing up from bridges along the burn and bank overtopping during high flows due to limited channel capacity. This results in flows to the east of Insch affecting Drumrossie Street, Largie Road and the east side of Market Street (Figure 1-7). Areas of fluvial flooding are also exacerbated by surface water flooding, particularly at the location of the drainage ditches along the Valentine Burn near Market Street, illustrated in Figure 1-8.



Contains Ordnance Survey (OS) Crown copyright and database rights (2017)

Figure 1-7: SEPA fluvial flood map extents for the Valentine Burn

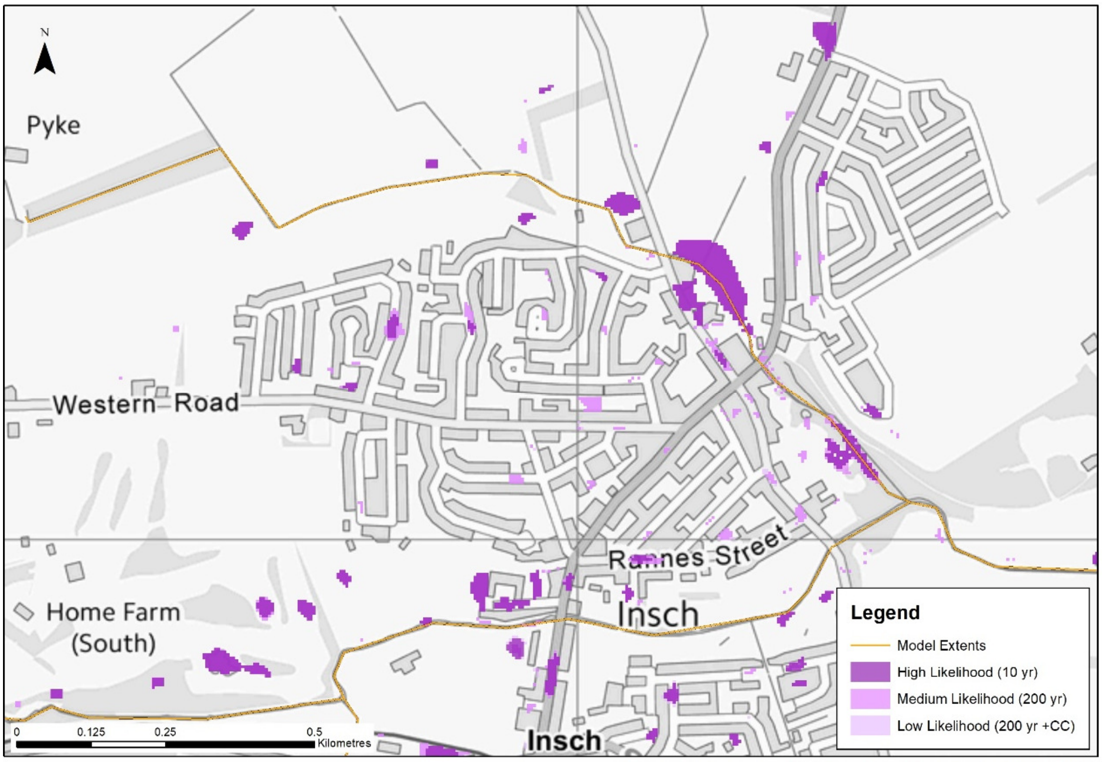


Figure 1-8: SEPA pluvial flood map extents for the Valentine Burn

1.4.3 Flood mechanisms for unnamed tributary (Newton of Rothney)

The SEPA Flood Map (2014) shows no flood inundation occurring from the Newton of Rothney tributary for the Low (0.1% AP (1000 year)), Medium (0.5% AP (200 year)) or High (10% AP (10 year)) likelihood events. There are also no documented flood events for this burn.

1.4.4 Flood mechanisms for unnamed tributary (Mill of Rothney)

The key flooding mechanism from the Mill of Rothney is the insufficient channel capacity, which results in overbank flows into surrounding agricultural land, as well as to the B9002 and Aberdeen - Inverness rail line. Flooding from the Mill of Rothney is shown in Figure 1-9.

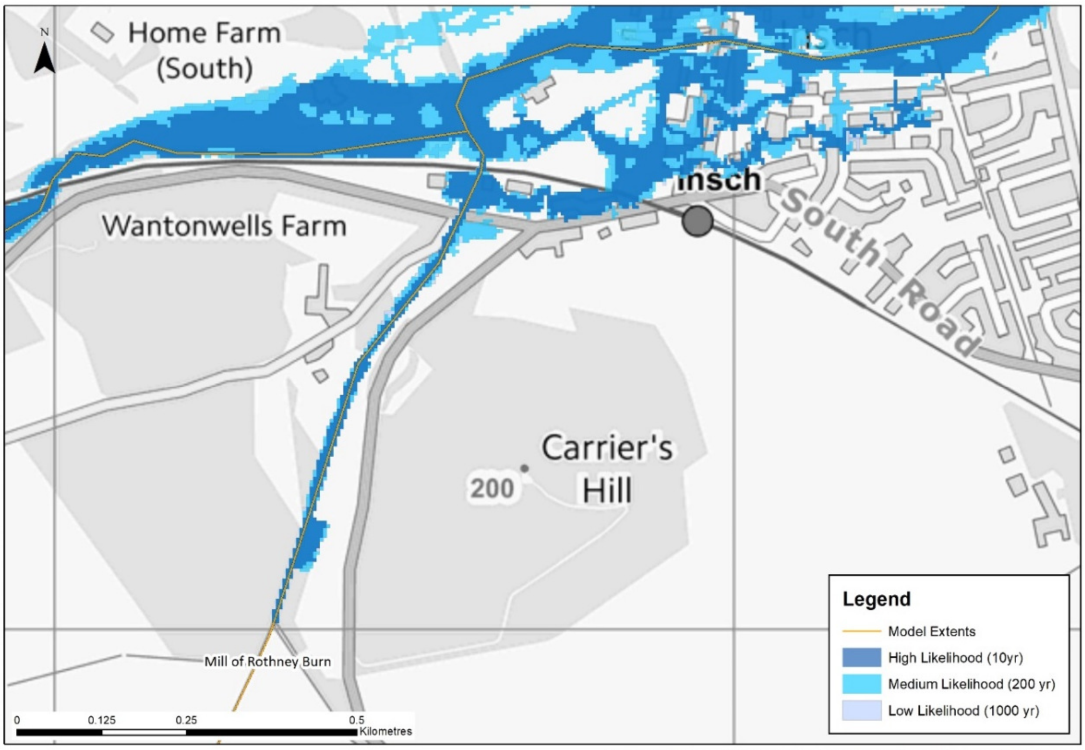


Figure 1-9: SEPA fluvial flood map extents for the Mill of Rothney Burn

1.4.5 Coastal flooding mechanisms

Insch is located over 40 km inland from Aberdeen and the mouth of the River Don and has typical elevations over 100 mAOD. Therefore, it is not susceptible to coastal flooding.

1.5 Watercourses

The following watercourses are included within the Aberdeenshire Council specification for assessment of flood risk in Insch (Table 1-2).

Table 1-2: Summary of model and survey available

Watercourse	Modelled	Survey data
Shevock Burn	Yes	Yes
Valentine Burn	Yes	No
Unnamed tributary (Newton of Rothney)	No	No
Unnamed tributary (Mill of Rothney)	No	No

1.6 Current flood defences

There are no formal or informal flood defences on the Shevock Burn or its tributaries in Insch.

2 Review of previous studies

The previous modelling study carried out in Insch is documented in Table 2-1 below. Potential sources of flooding are site specific but those applicable to the wider area are highlighted under key findings:

Table 2-1: Previous study and key findings

Document name	Author	Model Available	Key Findings
Insch drainage study - Dec 2005	EnviroCentre	Yes - InfoWorks RS hydraulic model and combined with Scottish Water (SW) sewer network model (InfoWorks CS)	• Purpose of the study was to assess drainage pathways in Insch • Model covers Shevock Burn and Valentine Burn • Capacity of Shevock Burn bridges - Bridge of Rothney = 38.5 m^3/s = 0.5% AP (200 year) Bridge of Insch 17.18 m^3/s = 10% AP (10 year) Bridge west of sewage works = 11.82 m^3/s = 50% AP (2 year) • Capacity of Valentine Burn bridges - Bennachie Bridge = 0.90 m^3/s = 50% AP (2 year) Drumrossie Street Bridge = 1.08 m^3/s = 50% AP (2 year) • Limited channel capacity; surcharging and topographical low points on surface water drainage network • Shevock Burn impacts flooding conditions of surface water drainage networks at 1% AP (100 year) and 0.5% AP (200 year) events • Valentine Burn has extensive vegetation between Bennachie Bridge and Drumrossie Street Bridge which limits capacity

3 Hydrological review

A review of readily available archives has been undertaken in Section 1.3 to develop the understanding of historical flood risk. Liaison with SEPA will be sought to ensure that up to date river flow data is being used, to discuss the estimation of flood flows used and to gain stakeholder and regulator 'buy in' at an early stage. This study will build on our experience of flood estimation on the River Don where we are presently undertaking flood studies for SEPA.

The previous study, discussed in Section 2, has utilised the Flood Estimation Handbook (FEH) methodologies for estimates of design flows. Updates have since been made to the FEH methods and additional data are available; therefore, new peak flow estimates will be obtained using the most up to date FEH techniques. The FEH Statistical method and Rainfall-Runoff methods (including ReFH2 and FEH13 rainfall) will be used and the most appropriate method selected for use in the hydraulic model. In general, this will be the Statistical method for large rural catchments and a Rainfall Runoff approach for smaller catchments. Where possible, historical flood data will also be incorporated for use in model calibration. The following return periods will be used.

Table 3-1: Return periods and annual probability

Return Period (years)	Annual Probability (%)
2	50
5	20
10	10
25	4
30	3.33
50	2
75	1.33
100	1
200	0.5
1000	0.1
30 +CC	3.33 +CC
200 +CC	0.5 +CC
500	0.2
1000	0.1

The catchment parameters will be extracted from the FEH Webservice[9] and reviewed against suitable OS mapping, geological and soil data. All catchments will be digitised within ArcGIS.

The preferred methods for each watercourse are presented in Table 3-2.

9 https://fehweb.ceh.ac.uk/

Table 3-2: Preferred method

Watercourse	Peak flow location	Preferred approach to FEH peak flows and hydrograph	Flow estimate locations
Shevock Burn	US Insch DS Insch	FEH Statistical Pooling Group analysis ReFH2 hydrographs	US boundary US and DS of Mill of Rothney Burn US and DS of Valentine Burn US and DS of Newton of Rothney Burn DS boundary
Valentine Burn	Shevock Burn confluence	FEH Rainfall Runoff or ReFH2 with FEH13 rainfall REFH2 hydrographs	US boundary DS boundary
Unnamed tributary (Newton of Rothney)	Shevock Burn confluence	FEH Rainfall Runoff or ReFH2 with FEH13 rainfall REFH2 hydrographs	US boundary DS boundary
Unnamed tributary (Mill of Rothney)	Shevock Burn confluence	FEH Rainfall Runoff or ReFH2 with FEH13 rainfall REFH2 hydrographs	US boundary DS boundary

For the Statistical method, the preferred method is a pooling group (P) analysis owing to the fact that Insch lies in an ungauged catchment. Where possible, the accuracy of the resulting flood estimates will be considered in the context of any longer flood history available through the review process. JBA Consulting also has access to WINFAP v4, which allows for the incorporation of historical data within flood estimation.

Data from the Old Rayne river level station will be used to help inform Time to Peak (Tp) for the Rainfall Runoff approach. The Tp value from Old Rayne will then be used as a donor for the sites using the Rainfall Runoff approach. If flow data are also available, then, the ReFH2 calibration facility will be used to calibrate ReFH2 to between 3 and 5 representative events recorded at the donor site (daily and 15-minute rainfall data and 15-minute flow data will be required) and the ReFH2 parameters at the target site adjusted per FEH guidance. The final choice of Rainfall Runoff method (i.e. ReFH2 or FEH Rainfall Runoff) will be made on the basis of which method appears to be most representative of the catchment in question. Hydrographs for the smaller catchments will be derived using ReFH2 and scaled according to the final peak flow estimates from the preferred methods. Depth Duration Frequency (DDF) data (which enable estimation of extreme rainfall at a particular location) and Areal Reduction Factor (ARF) parameters (which relate point rainfall data across a catchment) will be derived from FEH13 rainfall data via the FEH Webservice.

Where a catchment-wide critical duration is required, this will be calculated using the target point of the downstream end of the hydraulic model using the functionality within Flood Modeller.

Within the hydraulic model, the fluvial inflow locations will be represented by ReFH units. The peak flow will be overwritten with the information described in the preceding paragraphs and the same critical duration will be applied throughout the catchment. The ReFH unit is proposed in preference to the ReFH2 unit as it will increase model portability (e.g. to external organisations) by minimising licencing issues.

Where tributaries need to be represented in the hydraulic model along a main watercourse, these will also be represented by point ReFH units with peak flow values derived as follows:

- The growth curve for the main watercourse at the downstream point of the model extent will be assumed to be appropriate for all locations along the main watercourse.
- Depending upon the size of catchment, this growth curve will have been derived from either the FEH Statistical method or a Rainfall Runoff approach.
- Where the Statistical method has been used, for consistency, the gauging station used as the donor site for QMED adjustment at that location will also be used as the donor site for QMED adjustment throughout. Where a Rainfall Runoff approach has been used, QMED will be scaled via catchment area.
- Catchment descriptors will be derived from the FEH CD-ROM upstream and downstream of each tributary.
- Area adjustments will be made for consistency with other analyses.
- At each location, QMED will be calculated from the adjusted catchment descriptors, the multiplier applied to QMED and the growth curve also applied.
- This will allow a consistent increase in flood flows from upstream to downstream.
- The lateral inflows themselves will be obtained by subtracting the peak flows from the reach immediately upstream of each tributary from the peak flows immediately downstream.
- The critical duration for the lateral inflows will be set to that of the model downstream extent as derived from Flood Modeller and checked against observed data.

Where possible, hydraulic modelling will be used to inform the suitability of the flood frequency estimates, whereby the frequency of flooding established by the hydraulic modelling will be compared with the observed frequency available from the historical record and this information then used to best select the most appropriate method of flood flow estimation (e.g. FEH Statistical or Rainfall Runoff). All hydrological analysis will be written up into an Interim Hydrology Report for review by both the client and SEPA. The river and rain gauges in the vicinity of the Insch scheme are illustrated in Figure 3-1.

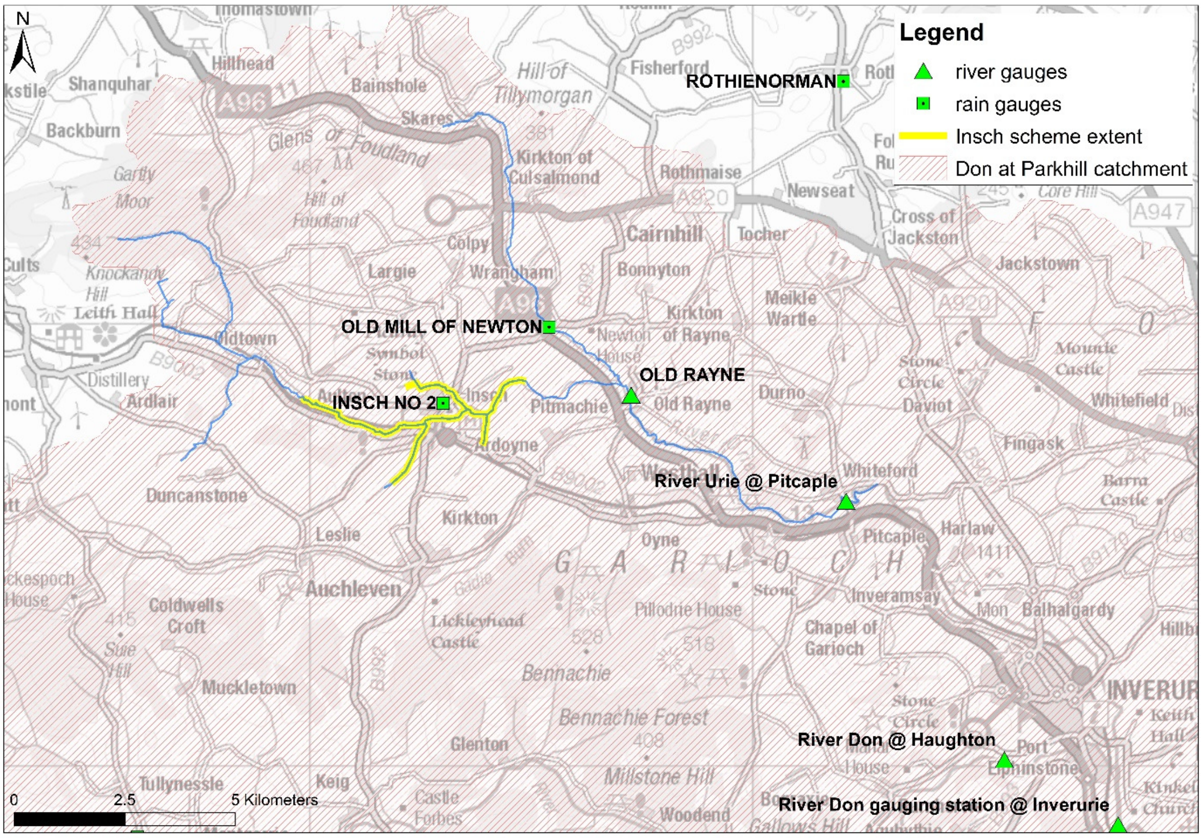


Figure 3-1: Hydrometric data available in the vicinity of the Insch scheme

4 Model summaries

4.1 Shevock Burn

The Shevock Burn was modelled by EnviroCentre in 2005 using an InfoWorks RS software to simulate open channel flows and water levels on the Shevock Burn, and an InfoWorks CS model to simulate the piped urban network. The model extended from where the Shevock Burn flows adjacent to the railway line to approximately 75 m north west of the Scottish Water wastewater treatment works (WwTW, NJ 6409 2802). The model had a total of 27 cross sections as well as various structures used to represent bridges and other structures along the watercourse. Spill units have been included to accurately simulate the flows behind bridge structures.

4.2 Valentine Burn

The Valentine Burn was modelled by EnviroCentre in 2005, using a hydrodynamic InfoWorks RS model to simulate flows and water levels from the area where the burn flows past the Insch Golf Course to its confluence with the Shevock Burn. The model had a total of 15 cross sections along the length of the watercourse, with bridge structures modelled using culverts due to low bridge capacity and spills included allowing for spilling on the road.

4.3 Unnamed tributary (Newton of Rothney)

This tributary has not previously been modelled.

4.4 Unnamed tributary (Mill of Rothney)

This tributary has not previously been modelled.

5 Survey implications

5.1 DTM

Table 5-1: Details of the DTM data requested/supplied

Dataset	Supplier
LiDAR Data	AC
NextMap Data	AC
NFM GIS dataset	SEPA
OS background mapping (MasterMap, 10K, 25K)	AC

5.2 Cross sections

The project tender required the pricing of 83 cross sections for the Insch Study area based on Figure 3-3 in the ITT, which displayed 79 cross sections surveys for the previous Insch study, and a subsequent ITT amendment requesting an additional 3 cross sections to extend the model reach to the confluence with the Urie. Upon further examination of the model extent, a total of 92 cross sections is recommended for the survey in order to accurately capture the key features and structures relevant to this study, particularly for development of the hydraulic model.

Table 5-2: Details of the cross-section data

Element	Number priced as per ITT	Number of sections with figures 3.1;3.2 &3.3.	JBA specification
Insch cross sections	83	79	92
Insch threshold survey	150	n/a	TBC

The number of threshold surveys priced in the tender totalled 150, but the exact number required will be determined later in the project after the hydraulic modelling has been undertaken. This is so that the modelled flood extents and depths can inform the locations where threshold surveys will be of most interest to understand flood risk and potential flood mitigation measures.

5.3 CCTV

No culverts of sufficient length to require CCTV survey have been identified in the Insch study area at this stage. Therefore, CCTV survey will not be required.

6 Additional requirements

Table 6-1: Additional data requested/supplied

Dataset	Source
River Basin Management Planning datasets	SEPA
Morphology pressures datasets	SEPA
Scottish Digital Rivers Network	CEH
Receptor Dataset	SEPA
PRFA dataset	SEPA
Flood hazard mapping and model extents	SEPA/AC
Scottish Water Section 16 data, DAS model data and GIS data	SW
Flood Event Database	SEPA
River - 15 min, AMAX, Ratings - Pitcaple	SEPA
Rainfall - TBR as priority	SEPA
Hydraulic Models	AC/SEPA
Council survey spec lines	AC

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