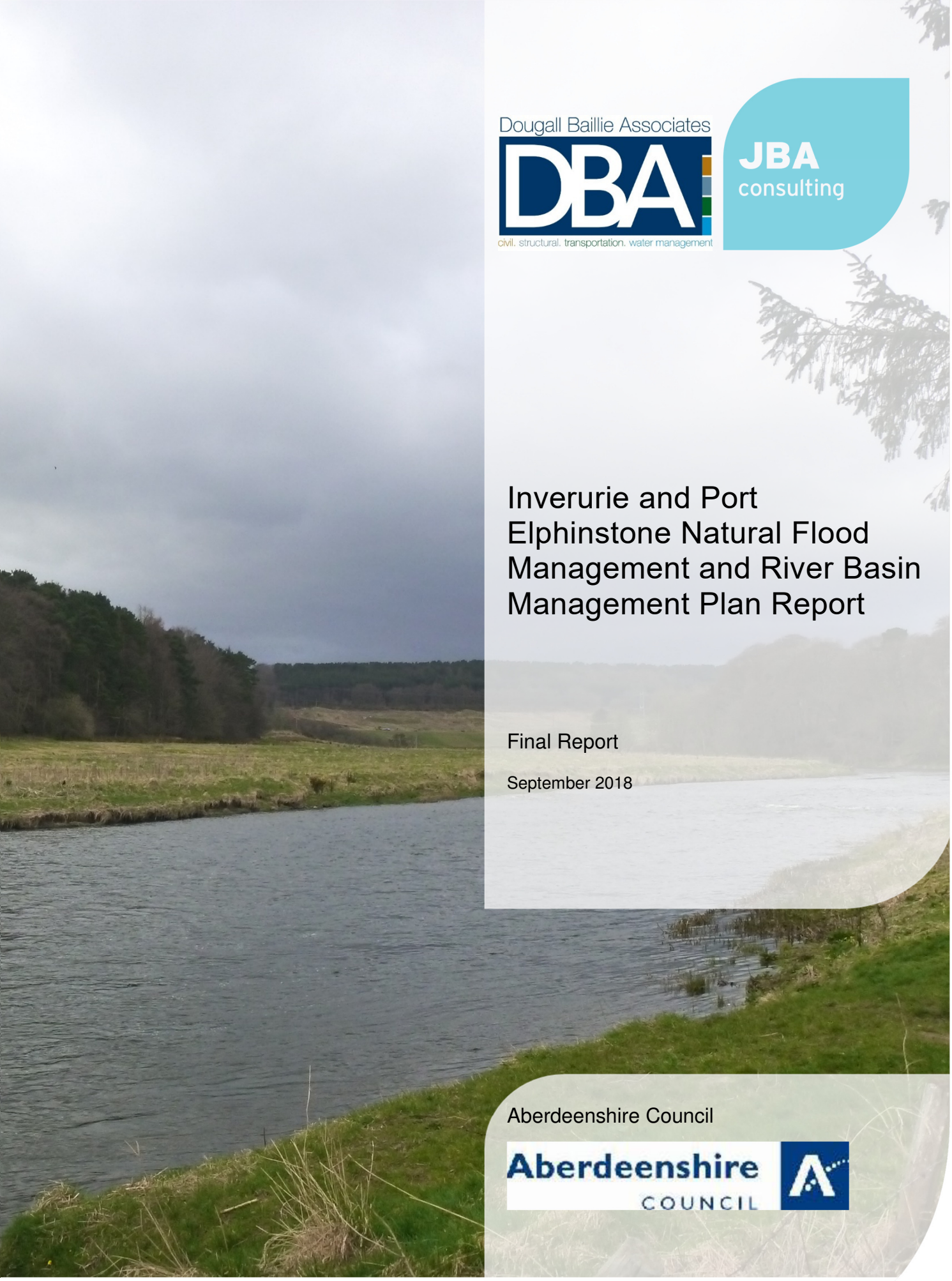

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Inverurie and Port Elphinstone Natural Flood Management and River Basin Management Plan Report

Final Report

September 2018

Aberdeenshire Council

Aberdeenshire COUNCIL

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Revision History

Revision Ref / Date Issued	Amendments	Issued to
P01 / June 2018	-	Alistair Scotland and Lee Watson, Aberdeenshire Council
P02 / July 2018	Page numbering, grid references added, appendix photo maps updated.	Alistair Scotland and Lee Watson, Aberdeenshire Council
P03 / Sept 2018	Aberdeenshire Council and SEPA comments addressed.	Alistair Scotland and Lee Watson, Aberdeenshire Council
C01 / April 2019	Published.	Alistair Scotland and Lee Watson, Aberdeenshire Council

Contract

This report describes work commissioned by Gavin Penman, on behalf of Aberdeenshire Council on 10 October 2017 by Purchase Order Number 1095192. Dougall Baillie's representative for the contract was Scott Macphail and Aberdeenshire Council's representative for the contract was Alistair Scotland. Hannah Otton, Briony McIntosh and Caroline Anderton of JBA Consulting carried out this work.

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Purpose

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Acknowledgements

JBA wishes to thank SEPA for supplying the natural flood management, morphological pressures and river basin management plan datasets. JBA also thanks Aberdeenshire Council for the supply of data.

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Executive Summary

Context

Under the Flood Risk Management (Scotland) Act 2009, this report forms part of the appraisal study for Inverurie and Port Elphinstone commissioned by Aberdeenshire Council. The purpose of this report is to assess the current condition of the watercourses within the River Don catchment, based on parameters set out in the River Basin Management Plan (RBMP) for catchments with status less than good, and identify opportunities for Natural Flood Management (NFM).

This has been achieved through an initial desktop study of the catchment, determining the hydrological conditions and characteristics of the catchment, alongside NFM potential screening maps. The River Don catchment comprises several smaller sub-catchments, the greatest contribution in terms of peak flows is from the River Urie which itself is comprised of a number of smaller sub-catchments which collectively contribute a substantial volume (17% of the overall catchment discharge) to the River Don. Outwith the larger Urie sub-catchment the greatest proportional flow originates in the River Don headwaters and Water of Nochty sub-catchments which contribute 14% and 7% respectively.

Natural Flood Management Summary

A long list of the relevance of a range of NFM options was created for each of the key areas in the catchment. A screening exercise was undertaken using the collated GIS data to derive key locations for site inspection, with site walkovers resulting in a short list of suitable opportunities for each of the prioritised catchments.

NFM opportunities are numerous across the wider River Don catchment. Key regions where it is considered NFM measures would be of greatest benefit to flood risk at Inverurie and Port Elphinstone (and Kemnay) are: the Ton Burn sub-catchment, upper Don tributary sub-catchments, the Lochter Burn and the wider River Urie catchment as a whole. The River Urie contributes a high proportional flow to the River Don and is itself a flood risk to Inverurie. NFM within this catchment would therefore directly benefit the community of Inverurie, as well as the smaller communities at Old Rayne and Pitcaple. Land use in the River Urie and lower Don catchments is dominated by agricultural land which has resulted in straightened watercourses, drainage channels and high runoff. Good land management practices such as the use of hedgerows, buffer strips, leaky bunds and along-contour ploughing are therefore key NFM measures. Within the scheme extent NFM potential is greatest along the River Urie at Uryside where floodplain storage could be enhanced. There is potential for wetland development which has the multi-benefit of improving ecological habitat diversity and educational opportunities for the nearby school.

A summary of NFM measures for the key sub-catchments visited are provided in Table 1, with specific locations and additional NFM measures recommended for the wider catchment as a whole mapped in Figure 1. It should be noted that the opportunities mapped in Figure 1 are primarily based on the areas visited during the catchment walkovers and are not exhaustive, with similar measures applicable across the River Don catchment.

River Basin Management Plan Summary

The River Don within the scheme extent is classified as being in 'Good' physical despite there being a number of physical pressures including: embankments and grey bank protection along the Old Canal; embankments south of Kirkwood Commercial Park; informal defences not listed within the SEPA morphological pressures dataset which include a concrete wall downstream of the B993 road bridge, embankments adjacent to Davidson Fields and one east of the B993 road bridge put in place by Scottish Water; and excessive bank erosion along the Don adjacent to Port Elphinstone. Removal of the majority of the embankments is not advised due to the protection they are currently providing. It may however, be possible to increase channel capacity by setting-back the Scottish Water embankment (ensuring the assets behind are not at increased flood risk). Embankments along the Old Canal could also be breached to establish a hydraulic connection with the canal to encourage storage in this area at times of spate but may be hard to remove entirely due to their considerable height. It is recommended the excessively eroding sections of bank by Port Elphinstone be stabilised to limit high sediment influx which can ultimately decrease channel capacity. The River Urie within the scheme extent is also classified as being in 'Good' physical condition and in contrast to the Don is far less constrained. The primary pressures are embankments west of Uryside Housing estate which could be set-back or removed. It is

recommended the existing condition of the River Urie in this reach is maintained, ensuring any future flood prevention measures do not impact the 'Good' morphological status.

Outwith the scheme extent, the Ton Burn and Tuach Burn tributaries of the Don are classified as being in 'Moderate' and 'Poor' physical condition respectively, and the majority of the River Urie sub-catchments are classified as being in 'Moderate' physical condition. The primary reason for downgrade in physical condition is due to the watercourses having undergone high impact realignment, being over-straightened for the majority of their reach and many are constrained by a series of embankments. The site visits indicated the opportunity to improve the physical condition of these tributaries was high. For example, within both the Ton Burn and Lochter Burn sub-catchments numerous areas were identified where channel sinuosity could be increased to slow flow towards the primary watercourses (Don and Urie) and embankments removed to release channel capacity and improve floodplain connectivity.

Implementation Approach

The approach to implementing the above recommendations will depend on a number of factors, not least landowner involvement and the availability of funding for this type of measure. However, the recommended methodology for the delivery of river restoration and NFM within the catchments is suggested as follows:

- Incorporation of NFM within a proposed FPS either as a separate option or to supplement other more structural options to provide future adaptation against climate change.
- Inclusion within any wider Aberdeenshire Council NFM funding mechanism to deliver NFM and river restoration when specific funds become available on an ad-hoc basis.
- Delivery of measures via an FPS as a percentage uplift included within the total FPS costs set aside for local NFM and RBMP measures.

The following are considered key areas for NFM/ RBMP improvements and specifically we recommend the following:

- **River Don at Inverurie:** Floodplain storage potential upstream of the A96 at Inverurie, stabilise excessively eroding sections of bank east of Port Elphinstone and potential to set-back embankments through Inverurie.
- **River Urie at Uryside:** Floodplain storage potential with recommended measures including wetland development, large scale debris dams and removal, set-back or breaching of agricultural embankments. Buffer strips, leaky bunds and floodplain woodland planting in this region would also reduce runoff and encourage floodplain storage.
- **Ton Burn near the Don confluence** has potential for buffer strips, leaky bunds; wetland development, riparian planting and increasing sinuosity to reduce runoff and increase floodplain storage potential. At **Bilbo Bridge** embankment removal, wet-woodland creation, increased sinuosity and floodplain storage ponds would improve RBMP status and store water in the upper catchment. This sub-catchment contributes a high proportional flow and would also benefit the smaller community of Kemnay.
- **Lochter Burn sub-catchment:** particularly near the Lochter Activity Centre and Lethnay House where runoff reduction and floodplain storage potential are high.

Table 1: Summary of NFM options within the key sub-catchments assessed during the walkover.

	Summary of proposed NFM interventions			
Catchment	**Increased vegetation cover**	**Working within/ on the banks**	**Land management**	**Runoff Management**
River Don	Riparian vegetation planting. Along-contour, floodplain and riparian woodland.	Buffer strips. Meandering. Debris dams. Set back/remove embankments.	Along contour ploughing. Peatland restoration. Upland drain blocking.	Offline storage ponds. Leaky bunds.
Ton Burn	Gully; upslope, along-contour, riparian and floodplain woodland. Wet woodland.	Debris dams. Meandering. Buffer strips. Remove/breach embankments.	Prevent/ limit livestock poaching of the bank. Upland habitat restoration.	Leaky bunds. Wetlands.
River Urie	Floodplain and riparian woodland. Upper catchment and along contour woodland planting. Wet woodlands.	Buffer strips. Large woody debris dams. Meander in upper catchment. Set back embankments.	Prevent/ limit livestock poaching of the bank.	Offline storage ponds. Leaky bunds. Hedgerows.
Lochter Burn	Riparian vegetation. Woodland planting. Along contour planting.	Removal of embankments. Meandering. Buffer strips. Debris dams.	Along contour ploughing.	Wetlands. Storage ponds. Leaky bunds.

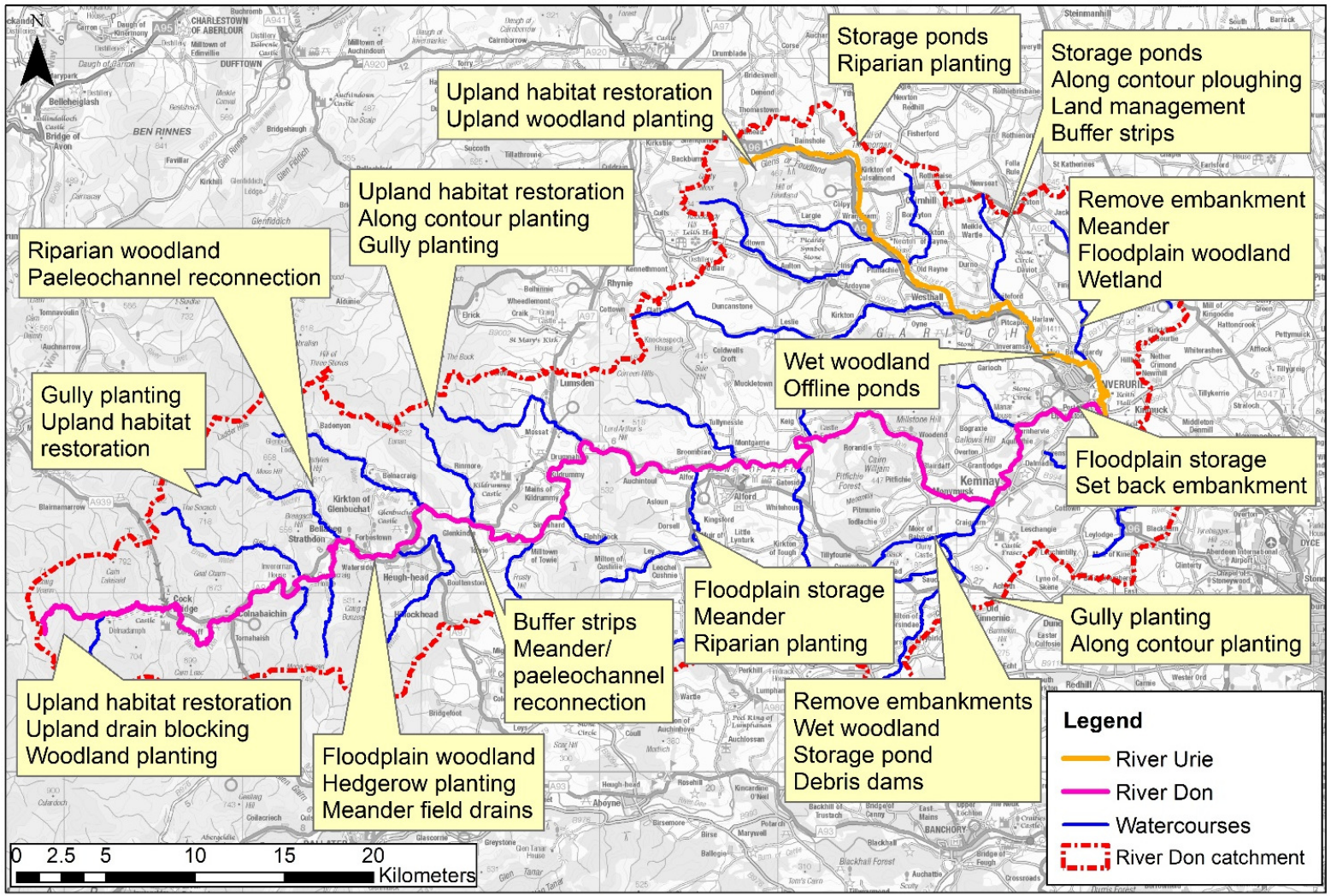

Figure 1: Summary of NFM recommendations in the River Don catchment.

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Abbreviations

BFIHOST…….	Base Flow Index estimated from soil type
BGS…….....	British Geological Survey
CAR…….....	Controlled Activity Regulations (2010)
DTM…….....	Digital Terrain Model
FPS…….....	Flood Protection Scheme
FRM……..	Flood Risk Mapping
GIS…….....	Geographical Information System
mAOD…….....	metres Above Ordnance Datum
NFM……..	Natural Flood Management
NGR…….....	National Grid Reference
OS…….....	Ordnance Survey
OS NGR……...	Ordnance Survey National Grid Reference
PFRA…….....	Preliminary Flood Risk Assessment
QMED……...	Median Annual Flood (with return period 2 years)
RBMP……...	River Basin Management Plan
SAAR……	Standard Average Annual Rainfall
SAC……..... …….	Special Area of Conservation, protected under the EU Habitats Directive
SAIFF……..	Scottish Advisory & Implementation Forum for Flooding
SEPA…….....	Scottish Environment Protection Agency
SPRHOST……	Standard percentage runoff estimated from soil type
SSSI…….....	Site of Special Scientific Interest
WFD…….....	Water Framework Directive

1 Introduction

The purpose of this report is to assess the current condition of watercourses within the River Don catchment as far as Kintore based on parameters set out in the River Basin Management Plan (RBMP) and identify potential opportunities for Natural Flood Management (NFM). A desk-based review of the catchment was used to identify areas to be investigated further through site walkovers. The results of these are presented in the following chapters.

1.1 RBMP

1.1.1 Legislation

The River Basin Management Plan forms part of the European Water Framework Directive (WFD) 2000. The WFD is currently in its second cycle (2015 - 2027) and sets out the objectives for protecting and improving the water environment, balancing the environmental, societal and economic costs and benefits. The Scottish Environmental Protection Agency (SEPA) are responsible for managing this within Scotland.

The RBMP defines and classifies the environmental condition of water bodies, with the overall condition graded from bad to high based on a number of categories including: access for fish migration; water flows and levels; freedom from invasive species; water quality; ecology and physical condition.

1.1.2 Aim

The aim of this RBMP assessment was to consider the current overall status of each watercourse within the defined catchment and in particular identify those classified as less than good based on their physical condition. Focus is given to the physical condition of the watercourse as this has a direct impact on flood risk from the river. Additionally, improvements to the morphology are likely to also improve the status of other RBMP categories. Multiple RBMP criteria will be considered in the optioneering stage.

For those considered less than good or within the modelled reaches (i) a desk-based review of the current significant morphological pressures along each watercourse was undertaken; (ii) the percentage capacity of the river used by these pressures was calculated using a methodology in keeping with SEPA's Morphological Impact Assessment System (MImAS) and (iii) a catchment walkover to review the constraints and identify opportunities to improve physical condition undertaken. The results of these are discussed in further detail in the following chapters.

1.2 NFM

1.2.1 Legislation

The Flood Risk Management (Scotland) Act 2009 requires SEPA and Responsible Authorities to consider sustainable approaches to managing flood risk. This includes considering the role that NFM has in reducing flood risk, where NFM was defined by SAIFF (2011)[1] as follows:

'Natural Flood Management can be defined as those techniques that aim to work with natural hydrological and morphological processes, features and characteristics to manage the sources and pathways of flood waters. These techniques include the restoration, enhancement and alteration of natural features and characteristics, but exclude traditional flood defence engineering that works against or disrupts these natural processes.'

1.2.2 Aim of the assessments

In the past, flood management has typically focused on traditional methods of mitigating flood risk, such as the use of flood walls and embankments, although such methods are not considered to be sustainable, particularly in the face of the increased frequency and severity of flooding predicted to impact Scotland as a result of climate change.

In contrast, NFM measures work together with the natural characteristics and processes of the landscape to help manage the sources and pathways of flooding as part of a catchment-wide approach and are generally considered to be more sustainable. Traditional measures do however,

1 Scottish Advisory and Implementation Forum for Flooding (SAIFF, 2011)

still have a role in terms of protection and cost benefit analysis with respect to large magnitude floods, as NFM measures may be more effective for smaller scale events.

NFM measures vary in scale and type depending on local conditions. The SEPA Natural Flood Management Handbook[2], Chapter 2, provides guidance on river- and catchment-based NFM measures. The ultimate goals of such measures are as follows:

- Reduce the rate or amount of runoff;
- Improve the ability of rivers and their floodplains to manage flood water.

These aims are largely achieved by storing more water within the catchment and slowing the flow of water overland or instream. The types of NFM measures considered for suitability within the catchment include those in Table 1-1.

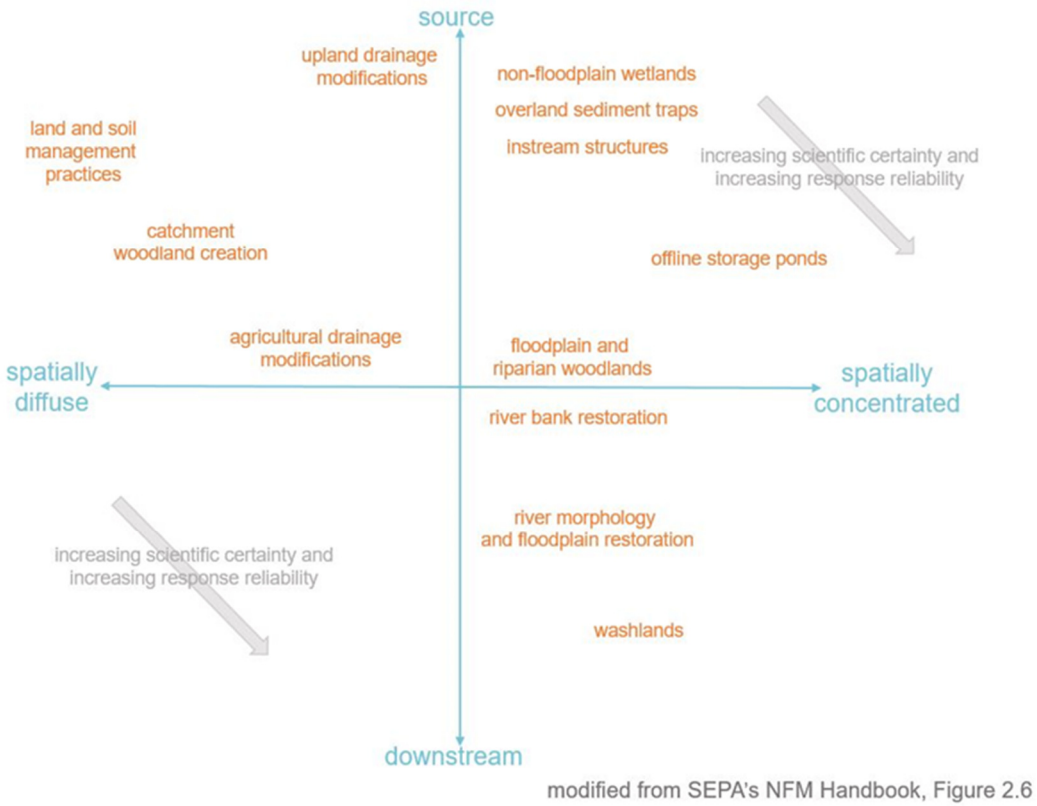
Table 1-1: Examples of types of NFM measures suitable for application across catchments

Type of NFM measure	Examples
Increased vegetation cover	Woodland planting (conifer, native and broadleaf) Gully woodland planting Creation of cross-slope tree shelter belts Riverbank woodland
Working within and on the banks of the channel	Placing of large woody debris and boulders In-channel barriers Bank restoration/erosion protection Managing channel instabilities (e.g. fencing) Reach restoration and floodplain reconnection Removal of obstacles to river flow
Land management	Soil and bare earth improvements Changing agricultural field drainage Blocking of upland drains
Runoff management	Overland flow interception Offline ponds Farm wetlands Sediment traps

NFM measures often offer a number of multiple benefits (such as improvements in water quality or increased access to nature) and can be used in conjunction with traditional engineering approaches to flood risk management where appropriate. The effectiveness of NFM measures is generally dependent on their location within the catchment (Figure 1-1).

2 https://www.sepa.org.uk/media/163560/sepa-natural-flood-management-handbook1.pdf [Chapter 2. Page 14].

Figure 1-1: Spatial distribution of NFM measures within a catchment



modified from SEPA's NFM Handbook, Figure 2.6

The aim of this NFM assessment was to consider the current state of the catchment and identify locations where NFM may be appropriate. Potential opportunities for NFM within the catchment are discussed in further detail in the following chapters.

2 Catchment characteristics

The River Don catchment to the downstream extent of the scheme (downstream of Port Elphinstone) has been reviewed and covers the three main communities of interest at Insch, Inverurie and Port Elphinstone. Insch is covered in greater detail in a separate report[3] while the aforementioned communities will be discussed in further detail in this report.

The catchment draining to Parkhill (the downstream extent of the model) covers a total area of approximately 1270 km^2 and is traversed by a number of watercourses. The River Don is the primary watercourse which originates to the west of Inverurie in the Cairngorm mountain range. It flows through a predominantly rural catchment with a number of tributaries discharging into the river along both banks. At Inverurie, the River Urie discharges into the Don from the north. This is the second major watercourse within the Don catchment, and has a sub-catchment area of approximately 305 km^2. From Inverurie the River Don flows south through the communities of Port Elphinstone and Kintore, and approximately 15 km further downstream through the city of Aberdeen ultimately discharging into the North Sea. The catchment is predominantly rural with the communities of Alford, Insch, Kemnay, Inverurie, Kintore and Oldmeldrum being small urban areas within the catchment.

2.1 Catchment geology, soils and topography

According to the British Geological Survey (BGS) 1:625,000 scale geological map of Britain[4], the catchment is predominantly underlain by Ordovician to Silurian aged igneous and metamorphic bedrock, overlain by superficial glacial deposits (Figure 2-1).

The James Hutton Institute's 1:250,000 scale Soils of Scotland map[5], indicates the upland regions of the catchment are dominated by peaty gleyed podzols; the central and northern catchment by brown earths and the southern catchment by humus-iron podzols (Figure 2-2).

The catchment is therefore dominated by relatively impervious bedrock but mixed permeability superficial deposits. The catchment BFIHOST (baseflow index estimated from soil type) of 0.584 and SPRHOST (Standard percentage runoff estimated from soil type) of 31% indicate the catchment as a whole is moderately permeable and would not therefore have a particularly flashy response to rainfall events.

3 JBA Consulting. June 2018. Insch Natural Flood Risk Management and River Basin Management Plan. Draft Report.

4 British Geological Survey http://mapapps.bgs.ac.uk/geologyofbritain/home.html [Accessed: December 2017]

5 http://www.hutton.ac.uk/learning/natural-resource-datasets/soilshutton/soils-maps-scotland/download#soilmapdata

Figure 2-1: Geology

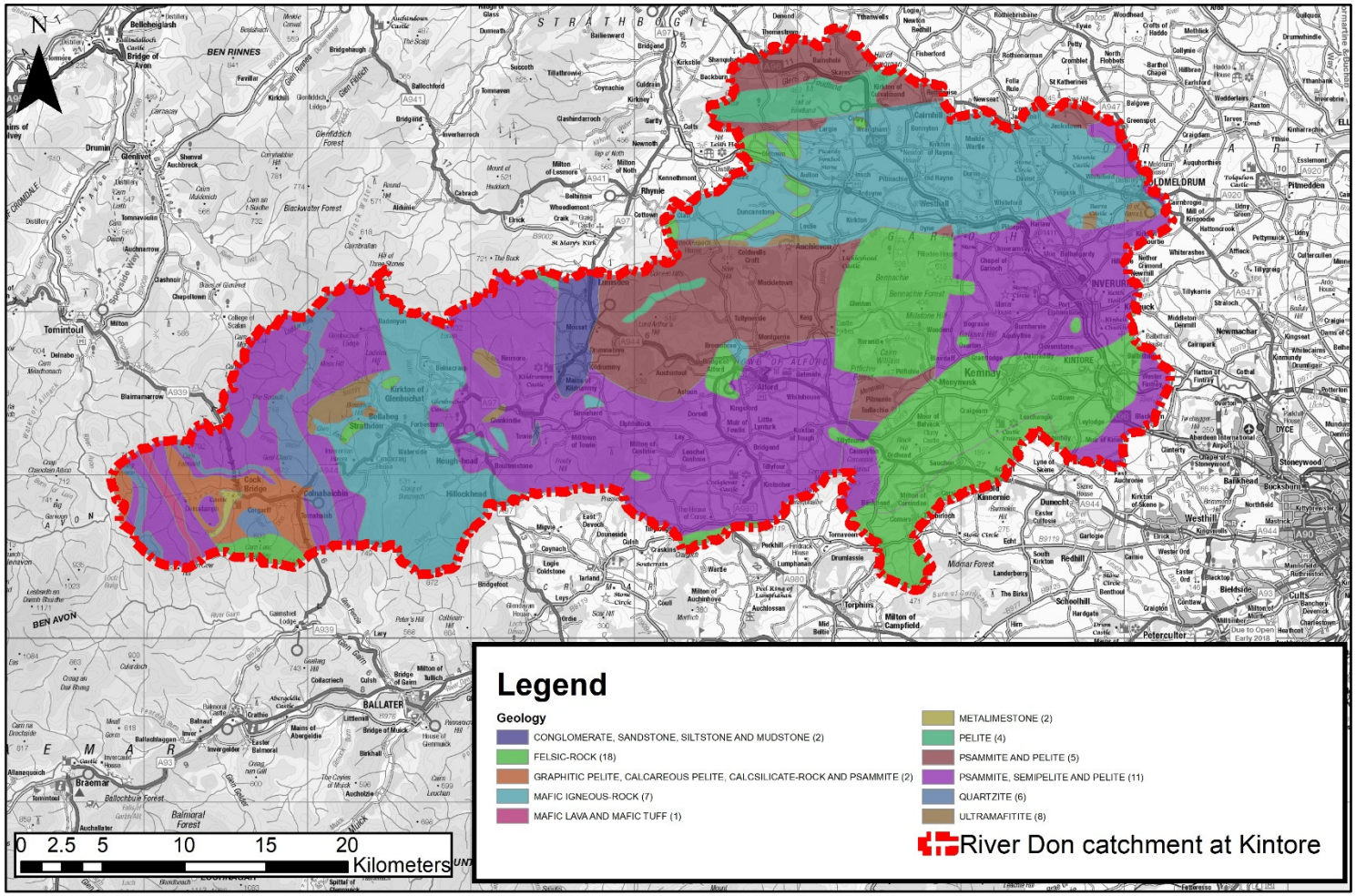
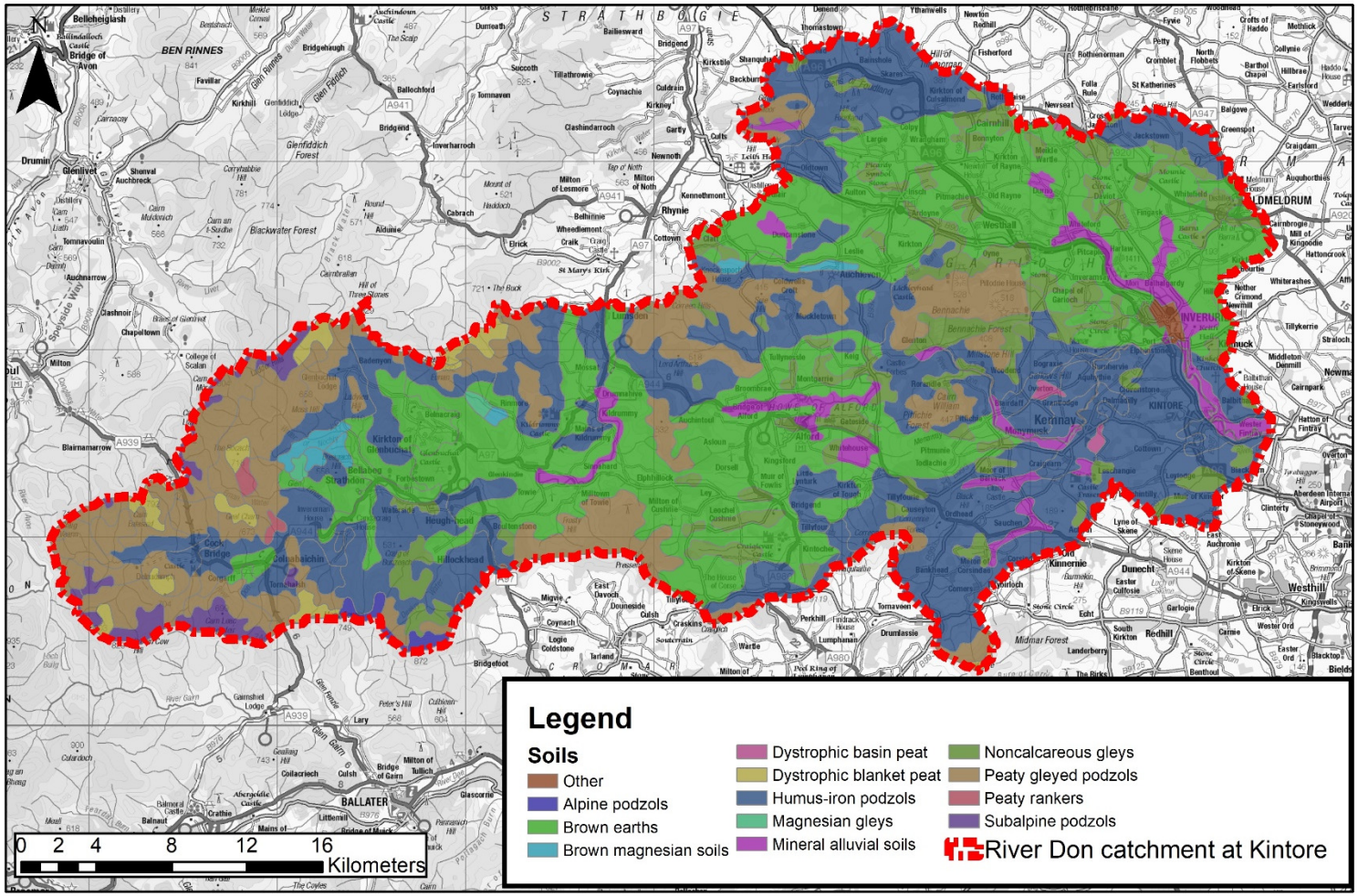


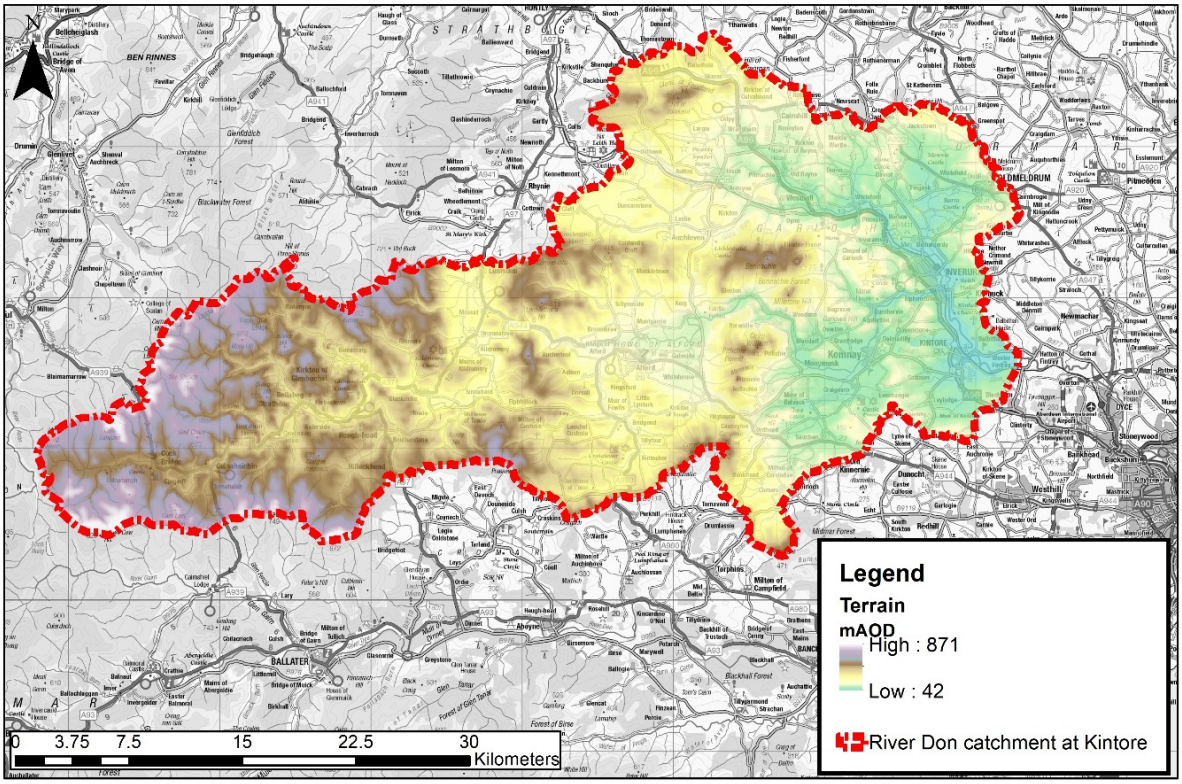
Figure 2-2: Soils



The geomorphology of the catchment reflects the glacial history of the region. During the last Ice Age, the Aberdeenshire region was covered by an ice sheet which flowed east toward the North Sea[6]. The western headwaters of the River Don lie within the Cairngorm Mountains where the ice sheet was stagnant or very slow moving, this region is therefore topographically steeper with narrow valleys through which a number of smaller tributaries now flow. The central catchment shows a more undulating topography where ice moved slowly leaving a number of large knolls such as Bennachie[6]. The eastern catchment around Inverurie and Kintore in contrast is topographically flatter where the ice sheet and subsequent meltwater channel flowed as ice sheet retreated forming a landscape of wide glacial valleys.

Elevations within the catchment are greatest in the west reaching approximately 800 metres above Ordnance Datum (mAOD) in the headwaters, decreasing to approximately 130 mAOD at Alford and 50 mAOD at Kintore. A Digital Terrain Model (DTM) of the catchment is illustrated in Figure 2-3.

Figure 2-3: Catchment topography



6 Merritt, J. and Leslie, G. 2009. Scottish Natural Heritage. Northeast Scotland. A Landscape Fashioned by Geology. http://www.snh.org.uk/pdfs/publications/geology/northeastscotland.pdf [Accessed: Nov 2017]

2.2 Catchment hydrology and watercourse characteristics

The River Don originates in the Cairngorm Mountains as a series of small, steep burns which converge near Delnadamph Lodge. From here the River Don flows east in a meandering channel towards Kemnay and Inverurie. A number of tributaries discharge into the River Don along both banks, notably the Ernan Water; Water of Nochty; Deskry Water; Leochal Burn; Esset Burn and Ton Burn upstream of Inverurie.

At Inverurie a major tributary, the River Urie, discharges into the left bank of the River Don. The River Urie originates to the north-west of Inverurie near Gartly Moor and flows south towards the town with a catchment area of approximately 305 km^2. The watercourse is relatively meandering and flows through a predominantly rural catchment. The community of Insch (covered in a separate report[3]) lies on the banks of the Shevock Burn, a tributary of the Urie. At Inverurie where the River Urie meets the Don, the Don changes course to flow in a southerly direction towards Port Elphinstone, Kintore and ultimately Aberdeen. The Don continues in a relatively sinuous channel through agricultural land towards Aberdeen. Tributaries of note include the right bank Bridgealehouse and Tuach Burn's at Kintore. Key watercourses within the catchment are highlighted in Figure 2-4.

A review of historical OS mapping[7] of the River Don indicated it has had a relatively similar planform to present since the 1800's. The River Urie has also had a relatively similar planform to present with the exception of meander migration immediately north of Inverurie. The most notable areas of change on the Don are: to the southeast of Kemnay where the channel has migrated to flow in a northerly direction forming a backwater pool (Figure 2-5) and at Kintore (Figure 2-6).

7 National Library of Scotland http://maps.nls.uk/geo/find/# Ordnance Survey (OS) One-inch Scotland, 1892-1960 to present maps. OS Six-inch 1st edition , 1843-1882. Roy Military Survey of Scotland, 1747-1755, Maps of Scotland (18th century), Highlands.

Figure 2-4: Key watercourses

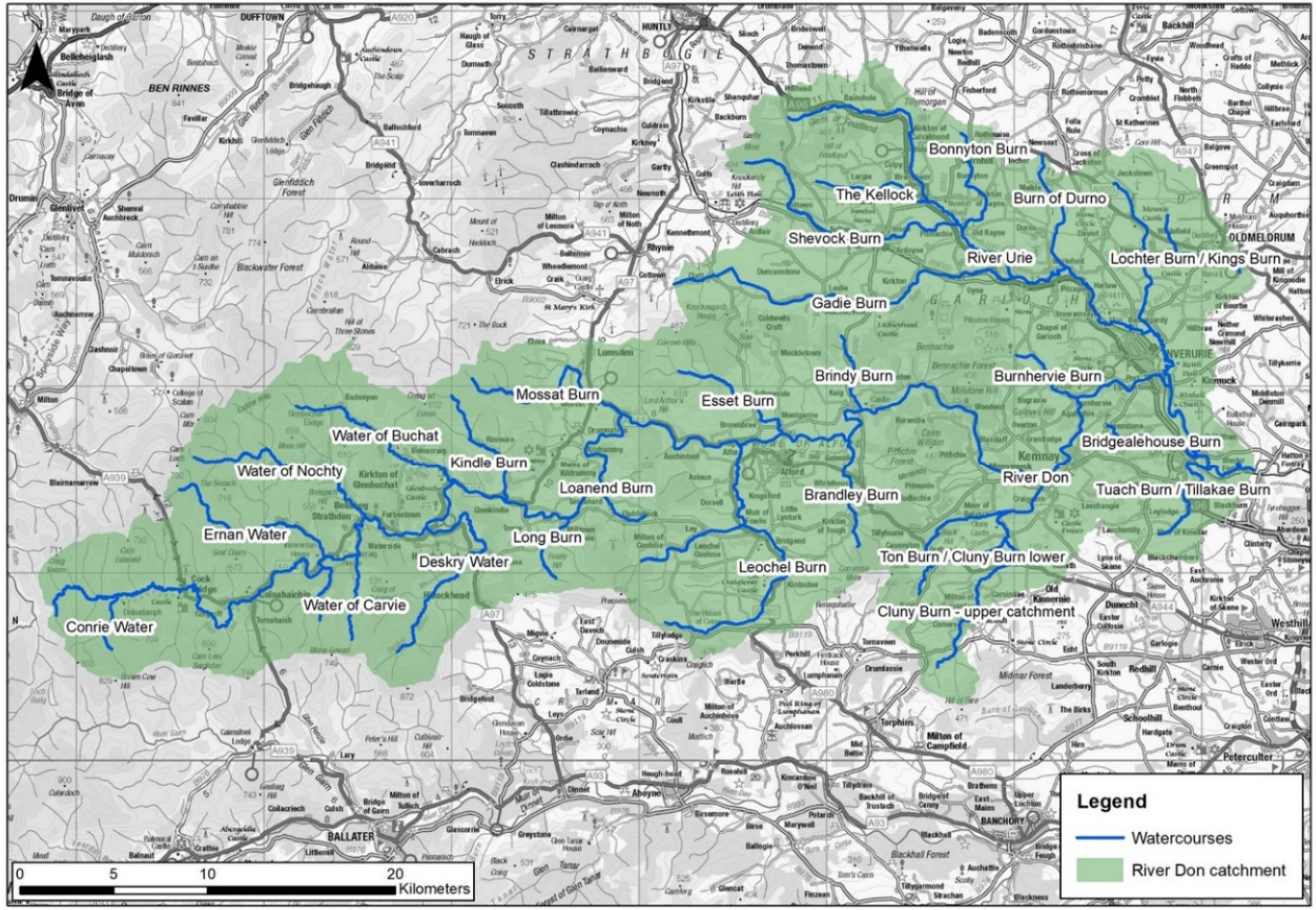
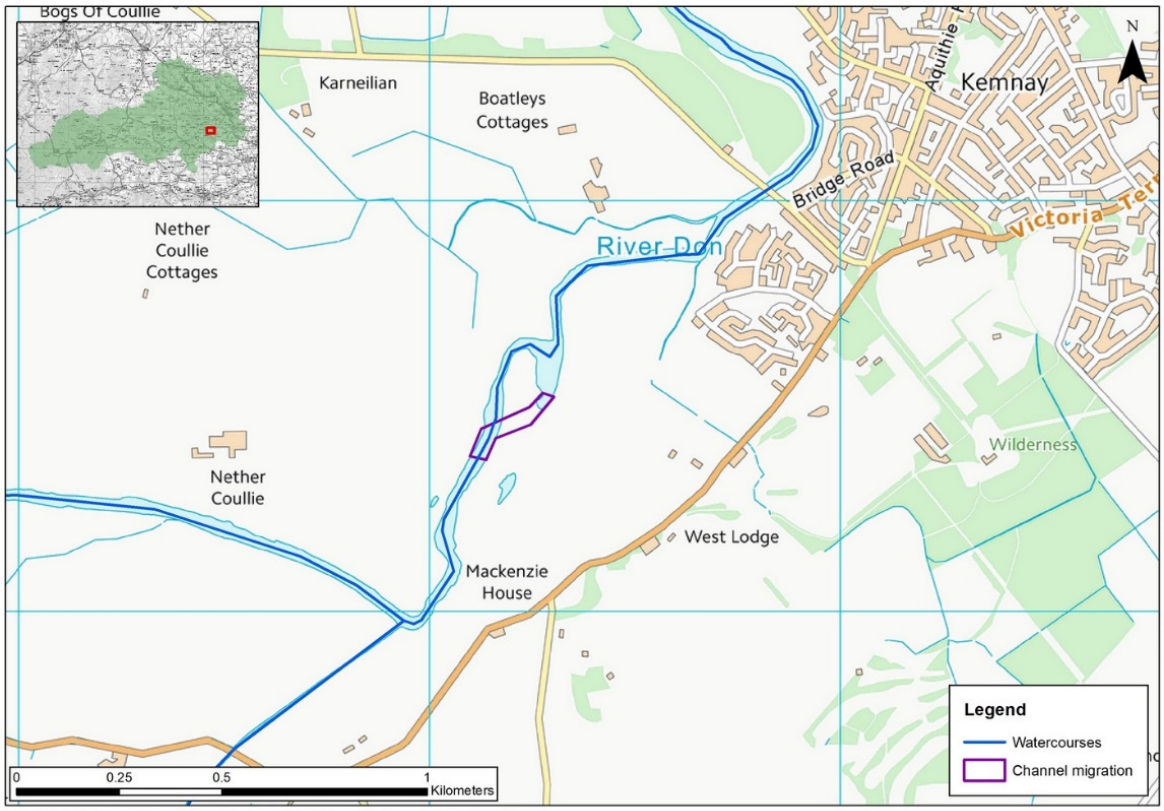


Figure 2-5: Channel migration at Kemnay[7]



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

Figure 2-6: Channel migration at Kintore[7]

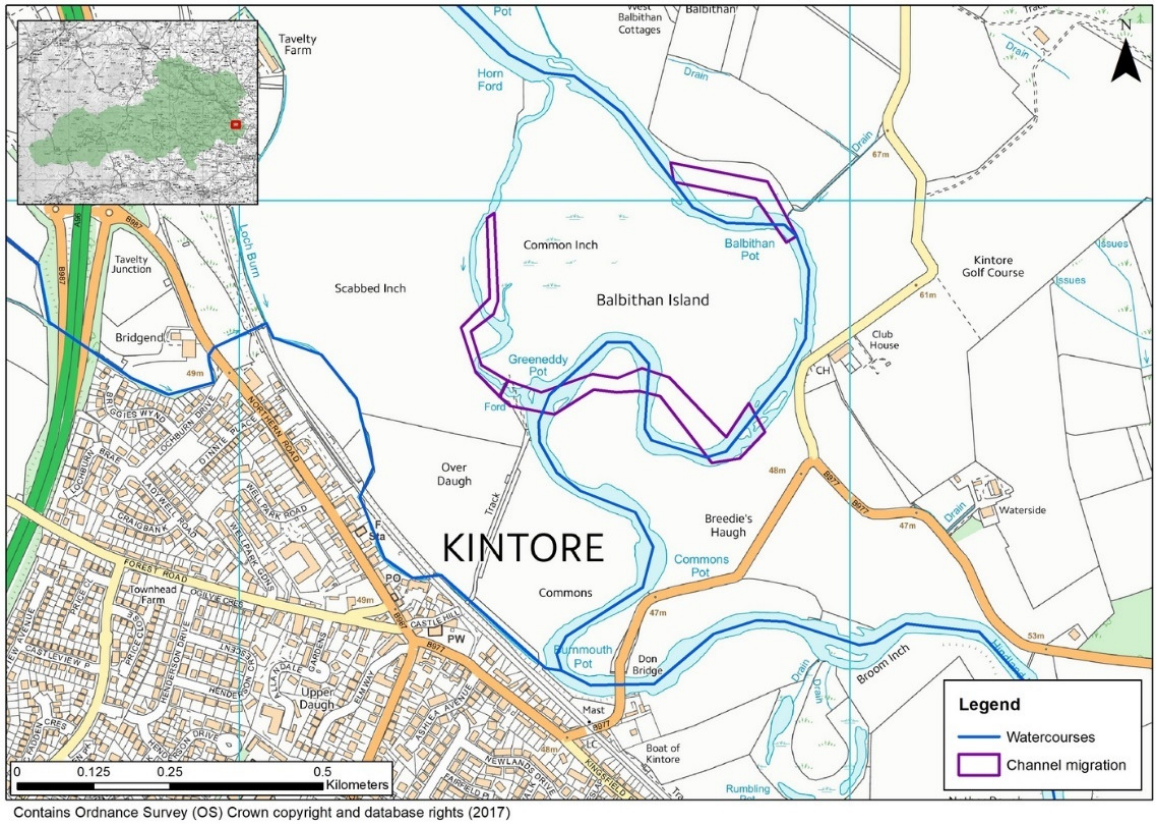


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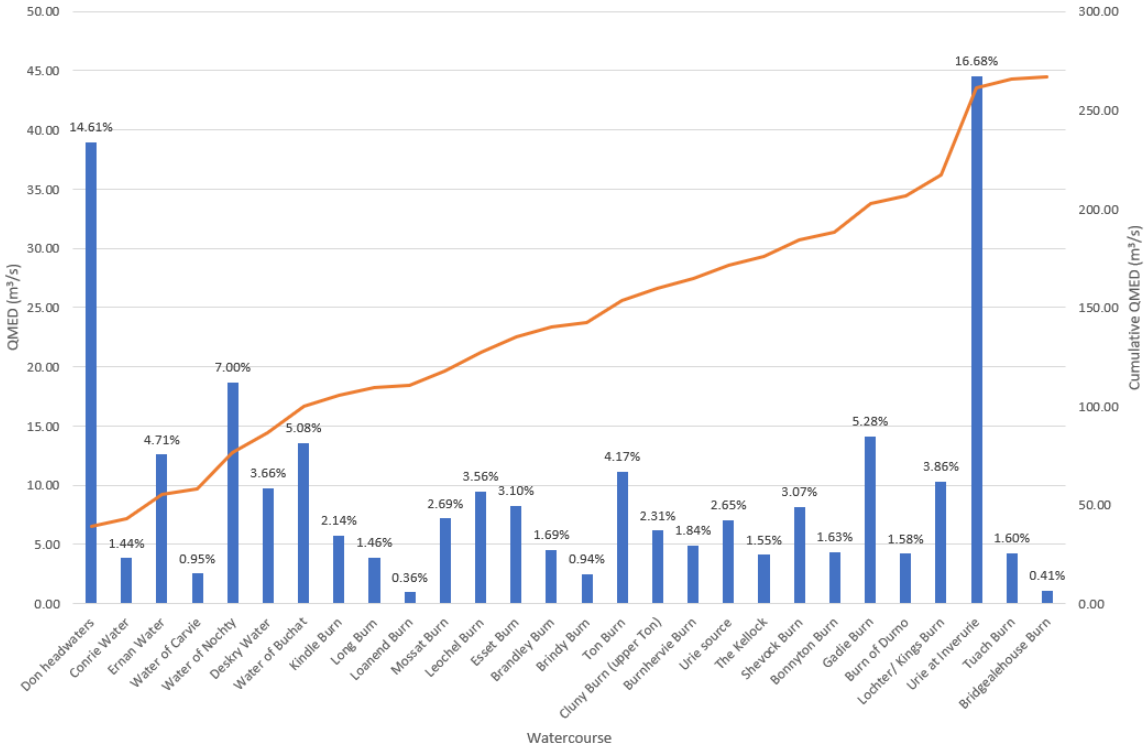
Figure 2-7 gives the median annual maximum flow (QMED)[8] of the watercourses highlighted in Figure 2-4 and the percentage this represents of the cumulative QMED downstream of Kintore. It shows upstream of Inverurie the greatest contributions are from the headwaters of the Don (15%) and Water of Nochty (7%), while the River Urie sub-catchment as a whole contributes approximately 17% of the total QMED to the River Don. The Standard average annual rainfall (SAAR) between 1961 and 1990 was approximately 884 mm.

Figure 2-7: QMED contributions



2.3 Land Management

2.3.1 Land Use

Figure 2-8 illustrates the land cover types in the catchment based on the Land Cover Map 2012[9]. Moors, heathland and peat bog dominate the eastern uplands with moderately large areas of forestry and pastural land use at lower elevations. In the central catchment many of the of the higher elevation hills, such as Bennachie, are forested while the lowlands and eastern catchment is dominated by pasture and arable land use. The main areas of urban land use include: Alford; Insch; Oldmeldrum; Kemnay; Kintore and the largest town Inverurie.

2.3.2 Protected areas

A review of Scottish Natural Heritage[10] and Historic Environment Scotland datasets indicate the western headwaters of the River Don lie within the Cairngorm National Park. Within this area the Green Hills of Strathdon and Ladder Hills are both Special Areas of Conservation (SAC) and Sites of Special Scientific Interest (SSSI). In addition, the Morven and Mullachdubh hills are also SSSI's in this region containing protected upland habitats, plant and bird species. The wider catchment also contains several monuments and listed buildings as well as a number of Historic Scotland Gardens and Designated Landscapes (Figure 2-9).

8 QMED was calculated at the downstream point of each major tributary based on the catchment descriptors with no adjustments. This was deemed to be sufficient for providing high level analysis to indicate relative proportional contributions only.

9 Corine Land Cover European seamless vector database. Release v18_5 (02/2016) http://land.copernicus.eu/pan-european/corine-land-cover

10 Scottish Natural Heritage http://gateway.snh.gov.uk/sitelink/searchmap.jsp [Accessed: November 2017]

Figure 2-8: Land Use

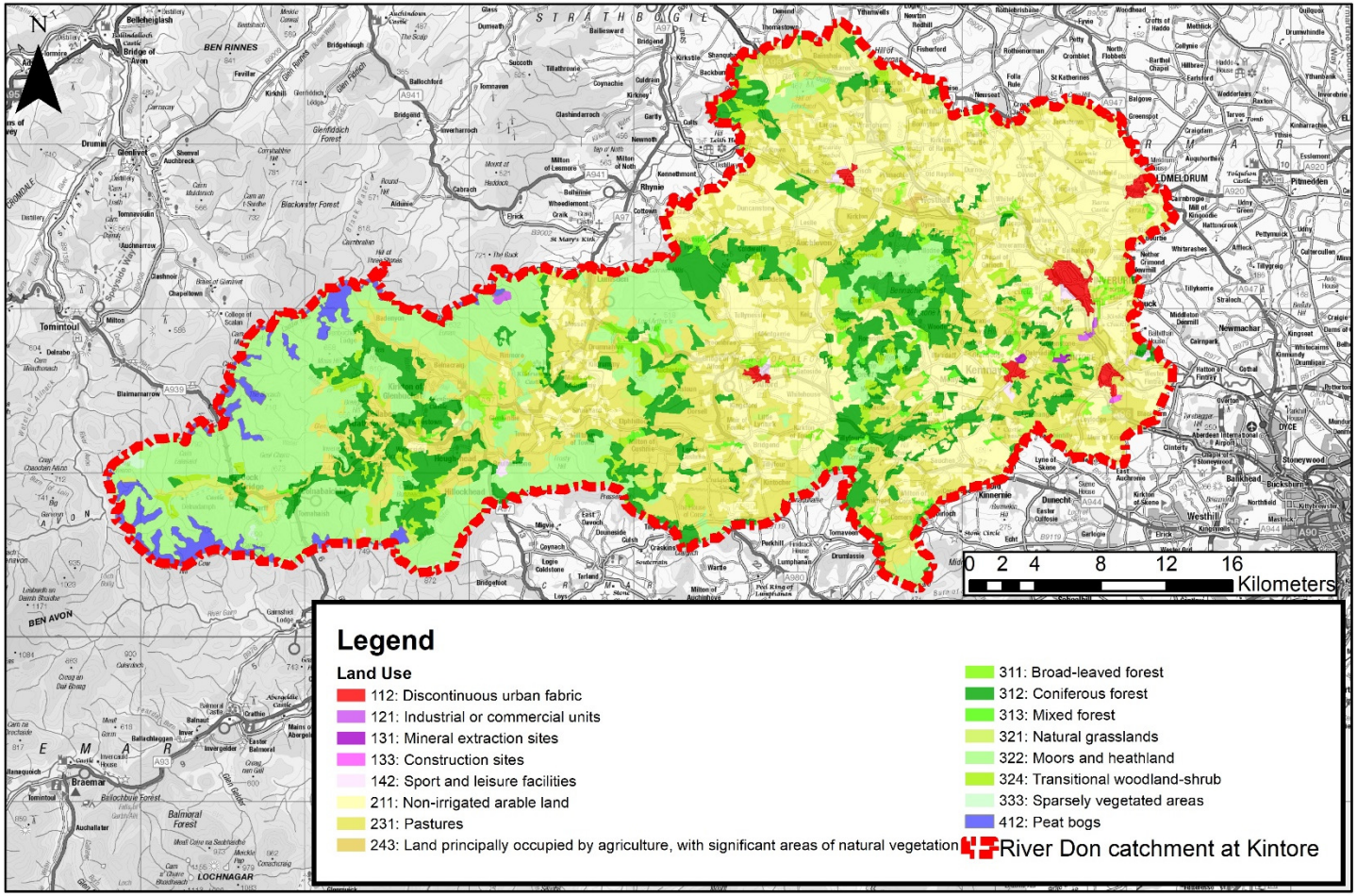
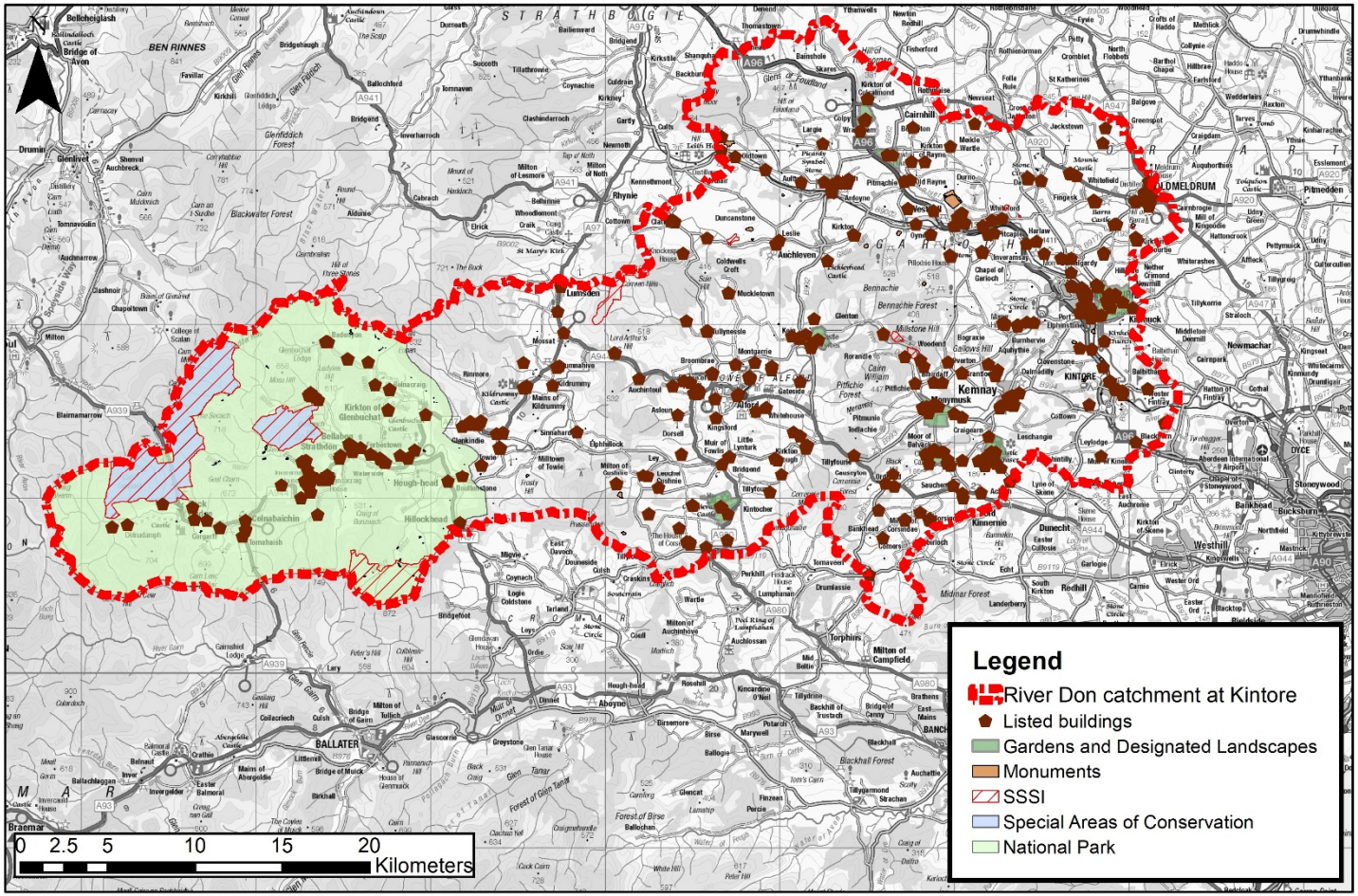


Figure 2-9: Scottish Natural Heritage and Historic Environment Scotland sites

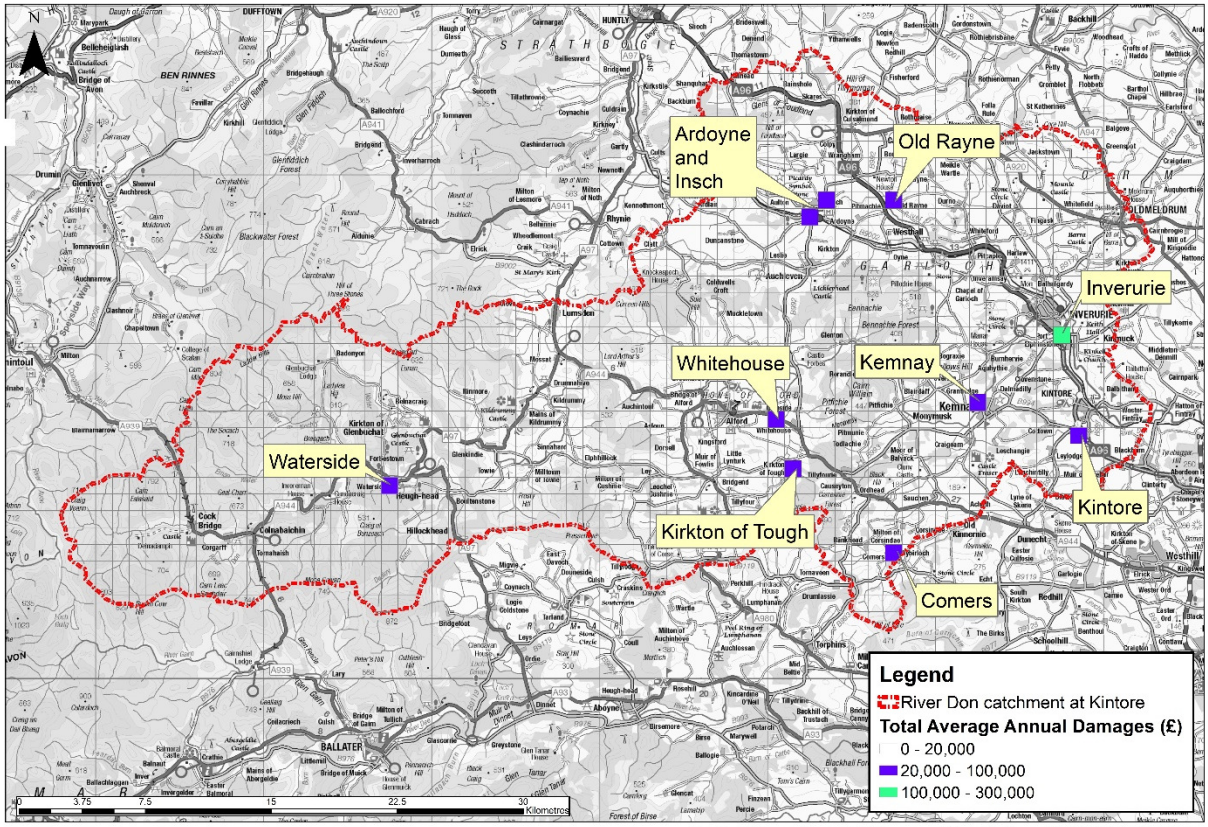


2.4 Flood damages and areas at risk

SEPA supplied their Preliminary Flood Risk Assessment (PFRA) analysis of flood damages. Figure 2-10 shows total average annual damages (AAD) within the Don catchment indicating key areas affected by fluvial flooding.

The dataset indicates estimated damages are generally high where the catchment is urbanised i.e. at Inverurie, Ardoyne, Kemnay and Kintore which is to be expected. However, additional smaller communities are indicated to occur damages as a result of fluvial flooding. These include Old Rayne, Whitehouse, Kirkton of Tough and Tillybirloch in the southern catchment, as well as Waterside in the headwater region.

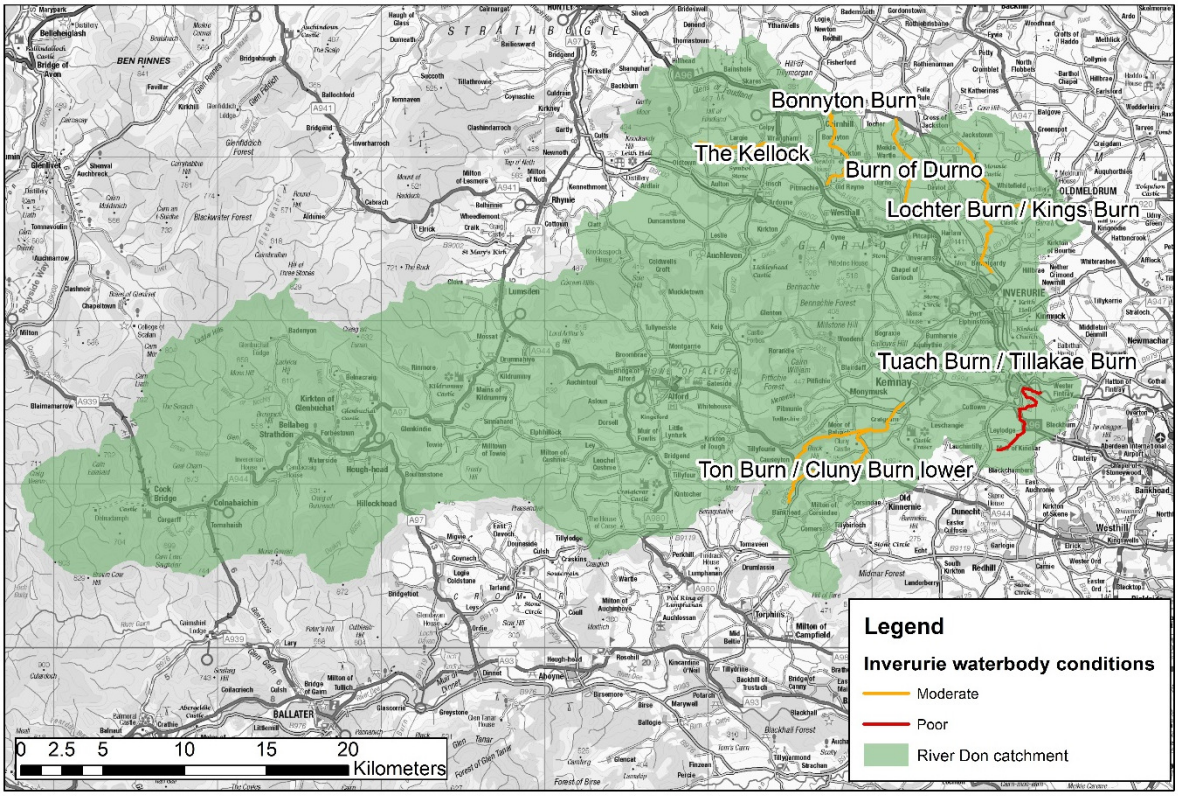
Figure 2-10: Fluvial Average Annual Damages



3 RBMP - review of physical pressures

RBMP data were examined using the Water Environment Hub[11] and RBMP datasets supplied by SEPA. Within the River Don catchment one watercourse (Ernan Water) is classified as having a 'High' overall condition based on the 2016 waterbody classifications; eighteen watercourses (56% of the watercourses within the catchment identified in the RBMP) as being in 'Good' overall condition, 10 (36%) as 'Moderate' and 3 (9%) as 'Poor'. Of these 6 are downgraded on the basis of their physical condition: the Ton Burn/ Cluny Burn lower; The Kellock; Bonnyton Burn; Burn of Durno and Lochter Burn/ Kings Burn have 'Moderate' physical condition while the Tuach Burn / Tilakae Burn has a 'Poor' physical condition (Figure 3-1).

Figure 3-1: Current waterbody classifications based on physical condition



For those watercourses identified as having less than 'Good' physical condition, the significant morphological pressures along each were identified using the SEPA morphological pressures dataset[12]. Significant pressures are defined as:

- Impoundments.
- Set back embankments.
- Embankments with and without reinforcement.
- Green and grey bank reinforcement.
- High and low impact realignment.
- Culverts.

These are shown in the following figures. It should be noted that the SEPA mapping does not necessarily follow the watercourses, as they are plotted as straight lines based on their start and end point.

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

12 SEPA is currently reviewing and revising the morphological pressures dataset, as such pressures indicated may have since been removed. It was outwith the scope of this contract for JBA to survey physical pressures along the watercourses .

Figure 3-2: Significant morphological pressures along the Kellock Burn

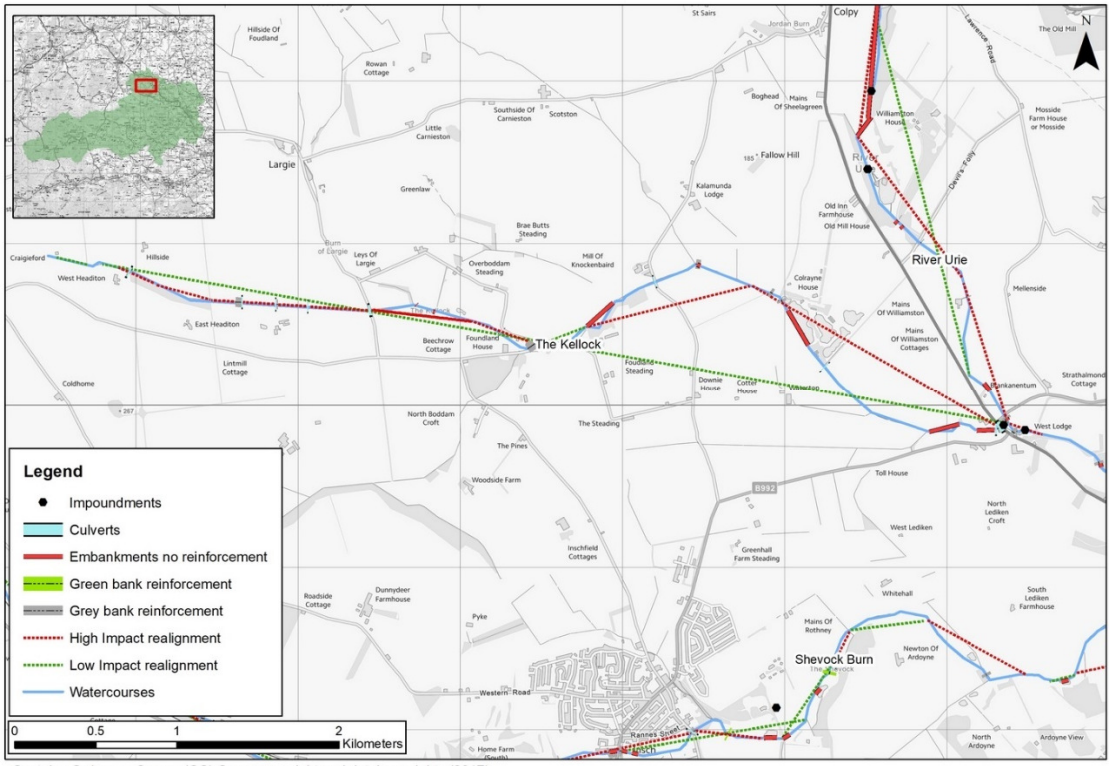


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Figure 3-3: Significant morphological pressures along the Ton Burn/ Cluny Burn lower

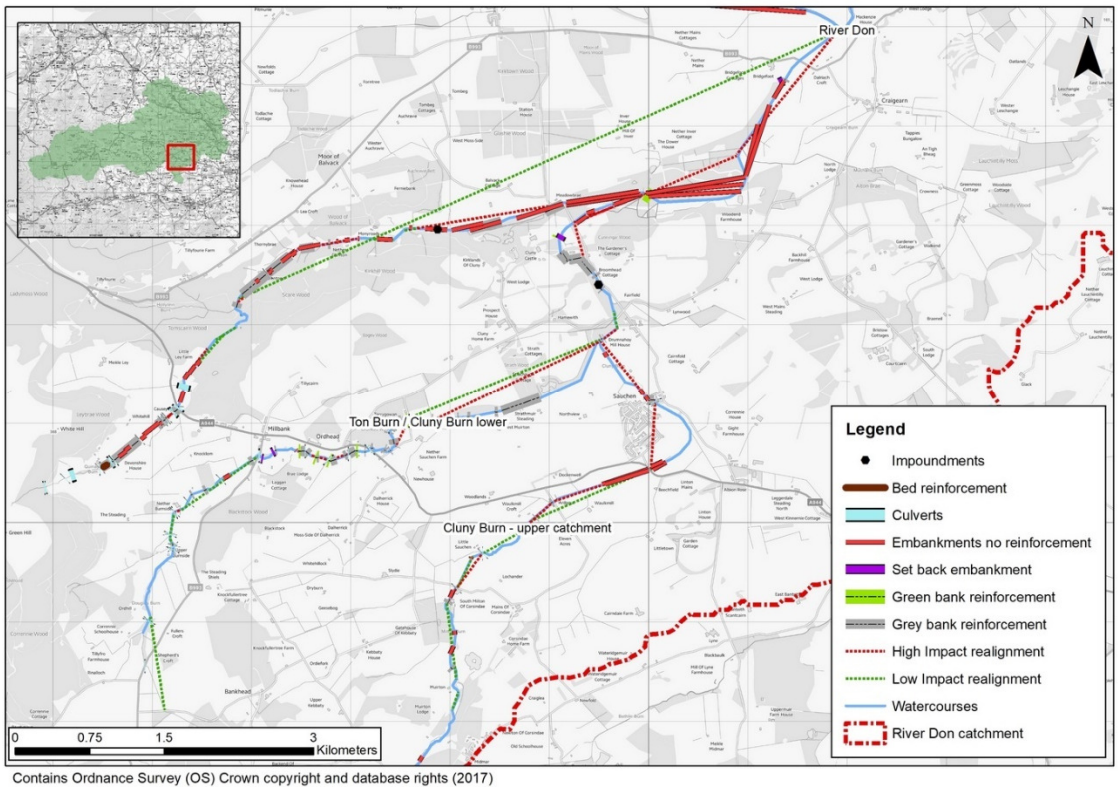

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Figure 3-4: Significant morphological pressures along the Bonnyton Burn

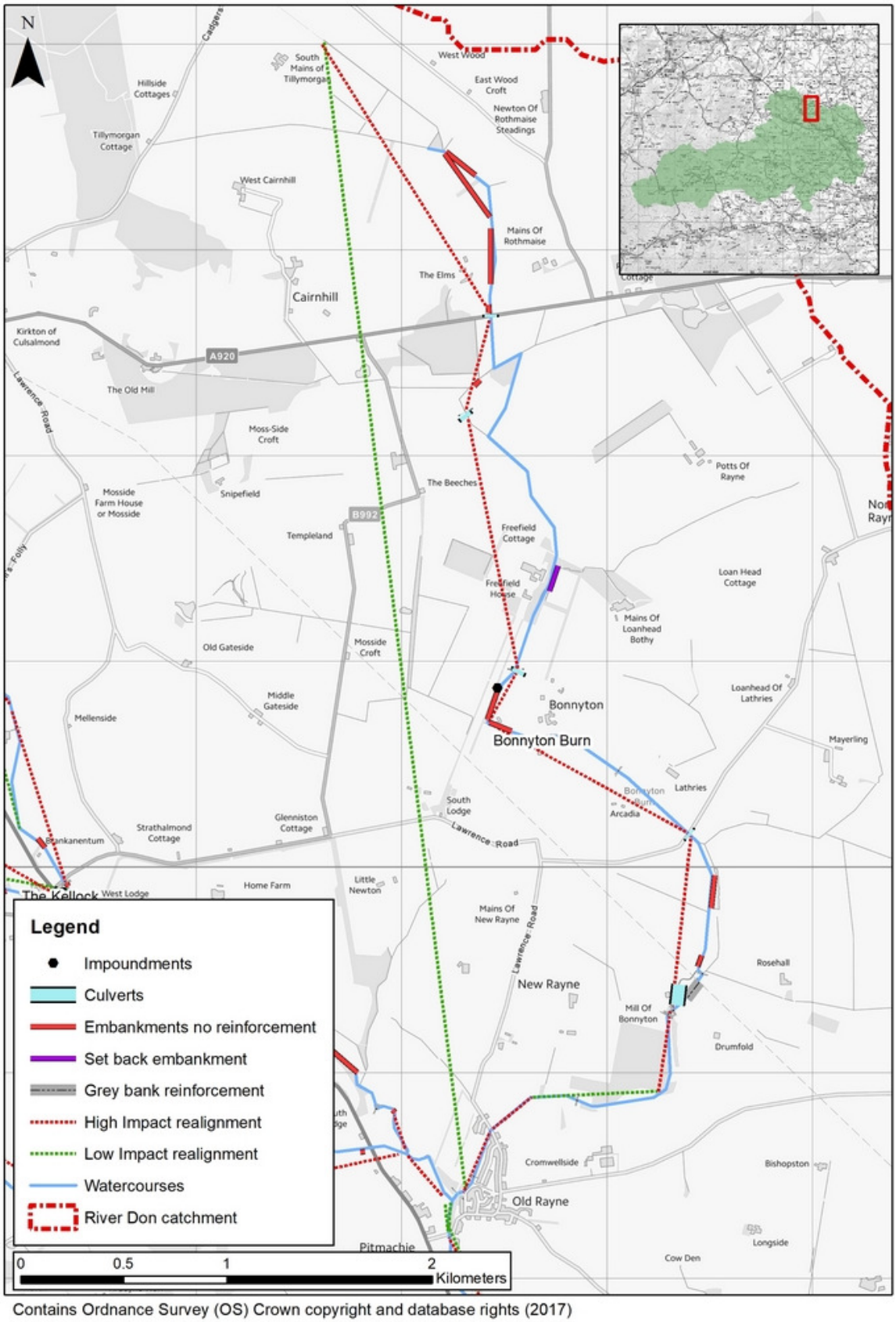

Figure 3-5: Significant morphological pressures along the Burn of Durno

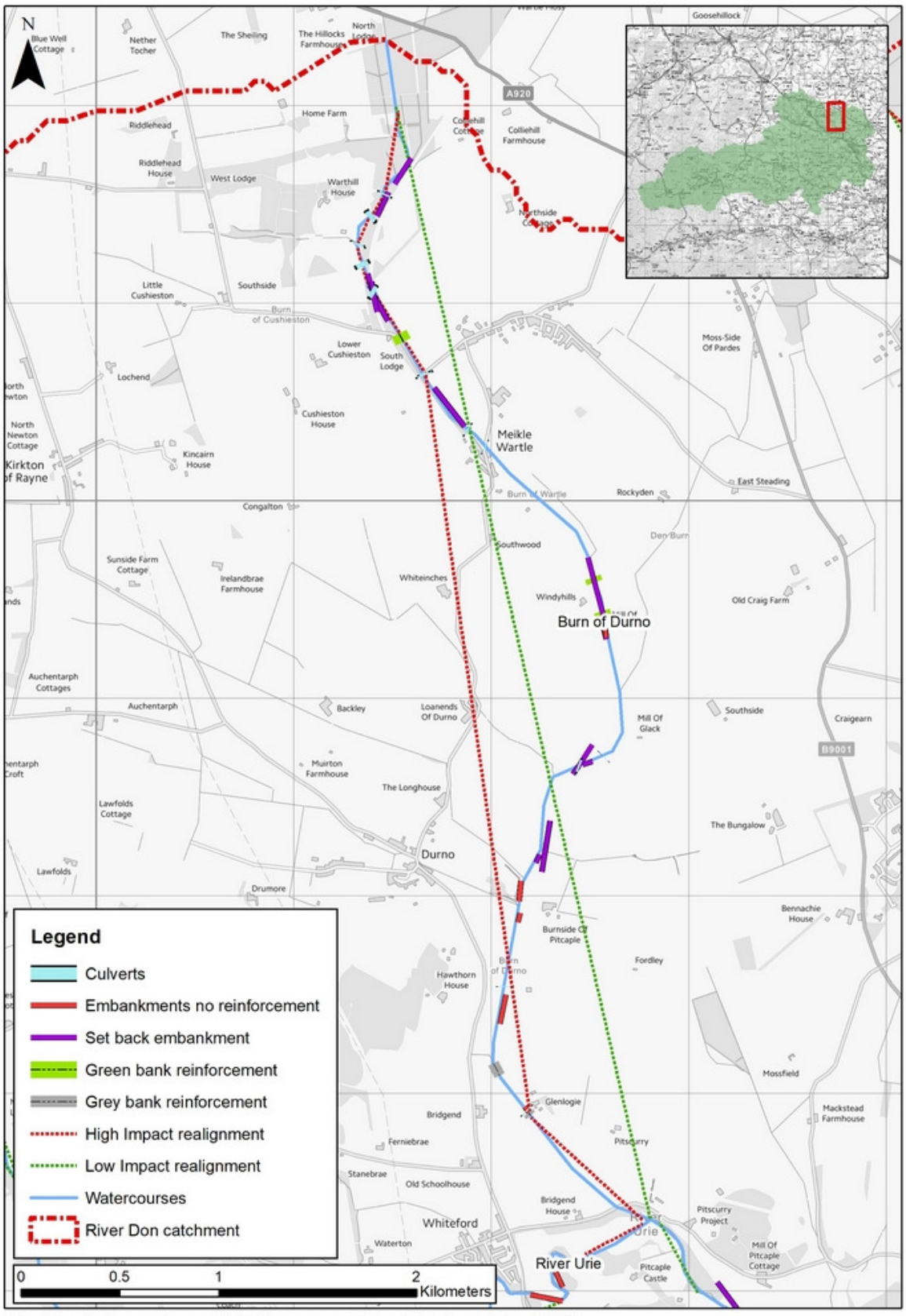

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Figure 3-6: Significant morphological pressures along the Lochter/Kings Burn

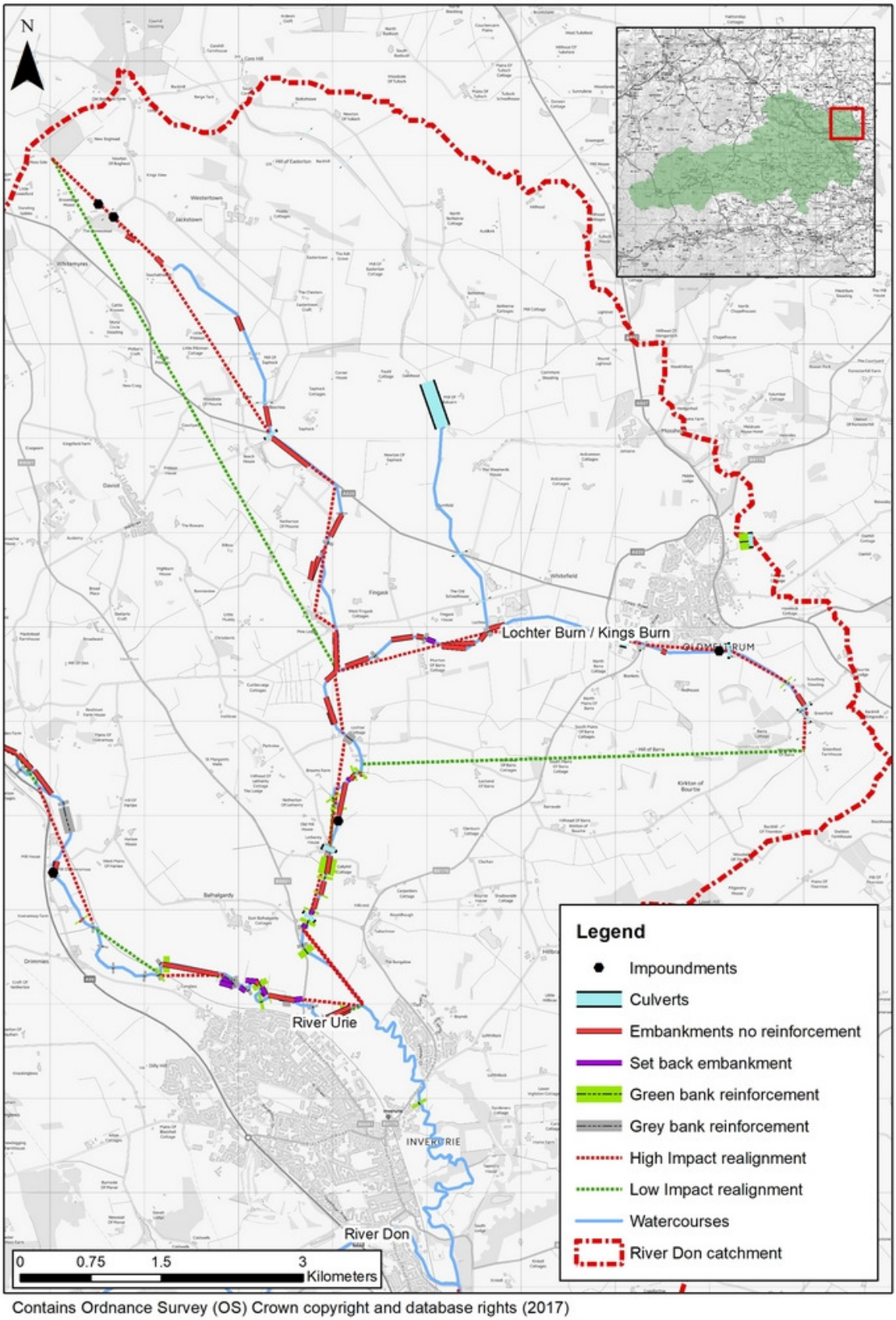
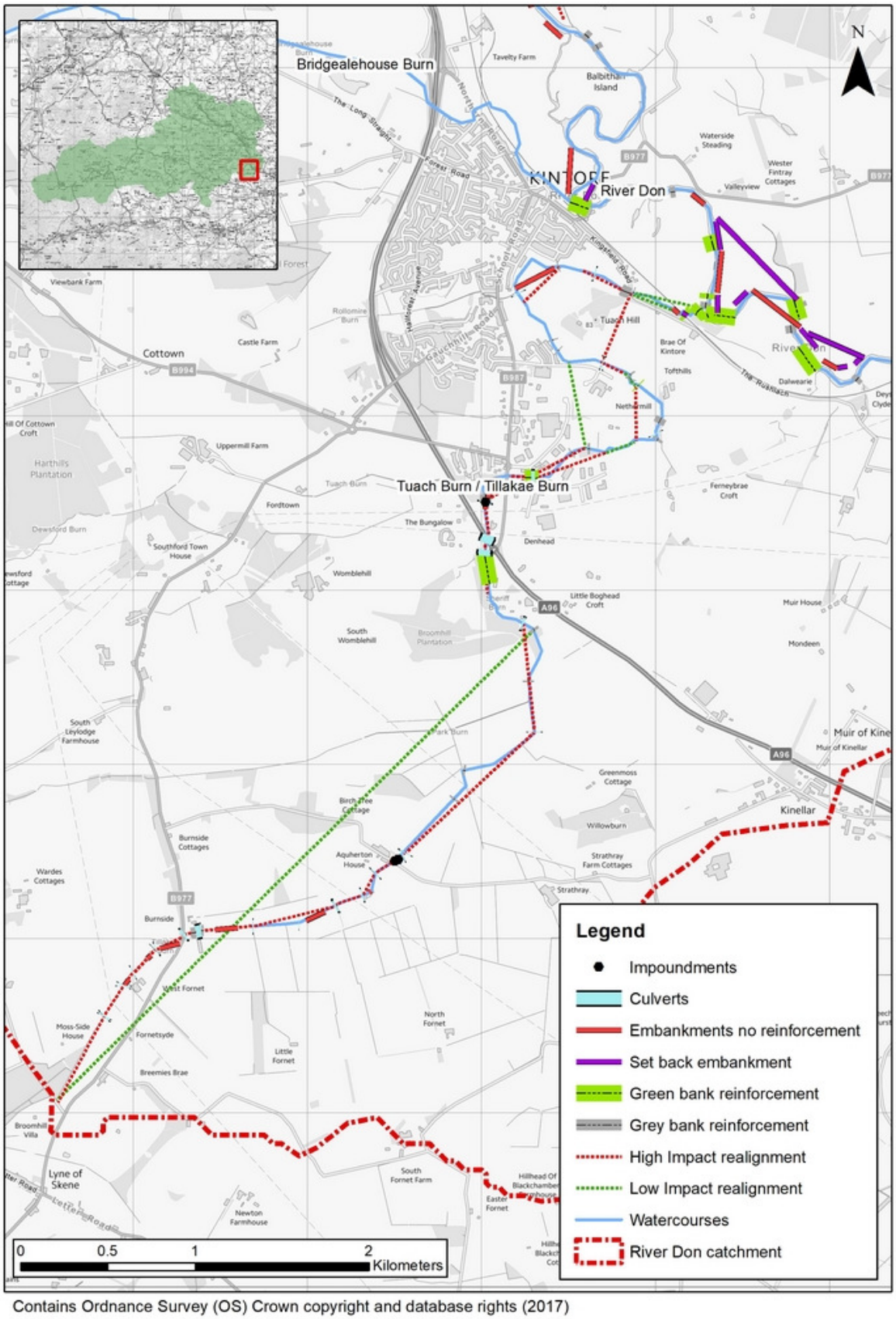


Figure 3-7: Significant morphological pressures along the Tuach/Tillakae Burn



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3.1 Morphological Impact Assessment Results

Morphological impact assessments were undertaken for each of the watercourses identified above as being of less than good physical condition. The results of these are given in Table 3-2 below. The results of the site visits and potential release for those watercourses are discussed in further detail in the relevant chapters within this report.

3.1.1 Methodology

The physical condition status of a waterbody is defined according to (i) the relative impact of a pressure on the river bank and channel (Impact Rating[13]), which varies according to river typology; (ii) the length of the channel or bank taken up by the physical pressure (Pressure Footprint) and (iii) the total waterbody length. The capacity of the river used by a pressure is calculated for both the channel and banks according to the following equation and summed to obtain the total percentage:

$$Capacity\ Used = \frac{Impact\ Rating\ x\ Pressure\ Footprint}{Total\ Waterbody\ Length}$$

The watercourses are subsequently classified[14] as follows:

Table 3-1: Waterbody classification bands

Status	Total Capacity Used (%)
High	5
Good	25
Moderate	50
Poor	75
Bad	>75

3.1.2 Results

The MiMAS methodology is presently being updated and revised. The above methodology was however, applied to all watercourses within the Don catchment of less than good physical condition. This resulted in considerably different classification results to those defined above, therefore the results have been to used to determine the relative improvement that could be made, and are not indicative of present waterbody conditions. Further information on pressure lengths and capacities are given in Appendix A.

Table 3-2: Morphological condition results

Watercourse	Physical condition status*	Length (km)	Majority typology	Total capacity used (%)
Lochter Burn/ Kings Burn	Moderate	17.65	C	320
Ton Burn/ Cluny Burn lower	Moderate	20.77	C	244
Cluny Burn (upper catchment)	Moderate	11.56	C	129
Bonnyton Burn	Moderate	7.89	C	271
Burn of Durno	Moderate	6.80	C	276
The Kellock	Moderate	6.64	B	270

*Based on the 2016 RBMP waterbody environment hub map

13 The Scotland River Basin Directives 2009 http://www.gov.scot/Publications/2010/01/06141049/4
14 http://www.gov.scot/Resource/0045/00457867.pdf

4 Opportunities for Natural Flood Management

SEPA as part of the FRM Act Section 20 screening process has undertaken a high-level strategic analysis of Scotland to determine the areas on which NFM measures could be most effective[15]. In particular, for the River Don this broad-scale analysis has demonstrated where opportunities exist for the following:

- Runoff reduction.
- Floodplain storage.
- Sediment management.

4.1 Runoff Reduction

To identify the areas with the greatest potential for runoff reduction, SEPA has produced a map showing which areas make the greatest contribution to overland flows, based on factors including land cover, soil type, slope and rainfall.

Areas with medium to high potential for runoff reduction within the catchment are illustrated in Figure 4-1. The dataset suggests the western headwaters have considerable high to medium potential for runoff reduction. The central and eastern regions of the catchment are not indicated to have high potential but there are areas of medium potential for runoff reduction. Key catchments of interest include the following sub-catchments:

- River Don headwaters.
- Ernan Water.
- Water of Nochty.
- Water of Buchat.
- Kindle Burn.
- Mossat Burn.
- Esset Burn.
- Cluny Burn - upper catchment.

4.2 Floodplain Storage

SEPA has also produced a map to identify areas with potential for floodplain storage, considering factors such as floodplain slope and land cover (in particular, the potential to increase surface roughness). Areas with medium and high potential for floodplain storage within the catchment are illustrated in Figure 4-2. It should be noted that SEPA's floodplain storage mapping was carried out only for areas of floodplain with an annual probability of flooding at least every 200 years.

The dataset indicates there is both high and medium potential for floodplain storage across the catchment. Upstream of the communities at risk there is medium potential for floodplain storage along the River Don in the western catchment at Strathdon and Kildrummy. High potential is also indicated at Alford and Kemnay, as well as between Inverurie and Kintore. Additionally, floodplain storage potential is indicated along much of the River Urie particularly in the vicinity of Inverurie. Key areas and sub-catchments to focus on with respect to floodplain storage are therefore:

- River Don near Strathdon and Kildrummy.
- River Don at Alford.
- River Don at Kemnay.
- River Don between Inverurie and Kintore.
- Brandley Burn.
- The Ton Burn.
- Tuach / Tillakae Burn.
- Lochter/ Kings Burn.
- Urie Water.

15 Nutt, N. 2012. Flood Risk Management (Scotland) Act 2009. Methods to screen and quantify natural flood management effects. Report commissioned by SEPA and Forestry Commission Scotland, May 2012.

4.3 Sediment Management

SEPA has also produced a map identifying areas of erosion, deposition and transport within Scottish rivers, thus identifying where sediment management measures may be appropriate for implementation to decrease flood risk. This was achieved using a model to estimate the amount of sediment entering and leaving a given reach and calculating the overall sediment balance. Sediment in a river is naturally eroded and transported downstream, however activities such as straightening of the channel and land management activities can disturb natural processes and cause excessive erosion or deposition.

A sediment management potential map for the catchment is illustrated in Figure 4-3. The dataset indicates many of the upper catchment tributaries (west of Alford) are moderately to highly eroding. As are the upper reaches of many of the Urie tributaries, the Ton Burn and Burnhervie Burn. Whereas the River Don east of Alford is in balance or depositing material.

4.4 North East Local Plan District

The River Don catchment falls within the North East Flood Risk Management Strategy (FRMS) and Local Plan District (LPD) in which Potentially Vulnerable Areas (PVA) Inverurie and Kintore (06/13), Insch (06/11) and Heugh-head (06/14) are identified. Conclusions on flood risk management within the LPD are as follows:

- Potential for runoff reduction is greatest in the west but within the PVAs is unlikely to have significant impact on flooding from the Don. However, runoff reduction may be effective on smaller tributaries.
- Floodplain storage potential along the Don at Inverurie and Kintore is highlighted as being a key opportunity to reduce flood risk and should be considered.
- Additionally, the LPD highlights the need to consider online/offline storage along the River Don and Urie.
- Long reaches of sediment deposition through Inverurie and Kintore indicate measures to manage sediment may be an option for reducing flood risk.

Figure 4-1: Areas with medium potential for runoff reduction

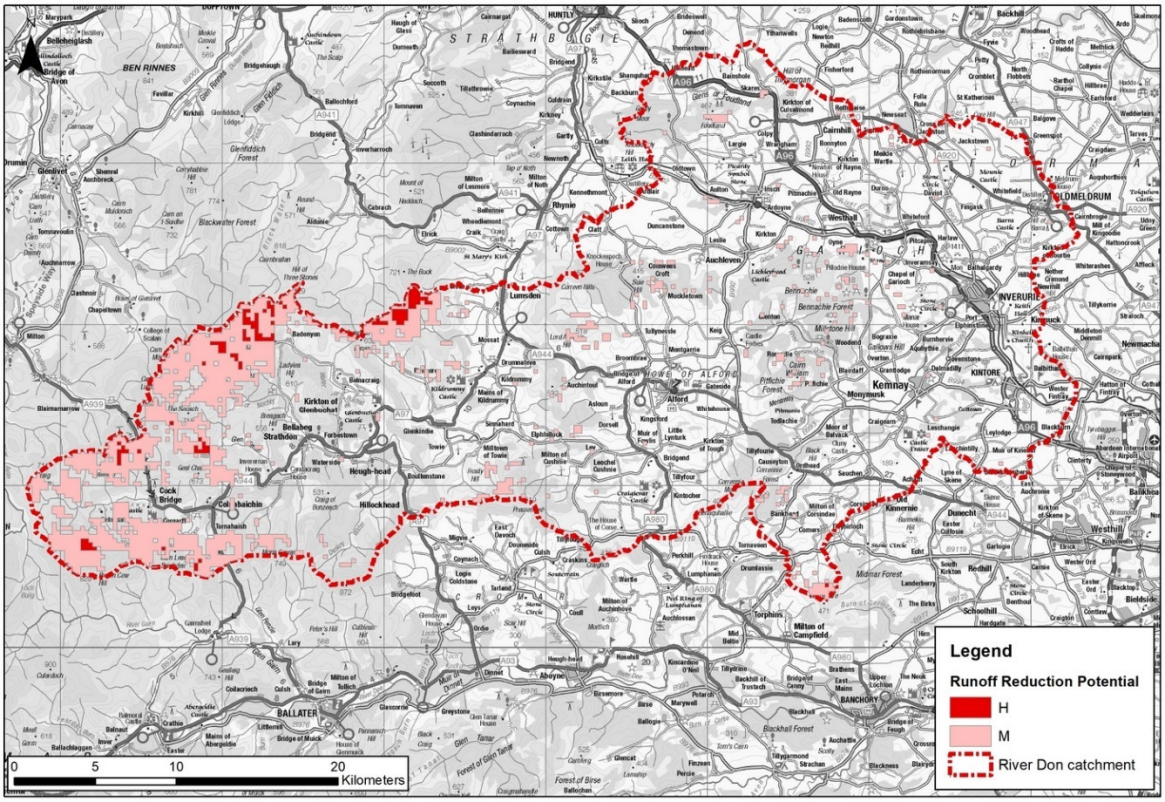


Figure 4-2: Areas with medium to high potential for floodplain storage

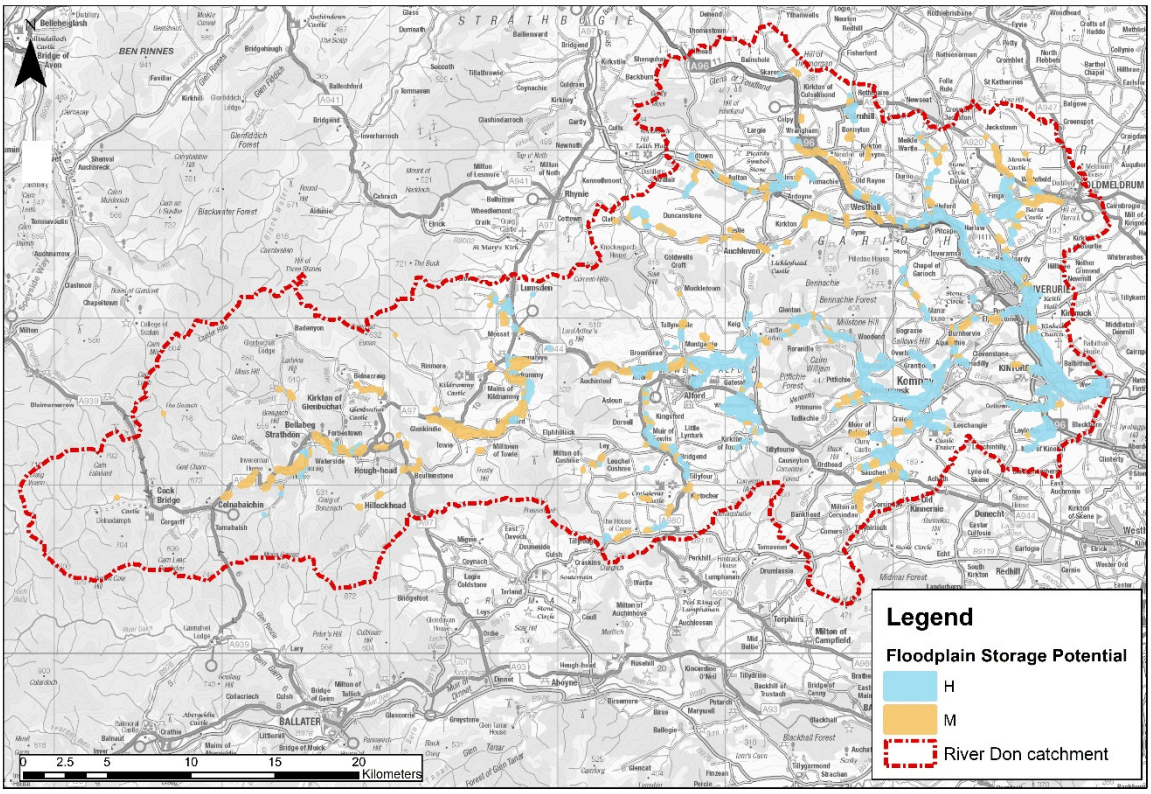
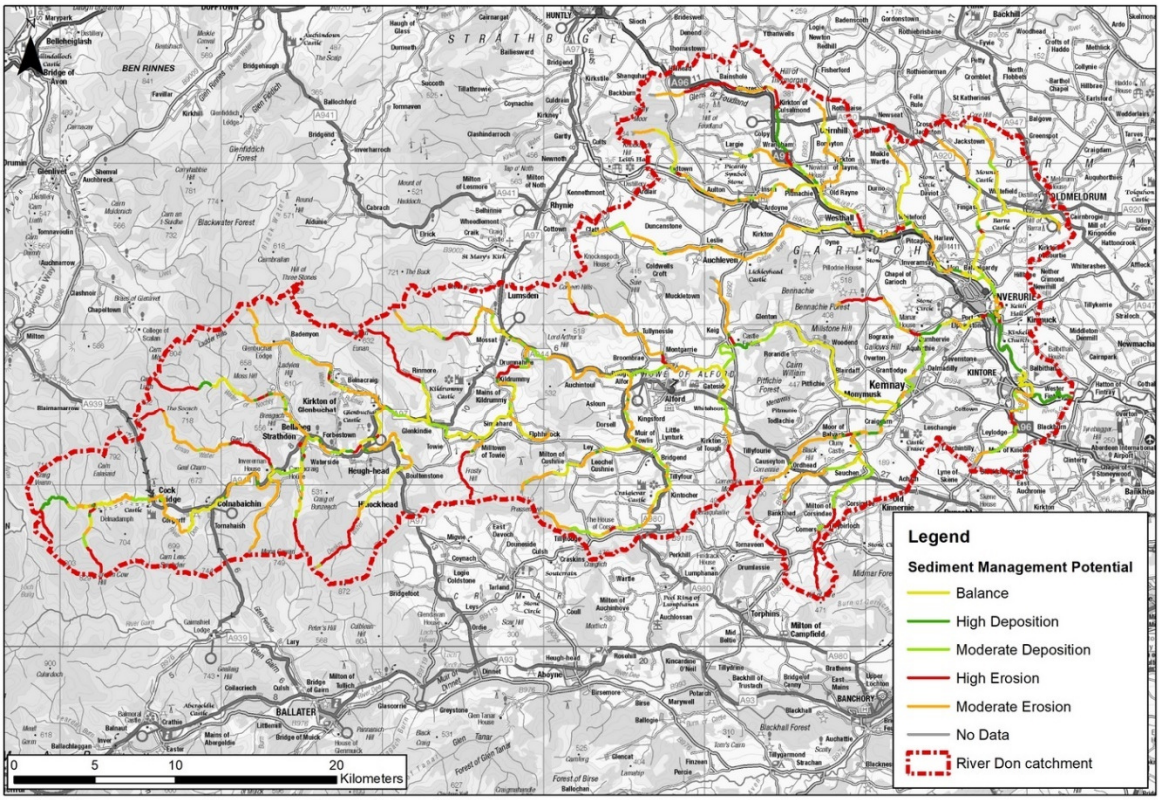


Figure 4-3: Potential for sediment management



4.5 Long list of options

Based on the SEPA mapping datasets and additional information in the preceding chapters, a long list of NFM options within key sub-catchments of the River Don are provided below. One to three ticks are used to indicate from a desk-based review the likelihood of being able to implement that NFM measure.

Table 4-1: Long list of NFM options

Category	Type of NFM measure	River Don source and upper catchment tributaries (west of Alford)	Leochal Burn and Esset Burn at Alford	River Don east of Alford inc. the Ton / Cluny Burn tributaries	River Urie sub-catchment
Increased vegetation cover	Woodland planting (conifer, native and broadleaf)	✓✓✓	✓✓✓	✓✓	✓✓✓
	Gully woodland planting	✓✓✓	✓✓	✓	✓
	Creation of cross-slope tree shelter belts	✓✓✓	✓✓	✓✓	✓✓
	Riverbank woodland	✓✓	✓✓	✓✓	✓✓✓
Working within and on the banks of the channel	Placing of large woody debris and boulders	✓✓	✓		
	In-channel barriers	✓✓✓	✓✓	✓✓	✓✓
	Bank restoration/erosion protection	✓			✓
	Managing channel instabilities (e.g. fencing)	✓			✓
	Reach restoration and floodplain reconnection	✓✓	✓✓	✓✓✓	✓✓
	Removal of obstacles to river flow				
Land management	Soil and bare earth improvements	✓✓✓	✓✓	✓✓	✓
	Changing agricultural field drainage	✓✓	✓✓	✓✓✓	✓✓
	Blocking of upland drains	✓✓✓	✓	✓	
Runoff management	Overland flow interception	✓✓✓	✓✓✓	✓✓	✓✓
	Offline ponds	✓✓	✓	✓	✓
	Farm wetlands				
	Sediment traps				

5 Screening process

The information highlighted in the preceding chapters is summarised in Table 5-1. This has been used to inform where to focus site visits (highlighted in bold) within the River Don catchment.

Table 5-1: Summary of desk based NFM and RBMP findings

Sub-catchment	Key flood risk sub-catchment	Watercourses have a high number of significant morphological pressures	Potential for runoff reduction	Potential for floodplain storage	Immediate area incurs major damages	High proportional contribution to River Don flow
River Don upper catchment (west of Alford)	No	No	**Yes**	**Yes**	**Yes**	**Yes**
River Don between Alford and Inverurie (including Kemnay)	No	No	**Yes**	**Yes**	**Yes**	**-**
River Don between Inverurie and Kintore	**Yes**	**Yes**	No	**Yes**	**Yes**	**-**
Headwater tributaries: Ernan Water, Water of Nochty, Water of Buchat	No	No	**Yes**	No	No	**Yes**
Alford tributaries: Leochal Burn, Esset Burn, Brandley Burn	No	**Yes**	**Yes**	**Yes**	**Yes**	No
Ton / Cluny Burn	No	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Kintore tributaries: Bridgealehouse Burn and Tuach Burn	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	No
River Urie	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Northern River Urie tributaries: Bonnyton Burn and Burn of Durno	No	**Yes**	**Yes**	**Yes**	No	No
Lochter Burn	**Yes**	**Yes**	**Yes**	**Yes**	No	**Yes**
Western Urie tributaries: The Kelloch, Shevock Burn and Gadie Burn	No	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

The priority based on the above table is for areas of greatest influence on the flood risk communities of interest, as well as where there are multiple NFM opportunities and existing RBMP constraints. It can be seen most regions of the catchment have multiple opportunities for improving the physical condition of the watercourses and implementing NFM measures. The following areas were therefore selected for further investigation on the basis they would have the greatest impact on the flood risk communities of interest (Inverurie and Port Elphinstone):

- The Ton Burn which contributes a high proportional flow to the River Don (4.17%) and therefore influences flood risk in Inverurie, has multiple NFM and RBMP opportunities, can be used as an analogue for sub-catchments further upstream and affects the community of Kemnay.
- The Lochter Burn (Urie tributary) which has multiple NFM and RBMP opportunities and can be used to inform opportunities for the other northern Urie sub-catchments, notably the Burn of Durno and Bonnyton Burn. Additionally, it contributes approximately 4% to the overall River Don discharge and flows within close proximity to Inverurie, the key area of interest.
- The River Urie at, and upstream of, Inverurie to assess NFM opportunities (runoff reduction and floodplain storage).
- The River Don upstream of Inverurie to assess floodplain storage and runoff reduction potential.
- Characterise the upper catchment west of Inverurie to inform NFM options that could be considered in the upper tributary catchments.
- The Shevock Burn (Urie tributary) will be assessed separately as part of the Insch FPS study report[3].

6 River Don

The River Don is the primary source of flood risk to Inverurie and Port Elphinstone. It has a large catchment area with many sub-catchments, therefore initial screening (Sections 2-4) was used to identify key areas to investigate further. These catchments were selected based on the potential NFM and RBMP opportunities they held according to the SEPA datasets, as well as those catchments of direct flood risk to the key urban communities. This chapter will focus specifically on the River Don within the scheme extent, as well as suggested NFM opportunities for the western catchment as a whole. The Ton Burn sub-catchment is covered in greater detail in Chapter 7, the River Urie region of the catchment in Chapter 8 and its tributary the Lochter Burn in Chapter 9.

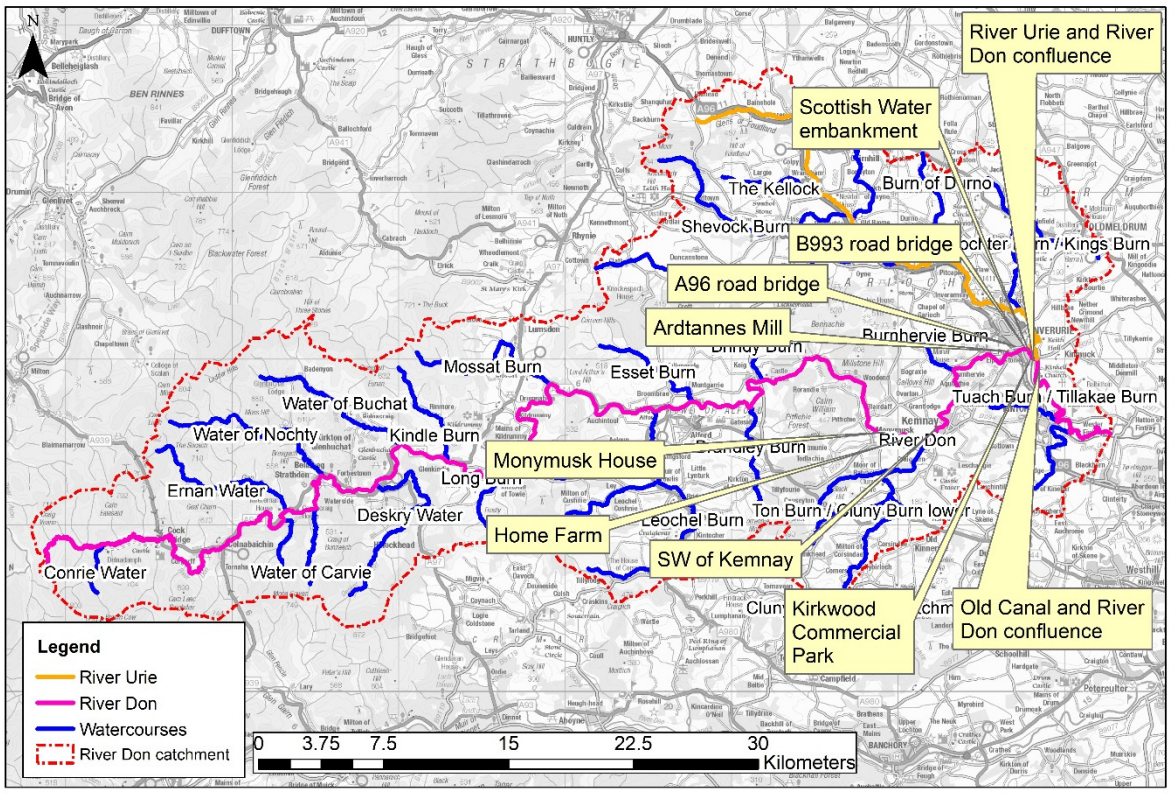
6.1 Catchment summary

The River Don catchment is large and land use is predominantly forestry in the upper catchment with agricultural land present in the lower elevations of the valley and on either side of the river. Pastures and arable land are more predominant further downstream, with forestry occurring on steeper slopes. The main urban areas are located in the lower catchment and include Alford, Kemnay, Inverurie and Kintore. Elevations in the Don catchment are greatest in the Cairngorm mountains to the west reaching 802 mAOD on Meikle Geal Charn and with similarly high elevations in the western margins of the catchment. Elevations drop to approximately 40 mAOD at the eastern extent of the catchment, east of Kintore.

The River Don according to the RBMP is classified as being in 'Good' physical condition between its source and Dyce at the outskirts of Aberdeen. The SEPA morphological pressures dataset indicates minimal significant pressures on the Don upstream of Inverurie, the primary constraint being embankments near Loanend Burn and upstream of Kemnay. Between the southern extent of Port Elphinstone and Kintore there are a greater number of pressures with a series of embankments indicated to be constraining the Don along both banks near the Kirkwood Commercial Park.

The NFM datasets indicate high to moderate floodplain storage potential along almost the entire length of the Don from Strathdon to Kintore. Runoff reduction potential within the scheme extent is indicated to be limited however, potential is high for the Don catchment as a whole particularly in the upper catchment and at higher elevations.

Figure 6-1: River Don key locations



6.2 NFM and RBMP Site Walkover Findings

The site visit took place over the 18 and 19 April 2018. Weather conditions on the days of the walkover were bright and dry with sunny intervals. Conditions in the week prior to the visit had been mixed with periods of rain throughout the week. River levels were within their normal range at the time of the visit but there was localised evidence of pooled stagnant water from recent rainfall and runoff.

The River Don was observed at the following locations: (i) west of Inverurie near Ardtannes at OS NGR NJ76250 19850, (ii) through the town of Inverurie, (iii) south along the Old Canal to Kirkwood Commercial Park at OS NGR NJ78300 19150, (iv) at the confluence with the River Urie at OS NGR NJ 78326 20044, (v) southwest Kemnay at OS NGR NJ 72650 15850 and (vi) at Monymusk House at OS NGR NJ 69250 15400. A map showing the location of photos taken in the Don catchment is included in Appendix B.1.

6.2.1 Eastern Don Catchment - Monymusk to Inverurie

The main land use along this stretch of river is agriculture and forestry. At Monymusk House the River Don is wide, meandering and has very few physical constraints, seen by the natural erosion of the banks. The small embankment opposite Monymusk House could be set back (Figure 6-2, A) to encourage greater floodplain connectivity and allow more room for riparian planting of shrubs along the river banks to reduce field runoff. A small pond is present on the left bank upstream of the House of Monymusk which is not connected to the River Don but is likely to store runoff from the agricultural land that slopes toward the Don. Similar floodplain storage features could be replicated elsewhere in the catchment.

There is an area of low lying floodplain beneath and downstream of the bridge by Home Farm which appears to be regularly inundated (Figure 6-2, B). Floodplain storage could be enhanced through wetland creation or riparian trees could be planted to encourage a wet-woodland area. An embankment abuts this area of floodplain limiting flood risk to the adjacent fields.

Southwest of Kemnay, the NFM dataset suggests floodplain storage potential across the valley floor. At the large meander where the former channel used to be (OS NGR NJ 72300 15650, Figure 2-5) there is scope for floodplain woodland planting to increase infiltration, floodplain roughness and

storage potential (Figure 6-2, C). Land use in this area is agricultural with much of the floodplain grazed and sediment and runoff pathways visible from the fields. There are a lack of buffer strips to buffer this runoff therefore increasing riparian planting (e.g. gorse shrubs) is suggested along both banks to trap sediment and runoff and increase infiltration (Figure 6-2, D). In addition, fencing the floodplain to limit livestock grazing to the bank edge is suggested to maintain bank stability and thus 'Good' RBMP status. The field on the right bank of the Don had marsh plants growing in it and did not appear to be cultivated/ grazed. Encouragement of, and the creation of further wetland regions would aid runoff reduction and enhance floodplain storage.

Figure 6-2: Monymusk to Inverurie - River Don characteristics

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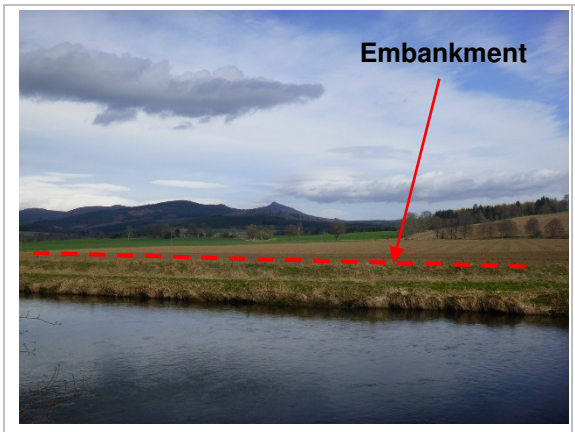
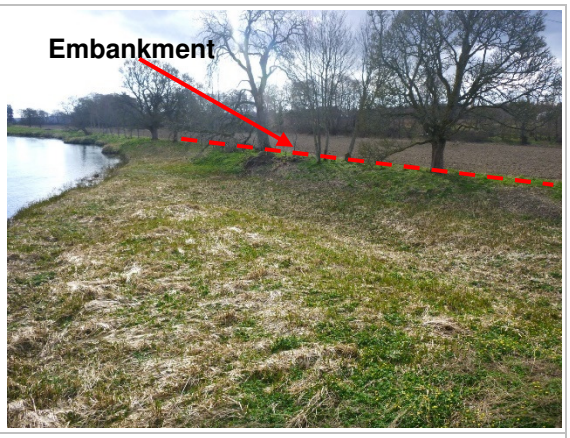
<tr><td> 
</td><td> 
</td></tr>
<tr><td>A: Embankment by the House of Monymusk that could be set back to release river capacity, increase floodplain connectivity and allow room for riparian shrub planting. (OS NGR NJ 68866 15530)</td><td>B: Area of low-lying floodplain by House Farm that could be turned into a wetland or wet-woodland to enhance current floodplain storage. (OS NGR NJ 68866 15530)</td></tr>
<tr><td> 
</td><td>  </td></tr>
<tr><td>C: Looking upstream from the SE outskirts of Kemnay. Woodland planting on the meander floodplain recommended. (OS NGR NJ 72343 15693)</td><td>D: Increase buffer strip along the banks of the Don to reduce the runoff from fields. Fence banks to limit livestock grazing of the bank edge to maintain stability. (OS NGR NJ 72576 15848)</td></tr>
</table>

6.2.2 The Don at Inverurie

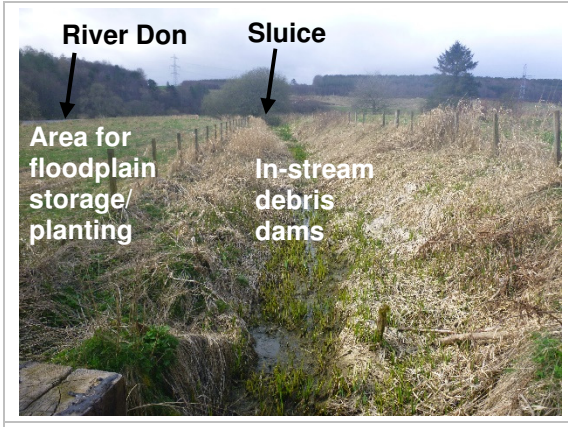
The River Don within the scheme extents was walked between Ardtannes and the Kirkwood Commercial Park (Figure 6-1). At the western extent of the scheme reach, near Ardtannes, there are few morphological pressures and the NFM dataset indicates the river is in balance. There is an old sluice gate at OS NGR NJ 76250 19850 that previously diverted water to Ardtannes Mill via a circa. 4 m wide mill lade (Figure 6-3, A). The Mill Lade is not currently used but is likely to act as an area of storage when the River Don is in high flow as well as storing runoff from the adjacent fields and surrounding area. A considerable buffer strip is present along the left bank of the Don upstream of and adjacent to the mill lade which is buffering runoff from the farmed land. Riparian woodland planting within the buffer strip as well as floodplain woodland planting on the area of land between the old mill lade and the River Don to encourage greater infiltration and storage. Alternatively, an

offline storage feature could be developed utilising the offtake and currently unused mill lade to divert water from the Don into a storage area as flows increase. Additionally, as the lade is currently not being used, in-stream debris dams to encourage retention within the channel rather than rapid transfer through it is suggested (Figure 6-3, A). Downstream of a small footbridge over the lade, the channel becomes overgrown and concrete lined and would again act to store runoff from a small field drain by the bridge but the concrete nature of the channel does not allow for infiltration (Figure 6-3, B).

Downstream of the Mill at OS NGR NJ 76469 20320 an outflow pipe was discharging a large volume of water across the footpath into a steep gully toward the River Don (Figure 6-3, C). It was unclear if this was an agricultural or road drainage outflow pipe but limiting and slowing runoff from the pipe towards the Don is recommended. Water was already ponding at the time of the visit due to a log across the small runoff channel which is allowing infiltration. The River Don itself at this location is not particularly incised and it would therefore be possible to create an area of floodplain storage on the right bank behind a small embankment (not within the SEPA dataset) on the inside of the meander opposite Ardtannes, such as an offline storage pond where water could be diverted and stored in times of high flow (Figure 6-3, D). Floodplain planting on the left bank is also recommended (Figure 6-3, E) whilst more planting on the right bank behind the embankment would also reduce runoff and contribute to floodplain storage.

As the Don flows beneath the A96 road bridge and enters Inverurie, floodplain storage capacity decreases due to urbanisation, the river becomes more constrained and high erosion is indicated in the SEPA NFM dataset in the vicinity of the road bridge. The left bank in particular was found to be undergoing a high degree of erosion, eroding the footpath at several locations (Figure 6-3, F) and filled gabion baskets lined much of the left bank (Figure 6-3, G). Additionally, a number of runoff channels were evident through the woodland on the steeper left bank. Whilst it is not marked on the SEPA physical pressures dataset, an embankment is also present along the right bank at the edge of Davidson Field playing fields (Figure 6-3, H). Works to reinstate the crest of this embankment were undertaken following the latest flood event. Improvements to the watercourse condition in line with the RBMP include setting back of the embankment and rebuilding it at the south of the park to increase the floodplain area, whilst still protecting properties beyond it. It is recommended the grey bank protection remains. Planting and improving bank stability in the heavily eroded areas to limit sediment input are highly recommended.

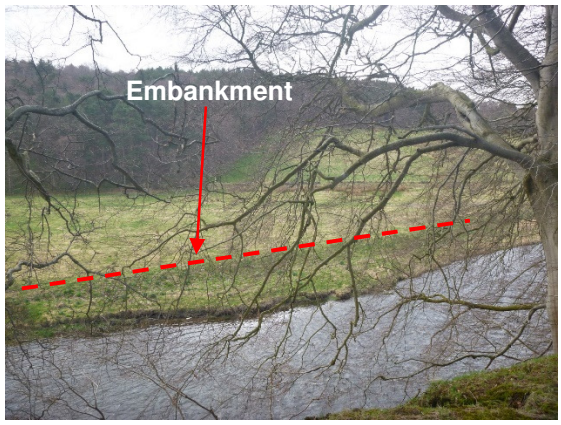
Figure 6-3: River Don upstream of the A96 road bridge characteristics



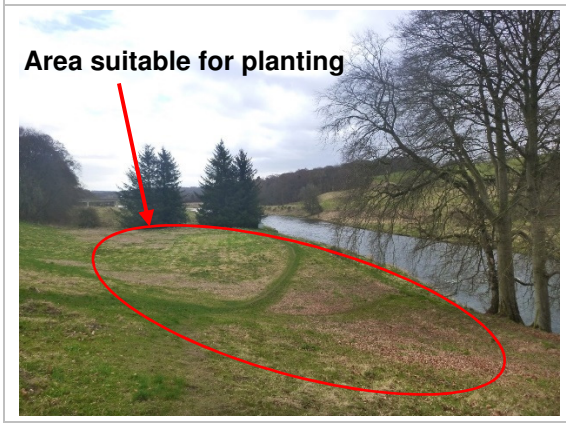
A: Looking upstream along the wide, vegetated mill lade. Potential for floodplain storage/ planting on the right bank and in-stream debris dams to hold water within the tributary channel of the Don. (OS NGR NJ 76339 20131)

B: Concrete lined, overgrown mill lade. (OS NGR NJ 76339 20131)

C: Outflow pipe discharging and creating a channel towards the Don across the public footpath. Slowing this outflow and channel formation recommended. (OS NGR NJ 76376 20204)



D: Small embankment behind which floodplain woodland could be planted or an offline storage pond created. (OS NGR NJ 76490 20302)



E: Potential area for increased planting to slow runoff. (OS NGR NJ 76673 20354)

F: Eroded footpath along left bank of Don south of the A92 road bridge. (OS NGR NJ 77403 20593)

G: Gabion basket lining the eroding left bank of the Don downstream of the B993 road bridge. (OS NGR NJ 77490 20616)

H: Embankment along Davidson Field playing fields. Works to reinstate the crest were carried out following the last large flood event. (OS NGR NJ 77490 20616)

Downstream of the playing field and B993 road bridge the River Don changes course to flow south and is constrained along the entire left bank by an embankment put in place by Scottish Water (Figure 6-4, A). There may be an opportunity to set back the Scottish Water embankment to allow for greater floodplain connection and water storage, however this will have to be agreed with Scottish Water as it was put in place as a flood prevention measure. High levels of bank erosion are occurring along the River Don through Port Elphinstone to the Urie confluence (Figure 6-4, B)

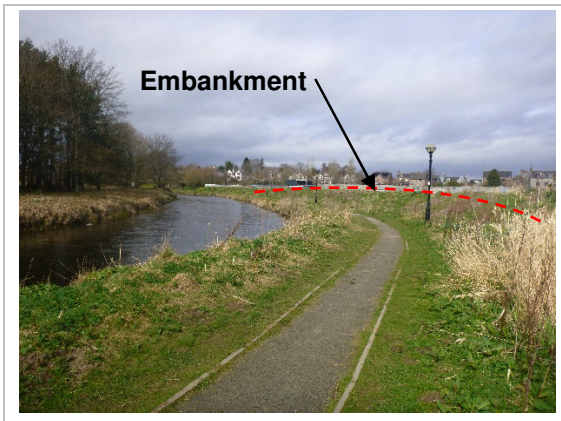
and the footpath is extremely eroded at points (Figure 6-4, C). Bank stabilisation is therefore recommended to reduce high levels of sediment input which can accumulate over time and reduce channel capacity.

The floodplain storage potential marked within the SEPA NFM dataset is not viable through Inverurie itself but is possible in the area of land between the River Urie and River Don at their confluence. Here there is a large area of rough, low lying active floodplain with a small embankment at its edges. It has potential to be further utilised as an area of floodplain storage by lowering the existing embankment at the northwest corner along the left bank of the River Urie, to direct out-of-bank flows from the Urie into the storage area while the existing embankment at the southern margin would prevent flow directly into the Don. Additionally, this area could be planted with floodplain woodland to increase infiltration (Figure 6-4, D).

An Old Canal runs parallel to the Don on the left bank at the eastern margin of Port Elphinstone. The canal opened in 1806 and ran between Port Elphinstone and Aberdeen used to transport commercial goods as well as foot passengers[16]. Historically Port Elphinstone was a large pond used to store boats, and the Kirkwood Commercial Park the site of the Inverurie Paper Mill. Although marked as the old canal on current OS mapping, the southern channel is believed to be a lade suppling water to the former paper mill[16].

Between the canal and Don the land is raised (Figure 6-4, E) built up of the dredged material from construction of the canal. There are also embankments marked in the morphological pressures dataset through Kirkwood Commercial Park and many other physical constraints are present along the canal including a sluice and weir near its confluence with the River Don and south of the Kirkwood Commercial Park (Figure 6-4, F). The canal is a man-made feature and does not therefore form part of the RBMP however from observations, it appears to be in poor condition. The sluice gates at the north end of the canal were open to receive water from the River Don (Figure 6-4, G), however this does not appear to be occurring regularly as the water in the canal was stagnant, very murky and there was a large build-up of both natural and man-made debris (Figure 6-4, H). In addition, several sediment and pollutant laden runoff channels from the Kirkwood industrial area were evident. Improving the condition of the canal would be of benefit to the overall Don catchment RBMP status and there is potential through improvements to condition and the green space between the Don and canal to have flood risk benefits e.g. through creation of storage regions.

Figure 6-4: River Don downstream of the A96 road bridge and through Inverurie



A: Scottish Water embankment. (OS NGR NJ 77856 20632)

B: Bank erosion on both banks of the Don exposing a manhole chamber. (OS NGR NJ 77906 20418)

16 https://en.wikipedia.org/wiki/Aberdeenshire_Canal [Accessed: June 2018]

C: Significant bank erosion below the footpath on left bank of River Don. (OS NGR NJ 77906 20418)

D: Utilise the existing embankment to encourage storage in the rough floodplain between the Urie and Don and increase floodplain planting. (OS NGR NJ 78214 20061)

E: Canal by Port Elphinstone with embankments on both sides, stagnant water and debris input. (OS NGR NJ 77796 20434)

F: Sluice leading to weir at downstream extent of the canal/ mill lade at Kirkwood Commercial Park. (OS NGR NJ 78282 19168)

G: Entrance to the Old Canal on the right bank of the Don and erosion on the right bank. (OS NGR NJ 77685 20648)

H: Natural and man-made debris in the canal. (OS NGR NJ 77945 20166)

6.3 Wider River Don NFM recommendations

The reaches of the Don discussed above are those primarily within the scheme extent, with findings and recommendations for the tributary sub-catchments discussed in further detail in the proceeding chapters. The findings and recommendations from the tributary sub-catchments have been used to inform NFM recommendations for the wider River Don catchment along with further desktop analysis.

The headwater region of the River Don catchment, west of Alford is predominantly forested with agricultural land present at lower, flatter elevations along the banks of the watercourses. There are very few physical pressures on the River Don and it has a sinuous morphology, although a number of tributaries have undergone high impact realignment with additional physical constraints. The greatest potential for runoff reduction is in the upper catchment. Much of this area is already forested although additional cross-contour woodland planting, gully planting and riparian planting along tributary watercourses is recommended, as appears to have been undertaken east of Bellabeg, at Newe Avenue OS NGR NJ 38223 12317. Peatbog covers large areas of the upper catchment where there is potential for upland habitat restoration and drain blocking to reduce runoff, regulate the water table and increase storage potential. The floodplain throughout the upper catchment is used predominantly for agricultural pasture and crops therefore potential for floodplain planting and/or storage would require landowner engagement but would be encouraged to improve upper catchment storage.

The middle region of the Don catchment between Bridge of Alford and Kemnay (where recommendations are given above) is again relatively unconstrained and sinuous in line with its 'Good' RBMP status. Catchment topography is less constrained and more undulating and as such floodplain storage potential is indicated to be much greater in this region, with runoff reduction potential greater on upland slopes. Upland habitat restoration in the forested regions to the east of Alford for example is suggested as one measure to reduce runoff toward the Don. Between Alford and Kemnay there are a limited number of tributaries but from a desktop review there is floodplain storage potential along the lower reaches of several Don tributaries, including the Leochel Burn, where there is evidence of paleochannels in the floodplain which have the potential to be connected to the main watercourse during times of peak flow. Planting within the floodplain e.g. at OS NGR NJ 55402 16686 would increase floodplain storage and infiltration upstream of the River Don.

6.4 Summary and recommendations

The River Don within the scheme extent is classified as being in 'Good' physical condition according the RBMP. Significant morphological pressures indicated in the SEPA dataset are the embankments and grey bank protection along the Old Canal through Port Elphinstone, and the series of left bank embankments south of Kirkwood Commercial Park. The site walkover revealed there are indeed few physical pressures upstream of Inverurie however, a number of significant morphological pressures are constraining the morphology of the River Don through and downstream of Inverurie. These include: the right bank embankment around Davidson Field playing field, the gabion baskets protecting the eroding left bank between the A94 and B993 road bridge and the left bank Scottish Water embankment. Removal or setting back of these features to increase channel capacity may be possible with agreement from Scottish Water and ensuring assets behind the embankments are not at risk. There may also be potential to remove the large historic embankment south of Kirkwood Commercial Park to allow greater floodplain connectivity and storage however, as this is cultivated land, landowner agreement would be vital and may result in significant loss of productive land. High levels of bank erosion are occurring along the River Don through Port Elphinstone and bank stabilisation is therefore recommended to reduce high levels of sediment input. These measures will work towards maintaining the 'Good' RBMP physical condition status.

Outwith the scheme extent the River Don is also classified as being in 'Good' physical condition from its source to Dyce. The watercourse is relatively sinuous with few physical constraints. Suggestions for continued improvements include setting back the embankment at Monymusk and increasing vegetation within and the area of buffer strip at field boundaries along the Don to limit sediment and fluvial runoff, as well as stabilise the river banks. This has the dual benefit of improving water quality in line with the RBMP objectives and has NFM benefits through runoff reduction.

NFM opportunities within the scheme extent include runoff reduction and floodplain storage opportunities upstream of the A96 road bridge (and community at risk) where there is potential for storage ponds, floodplain woodland and wetlands. Opportunities within the urbanised reach are

more limited but floodplain storage at the Urie/Don confluence is suggested as an option but requires careful consideration of potential risk to the nearby waste water treatment works.

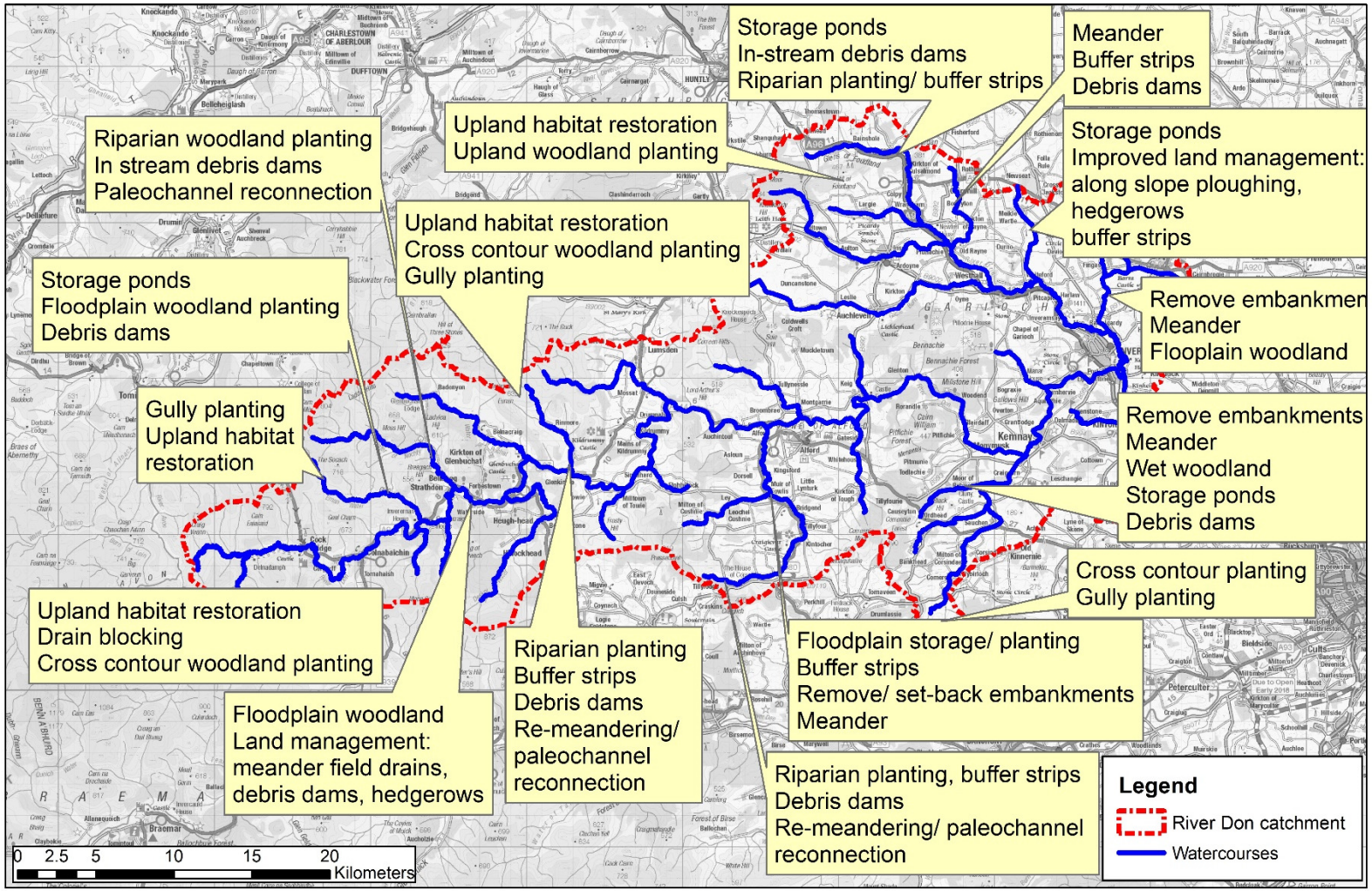
Overall the River Don has a relatively sinuous morphology and the catchment contains a variety of land use types including a relatively high proportion of woodland. Catchment wide land management practice improvements are the key recommended NFM measures which includes preventing grazing to the bank edge, along contour ploughing and ensuring suitably wide buffer strips in the agricultural regions, and upland habitat restoration in the peatland areas. Additionally, there are NFM opportunities within the numerous sub-catchments such as floodplain reconnection, gully woodland planting and meandering which will cumulatively benefit flood risk from the River Don through greater catchment storage.

Key recommendations based on the site visits and for the River Don catchment as a whole include:

- Increased floodplain planting across the catchment for example at the locations identified in Figure 6-2: B, C and Figure 6-3: A, D; E.
- Upland peatland restoration and drain blocking in the upper catchment to reduce runoff e.g. in the Strathdon region.
- Gully and upper catchment woodland planting e.g. in the upper Water of Nochty catchment.
- Riparian planting to create and/ or increase the area of buffer strips along field boundaries e.g. Figure 6-2: D, E to reduce runoff, buffer sediment and pollutant runoff from agricultural land and increase infiltration.Buffer strips should ideally be at least 6 m in width at field boundaries (as per Aberdeenshire Council guidelines[17]).
- Offline storage ponds along the River Don floodplain e.g. by Ardtannes Mill Figure 6-3: D and at the Urie confluence.
- In-stream debris dams along drainage channels feeding the main watercourses e.g. Figure 6-3, C.
- Re-meandering of field drains to slow the flow of water entering the River Don and tributary watercourses.
- Where possible set-back, remove or breach embankments along watercourses to release channel capacity and increase floodplain connectivity.

17 Aberdeenshire Council. Planning Advice: Buffer Strip Guidance [Accessed 24/08/18] https://www.aberdeenshire.gov.uk/media/21345/2015_09-buffer-strips-planning-advice.pdf

Figure 6-5: Suggested NFM measures for the River Don catchment



7 Ton Burn and tributaries

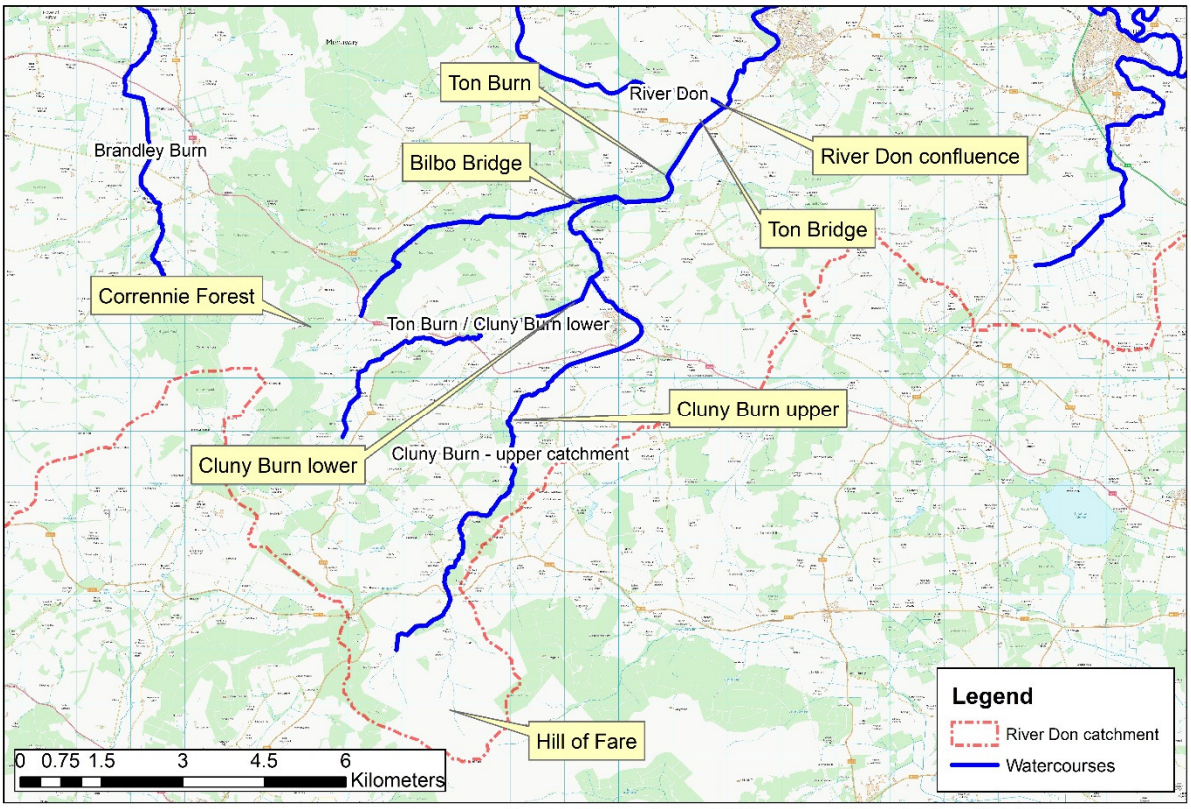
7.1 Catchment summary

The Ton Burn is a sub-catchment of the River Don and covers an area of approximately 74 km^2. The Ton Burn/ Cluny Burn lower originates in Corrennie Forest and flows northeast towards its confluence with the River Don, southwest of Kemnay, through agricultural and forested land. The Cluny Burn upper is a tributary of the 'lower' Ton which flows north from its source at Hill of Fare. Elevations in the Ton Burn catchment are greatest in the south reaching 425 mAOD in Corrennie Forest and decrease to 80 mAOD at its confluence with the River Don. The catchment is rural with no large urban extents. Land use is predominantly arable pastures with large areas of forestry particularly in the western catchment.

The Ton Burn is classified as being in 'Moderate' physical condition while the Cluny Burn (upper catchment) is classified as being in 'Good' physical condition. The upstream channel of the Ton is small and has undergone high impact realignment with embankments and grey bank reinforcement. As the Cluny Burn joins the Ton Burn, the burn becomes highly constrained by embankments, and is highly straightened as it approaches the River Don.

The SEPA NFM datasets indicate potential for floodplain storage along the Cluny Burn at the confluence with the Ton Burn and along the lower reaches of the Ton Burn. Runoff reduction potential is highlighted as being moderate to high in the upper catchment.

Figure 7-1: Ton Burn key locations



7.2 NFM and RBMP Site Walkover Findings

The findings and recommendations based on the site visit are presented in the following sections. The site visit took place on 19 April 2018 and weather conditions on the day of the walkover were bright and sunny. Conditions in the week prior to the visit had been mixed with periods of rain throughout the week.

Access to the watercourse was very limited within the catchment due to the land use and lack of road connections but key areas of interest were observed at the following locations: (i) confluence with the River Don at OS NGR NJ 71900 15000, (ii) the Ton Bridge on the B993 at OS NGR NJ

71500 14650 and (iii) the road bridges near Bilbo Bridge at OS NGR NJ 69150 13200. A map showing the location of photos taken in the Ton catchment is included in Appendix B.2.

7.2.1 Ton Burn lower catchment

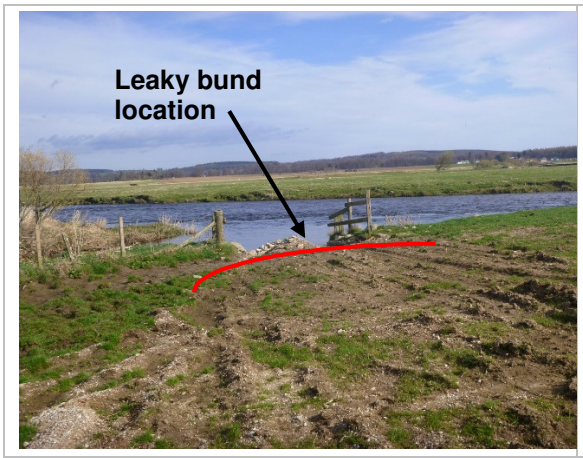
The lower catchment is defined as the area between the Cluny Burn lower/ Ton Burn confluence and its confluence with the River Don at OS NGR NJ 72650 15850. This area has undergone high impact realignment with the channel being highly straightened through the agricultural fields (Figure 7-2, A). A small buffer strip was present along both banks, however it is recommended the area of buffer strip be increased to reduce field runoff along both banks (Figure 7-2, H) and the Ton Burn meandered to increase sinuosity. This has both RBMP benefits as the Ton Burn is classified as being in 'Moderate' physical condition as well as NFM benefits as increased sinuosity also slows flow to the main River Don. Sparse trees were present along the watercourse which in some cases is contributing woody debris and thus natural debris-dams within the channel (Figure 7-2, B). Further riparian woodland planting to encourage greater natural debris accumulation would further act to slow flow and encourage out-of-bank floodplain connection.

At the confluence between the River Ton and River Don on the right bank, the field slopes steeply down to both watercourses where sediment runoff was high (Figure 7-2, C). The base of this field was waterlogged and marshy at the time of the visit (Figure 7-2, D) with runoff directed downslope from the ploughed fields to the east. A sediment trap and or leaky bund to hold back runoff at the field corner would reduce sediment influx to the River Don. Additionally, it is recommended preventing grazing to the bank edge as this encourages compaction and runoff to the bank edge as well as leading to bank instabilities.

Upstream of the confluence by the Bridge of Ton, the grey bank reinforcement indicated in the morphological pressures dataset was visible as a former railway bridge on the dismantled railway. The burn is highly straightened (Figure 7-2, E), the banks are eroding (Figure 7-2, F) and runoff from the right bank field was evident (Figure 7-2, G). There are fenced buffer strips on either side, however the area of buffer strip could be increased and more shrubs like gorse planted along with riparian woodland to encourage greater infiltration, bank roughness and woody debris dam formation within the highly straightened channel. In addition, leaky bunds in strategic locations e.g. in the corner of the field are suggested (Figure 7-2, G). SEPA indicates the potential floodplain storage along both sides of the watercourse (Figure 7-2, E) which would be plausible with the agreement of the landowner as the land is currently being used for agriculture.

Figure 7-2: Lower Ton Burn features

	
A: Highly straightened channel with minimal buffer strips on each bank. (OS NGR NJ 71632 14752)	B: Trees contributing woody debris within the watercourse. (OS NGR NJ 71632 14752)

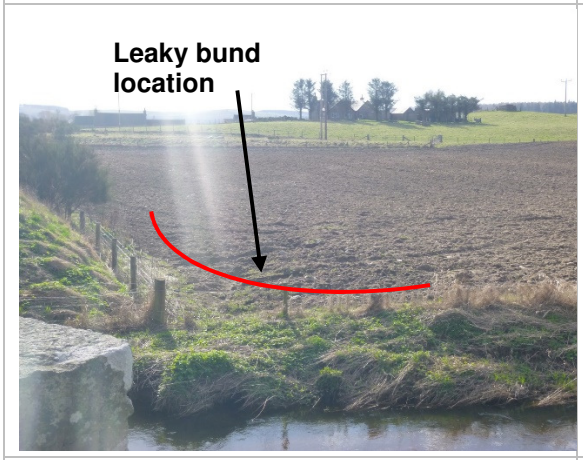


C: Sediment runoff from field into Ton Burn and River Don at their confluence. (OS NGR NJ 71926 14957)

D: Marsh on right bank at bottom of the sloped field where runoff originates from the road and ploughed fields to the south. (OS NGR NJ 71926 14957)

E: Looking upstream from the Bridge of Ton. Highly straightened channel with minimal buffer strip and sparse riparian trees. (OS NGR NJ 71512 14650)

F: Bank erosion causing instability upstream of the Ton Bridge. (OS NGR NJ 71512 14650)



G: Sediment runoff high at field corner, sediment trap or leaky bund to limit influx to watercourse recommended. (OS NGR NJ 71512 14650)

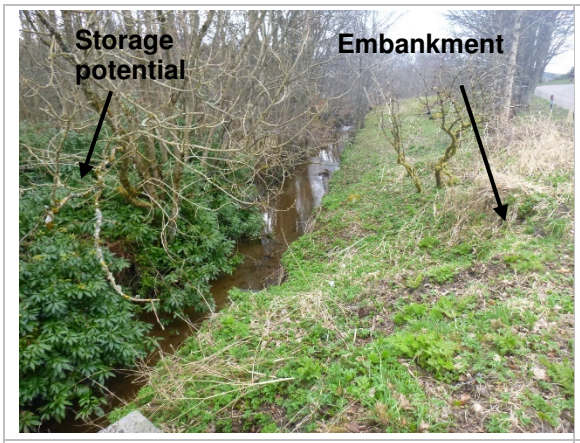
H: Looking upstream from the Don confluence. Potential for increased riparian planting along both banks and meandering. (OS NGR NJ 71926 14957)

7.2.2 Ton Burn upper catchment

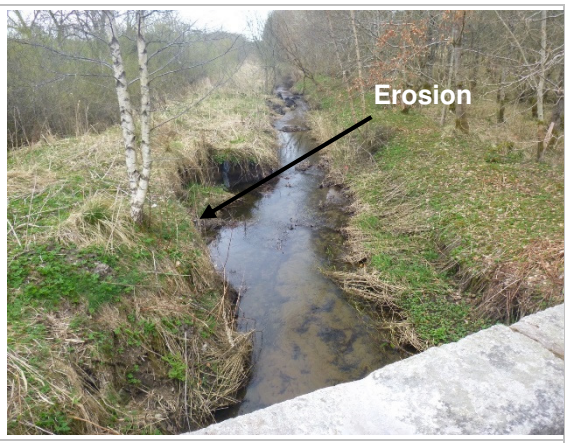
The Ton Burn upper catchment is defined as the area west of the confluence with the Cluny Burn lower at OS NGR NJ 69950 13300. This area of the catchment is considerably more forested with patches of agricultural land. At Bilbo Bridge, the main Ton Burn and a field drain flowing parallel to it were visible, all of which were narrow and highly straightened. Upstream, the Ton Burn is constrained by an embankment along the left bank (Figure 7-3, A), while the right bank is rough forested land. Removal of the embankment would release channel capacity by over 3% improving channel morphology in line with the RBMP objectives as well as increasing floodplain connectivity. Debris dams within the channel to encourage out of bank flow, as well as offline storage ponds could also be introduced within the right bank to allow for water storage within the wooded area. Downstream of the bridge the burn is eroding into the embankments on the left and right banks (Figure 7-2, B) naturally working to restore sinuosity. Between the Ton Burn and parallel field drain, there was an area of woodland (Figure 7-2, C) which could again be utilised for water storage creating an area of wet woodland. The right bank embankment could be removed to aid with utilising the area of woodland and would release 5% of overall watercourse capacity. Meandering of the straightened watercourses is also recommended to increase sinuosity and thus slow flow toward the lower catchment and ultimately River Don.

South of Bilbo Bridge the Cluny Burn lower flows in a highly straightened channel having undergone high impact realignment and is constrained on the right bank by a small low embankment. The left bank was forested but had recently been felled. Recommendations in this area include: removal of the right bank embankment; meander the watercourse into the floodplain; increase vegetation and buffer strip area on the right bank; and there may be potential to create storage ponds (Figure 7-2, D). Re-meandering of the Cluny Burn lower along this stretch would release 10% of channel capacity.

Figure 7-3: Ton and Cluny Burn features by Bilbo Bridge



A: Looking upstream from Bilbo Bridge showing embankments on both banks, along with an area of unused land on the right bank. (OS NGR NJ 69162 13181)



B: Downstream of Bilbo Bridge the river is eroding naturally into its banks. (OS NGR NJ 69162 13181)

C: Area of raised woodland between Ton Burn and parallel field drain. (OS NGR NJ 69205 13136)

D: Embankment on right bank of Cluny Burn: implementation of a buffer strip would reduce field runoff. (OS NGR NJ 69266 13024)

7.3 Summary

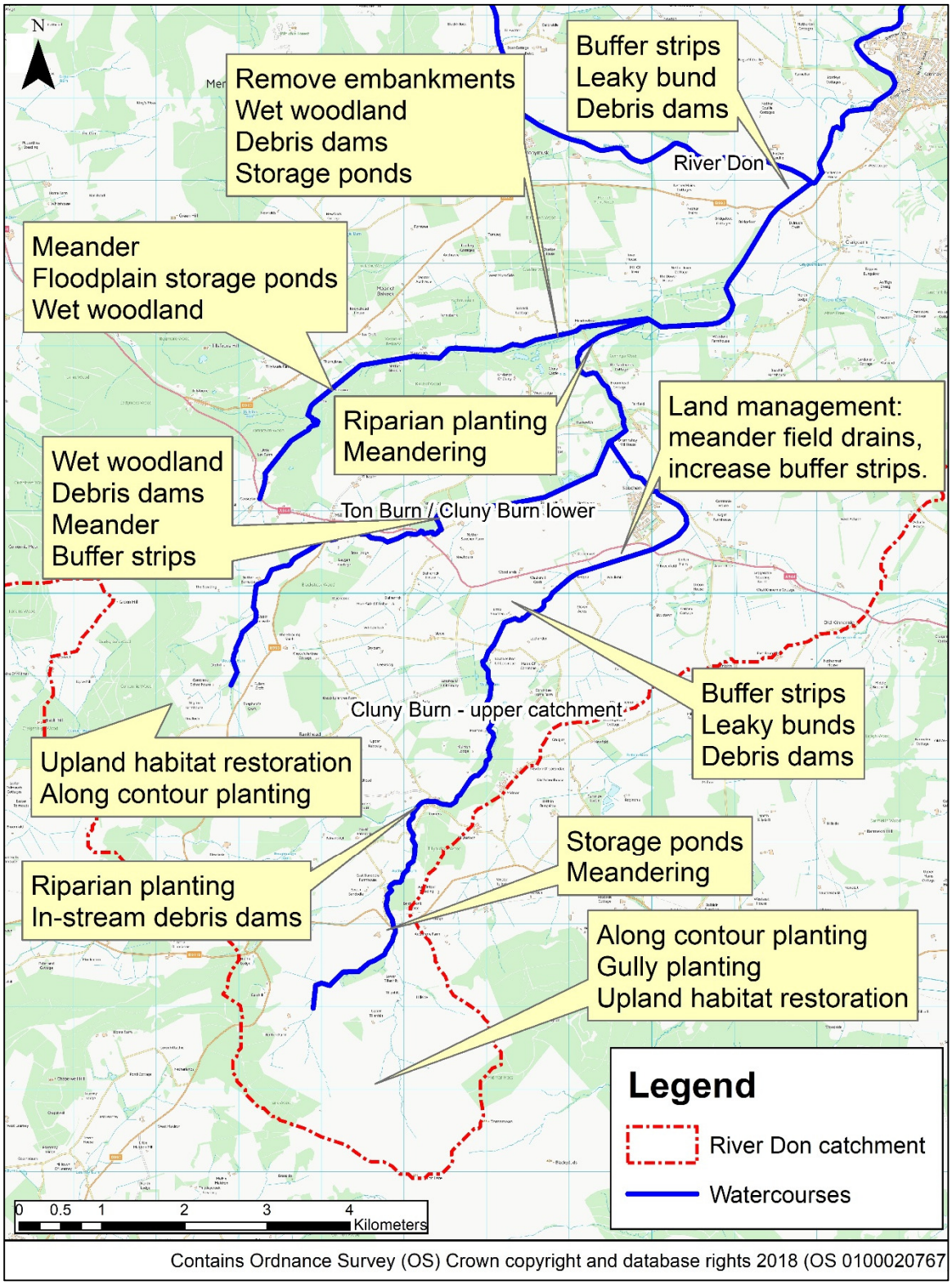
The Ton Burn is characterised as being in 'Moderate' physical condition due to the many physical pressures along its reach, as highlighted in the SEPA pressures dataset. The largest contributing pressures are embankments and high impact realignment. The site walkover indicated there are several locations where the embankments could be removed, particularly in the Bilbo Bridge area which would increase channel capacity and greatly improve RBMP status. In many places the river is eroding into the embankments working to restore sinuosity to the highly straightened channels which too would greatly improve the 'Moderate' physical condition classification.

There are multiple NFM opportunities within the Ton Burn catchment to reduce flood risk in the scheme extent, some of which are linked to the RBMP plan improvements for example increasing sinuosity to slow flow towards the River Don. In addition, although woodland cover is high in the catchment, removal of many of the embankments would increase floodplain connectivity in these wooded areas creating wet woodlands where storage and infiltration can occur, again reducing the proportional contribution of the sub-catchment to the River Don flows. The SEPA NFM mapping indicated floodplain storage potential to be high near Bilbo Bridge where it has been identified wet woodland floodplain storage would be a key option, as well as at the Don confluence however potential in this region may result in the loss of productive land. Runoff reduction potential in contrast was indicated in the mapping to be high in the upper catchment but the site visit indicated runoff reduction measures would be of benefit near the River Don confluence.

Key recommendations based on the site visits and for the Ton Burn catchment as a whole include:

- Increase the area of buffer strip, ideally to 6 m in width[17] and plant with shrubs and trees particularly in the lower reaches near the Don confluence, as well as a general increased riparian planting (Figure 7-2, A; E and Figure 7-3, D).
- Create leaky bunds to reduce runoff from fields and control sediment influx to the watercourse e.g. upstream of the Ton Bridge and near the confluence with the River Don (Figure 7-2, C; G).
- Limit bankside grazing to reduce soil compaction, runoff and ensure stabile banks.
- Debris dams in stretches of watercourses with uncultivated land nearby to encourage increased floodplain storage (Figure 7-3, A, B)
- Creation of a wet woodland to increase water storage in the upper Ton catchment (Figure 7-3, C)
- Cross contour woodland and gully planting in the upper catchment especially near the source of the Cluny Burn to reduce runoff.

Figure 7-4: Suggested NFM measures for the Ton Burn catchment



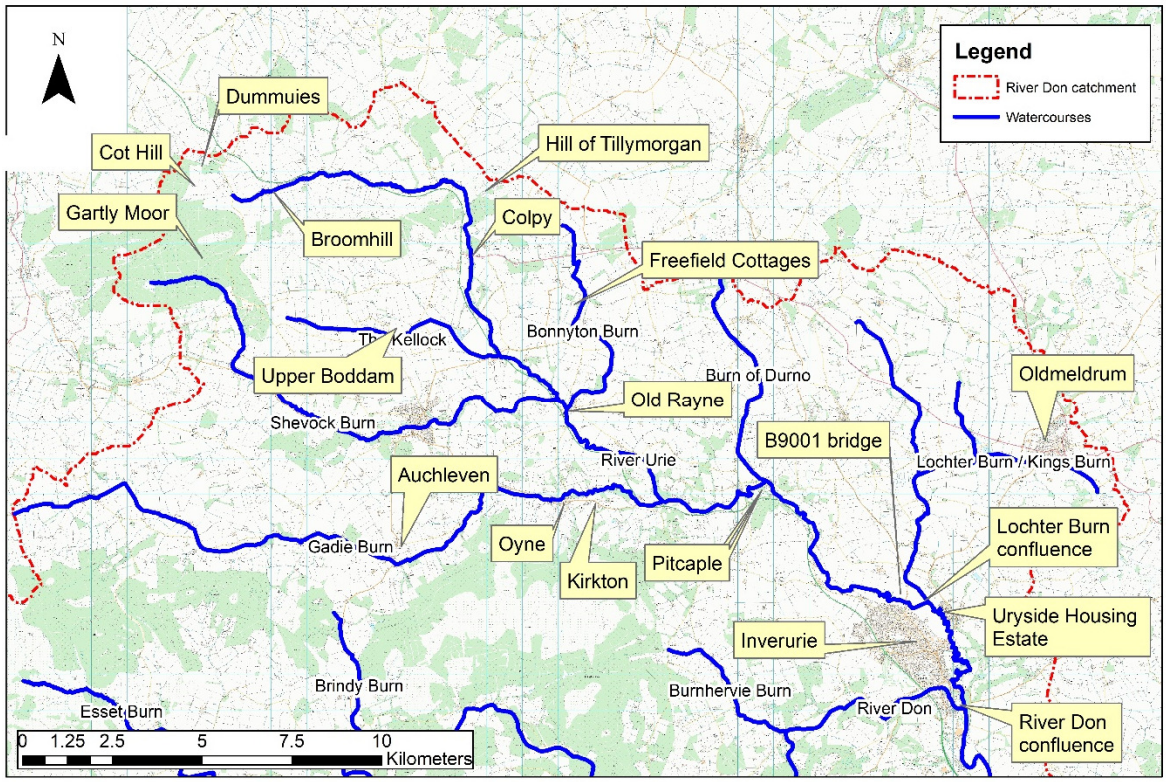
8 River Urie

The River Urie is the second largest watercourse in the Don catchment with an area of approximately 305 km^2. The watercourse originates in the Strathbogie region, southeast of Huntly, and flows southeast towards Inverurie, where it joins the River Don. A number of tributaries from the north and west discharge into it along its length. This chapter will focus specifically on the River Urie within the scheme extent, as well as NFM opportunities for the wider Urie catchment as a whole.

8.1 Catchment summary

The predominant land use is agriculture and mixed forestry, with three substantial urban areas at Inverurie, Oldmeldrum and Insch. Elevations in the catchment are greatest in the northwest reaching 311 mAOD at Cot Hill near its source and decreases to 67 mAOD at Inverurie. While the River Urie itself is classed as being in 'Good' overall condition, many of its tributaries from the north are classified as being in 'Moderate' physical condition. The SEPA NFM datasets indicate runoff reduction potential in the higher elevations of the catchment and floodplain storage potential along the majority of the Urie reach.

Figure 8-1: River Urie key locations



8.2 NFM and RBMP Site Walkover Findings

The findings and recommendations based on the site visit are presented in the following sections. The site visit took place on 18 April 2018 and weather conditions on the day of the walkover were bright and dry with sunny intervals. Conditions in the week prior to the visit had been mixed with periods of rain throughout the week. The Urie was assessed within the scheme reaches at the following locations (i) west of the B9001 bridge over the River Urie at OS NGR NJ 76650 23000, (ii) west of the confluence with the Lochter Burn at OS NGR NJ 77100 22900, (iii) west of the new housing estate at Uryside off Oldmeldrum Road at OS NGR NJ 77750 22550 and (iv) its confluence with the River Don at OS NGR NJ 78350 20100. A map showing the location of photos taken in the Urie catchment is included in Appendix B.3.

The recommendations from the site visits are focussed on the River Urie within the scheme extent. Findings and recommendations for the Lochter Burn tributary sub-catchment are discussed in

further detail in Chapter 9. The findings and recommendations within the scheme extent and from the Lochter Burn sub-catchment have been used to inform NFM recommendations for the wider River Urie catchment along with further desktop analysis.

8.2.1 River Urie lower catchment

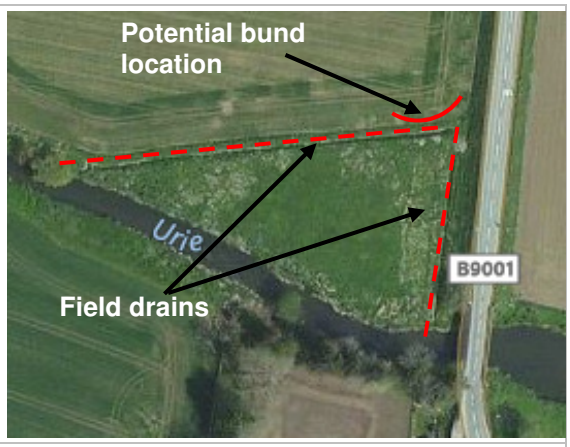
This is defined as the area south of Pitcaple to the confluence with the River Don and covers the entire scheme extent. The predominant land use in this area is arable pastures with evidence of both ploughed and grazed fields (Figure 8-2, A). Runoff from this type of land use can be high with buffer strips, hedgerows at field boundaries and preventing grazing to the bank edge, to increase infiltration and stabilise the banks being appropriate NFM measures which have both NFM and RBMP benefits. The river was accessed west of the B9001 bridge. The embankments indicated in the SEPA pressures dataset at this location were not visible and access further upstream to assess the additional embankments and grey-bank protection was very limited. The NFM mapping indicates high floodplain storage potential which was found to be a viable option on the uncultivated left bank. There are a number of straightened field drains in the area such as those in the rough ground on the left bank of the River Urie (Figure 8-2, B, C) which could be re-meandered to slow runoff to the main watercourses and the surrounding area used for floodplain storage. It was also apparent runoff from the fields flows into the Urie via another field drain that runs parallel to the road where a leaky bund at the top of the field drain would reduce the flow of water into the main watercourse (Figure 8-2, B). Woody debris dams could also be created within the field drain, allowing the area of rough ground to be periodically flooded and store water.

The River Urie has undergone high impact realignment west of its confluence with the Lochter Burn. The channel banks are eroding naturally (Figure 8-2, E) allowing for sinuosity to be restored, however embankments along both banks are a constraint on morphology. The right embankment could be set back to allow for meandering into the uncultivated land behind the existing embankment (Figure 8-2, D). In addition, complete removal of the embankments would prevent incision of the watercourse, contributing to a continued 'Good' RBMP physical condition status. Fields along both banks are used for crops and so input a large amount of sediment into the watercourse from runoff. Leaky bunds and shrub planting along the edges of the field boundaries would reduce the runoff and increase the overall condition of the river. East of the Lochter Burn confluence on the uncultivated left bank of the River Urie, floodplain woodland planting is recommended. This would increase infiltration within the soil and reduce runoff from the adjacent fields. Also, riparian planting/buffer strips on both banks would reduce runoff of sediment and pollutants from the field into the watercourse.

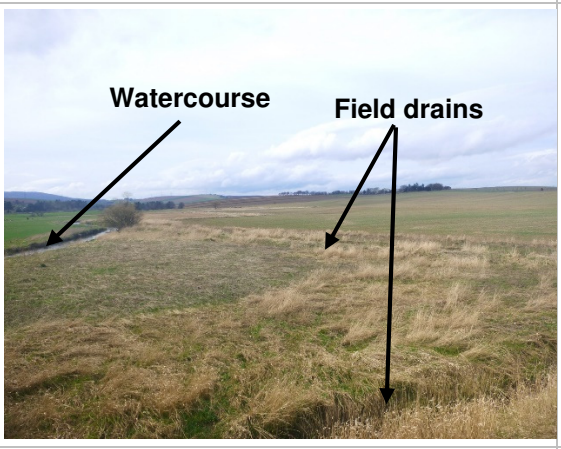
West of the Lochter Burn tributary and new housing estate at Uryside, the River Urie has no physical pressures, is highly sinuous and is naturally eroding and depositing material. At the margin of the confluence there is a large area of uncultivated floodplain on the left bank which is indicated as having high floodplain storage potential in the SEPA mapping (Figure 8-2, G). Floodplain woodland planting, wetland creation or a large storage pond are suggested NFM measures in this area to increase floodplain storage upstream of Inverurie. Wetland habitats would also provide multiple benefits as Uryside Primary School is located in the area and an NFM scheme with for example, trails through the woodland/ wetland would provide educational opportunities. Wetland areas also hold ecological benefits as they support a large range of biodiversity. Further downstream trees have fallen into the watercourse naturally (Figure 8-2, F), and additional man-made large woody debris dams could be installed along this reach to encourage out-of-bank flow and greater floodplain connectivity. The housing estate is located at a higher elevation from the floodplain and is therefore unlikely to be impacted by floodplain storage. Planting along the right bank field boundaries is also suggested to reduce runoff from fields and help store water when the river was in flood.

Figure 8-2: River Urie within the scheme extent

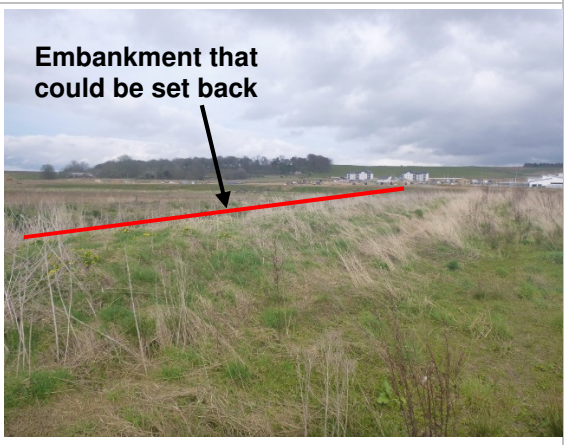
A: Catchment overview looking upstream from the B9001 bridge with grazed and ploughed fields on both banks. (OS NGR NJ 76684 22985)



B: Aerial photography[18] of field drains on left bank.



C: Area of rough ground on left bank of River Urie near B9001 which could be used for floodplain storage. (OS NGR NJ 76684 22985)



D: Embankment on right bank and area of rough ground behind. Debris dams in the watercourse would encourage out-of-bank flow and increase floodplain storage. (OS NGR NJ 76886 22850)

E: Eroding banks. Vegetation planting may stabilise the banks. (OS NGR NJ 76886 22850)

F: Trees in the main River Urie channel. (OS NGR NJ 77711 22547)

18 Google Imagery 2018 DigitalGlobe. Imagery date 5/4/2017 [Accessed: June 2018]

	
G: Area of uncultivated floodplain below new school where wetland could be created. (OS NGR NJ 77711 22547)	

8.3 Wider River Urie catchment recommendations

The River Urie is classified in the RBMP as being of both 'Good' overall and physical condition to the Lochter Burn confluence. There are few embankments present within the upper Urie catchment but the watercourse is indicated to have undergone historical realignment in many areas. For example, near its source the River Urie has undergone realignment. Historical mapping indicates the river was previously meandering and it is suggested from Broomhill east for 1 km it be re-meandered to increase sinuosity. At the embankment east of the River Urie at Pitcaple floodplain planting between it and the river could be undertaken to increase the storage potential. It may also be possible to place in-stream barriers at that location to encourage out-of-bank flow into the floodplain at times of peak flow.

Opportunities for runoff reduction in the wider catchment as determined from aerial imagery include along-contour shelter belts and woodland planting near Dummuies (Figure 8-1), on the east side of Gartly Moor, in the area around Hill of Tillymorgan and on the opposite side of the river to the hill, where the SEPA NFM mapping has highlighted medium runoff reduction potential. South of Old Rayne the catchment widens and opportunities for floodplain storage potential arise. The majority of land adjacent to the watercourse is used for crops or grazing and therefore at present there are limited areas for increased floodplain storage that will not conflict with farmers' land use. At OS NGR NJ 67753 27393 there is potential in the uncultivated land on the floodplain. While is it not suggested on the NFM dataset, beneath the A920 heading east at Colpy, there is a possibility to increase floodplain storage potential through planting and offline storage ponding in an area of land that at present appears to be uncultivated.

Desk-top reviews and recommendations for the Urie tributaries classified as being in 'Moderate' physical condition have also been made using the catchments and areas visited as analogues. The Bonnyton Burn has undergone high impact realignment with a number of embankments present along its reach. Re-meandering is recommended through the field north of Freefield Cottages and in the area south of Bonnyton, with the potential to release more than 20% of the channel capacity. If feasible, removal or set-back of embankments near its source would make the watercourse less constrained and release 12% of its total capacity. There is very limited riparian vegetation along the banks of the watercourse and so buffer strips and hedgerows are recommended to reduce water and sediment runoff from the surrounding agricultural fields. The Kellock is a very narrow watercourse that is highly straightened. It has potential to be meandered west of Upper Boddam which would slow flow downstream and make the watercourse less constrained. Leaky bunds at field boundaries, along with increased riparian planting is also suggested to limit sediment runoff with additional water quality RBMP benefits. Similarly, the Burn of Durno catchment is dominated by agricultural land and would benefit from runoff and sediment management measures such as leaky bunds and riparian planting at field boundaries to slow runoff into the watercourse. The Gadie Burn is classified as being in 'Good' physical condition and meanders along most of its length but contributes a large proportion of flow to the River Urie. West of Oyne, there is the potential to create offline storage ponds on the left bank. At present the land is marshy indicating water storage is already happening but encouraging further storage e.g. through bunding of ponds, would enhance

catchment storage and thus reduce flows into the River Urie. As with many of the other sub-catchments riparian planting is limited meaning runoff from adjacent land into the main channel is likely to be high . Buffer strips, hedgerows, along-contour woodland planting and leaky bunds are therefore recommended NFM measures. Increased woodland planting is suggested on the hillside near Kirkton and Auchleven.

8.4 Summary

The River Urie is classified as being in 'Good' physical condition according to the RBMP and the river was seen to be actively eroding. Significant pressures are the embankments present near Inverurie, Pitcaple and sporadically in the upper catchment as well as the realignment that has taken place in the upper catchment and near Inverurie. Opportunities to reduce these pressures include the set-back of the embankment west of Uryside housing estate to allow for increased floodplain connection whilst still protecting farmland from flooding; increasing sinuosity in the upper catchment and increasing floodplain connection at Pitcaple through debris dams encouraging out-of-bank flows.

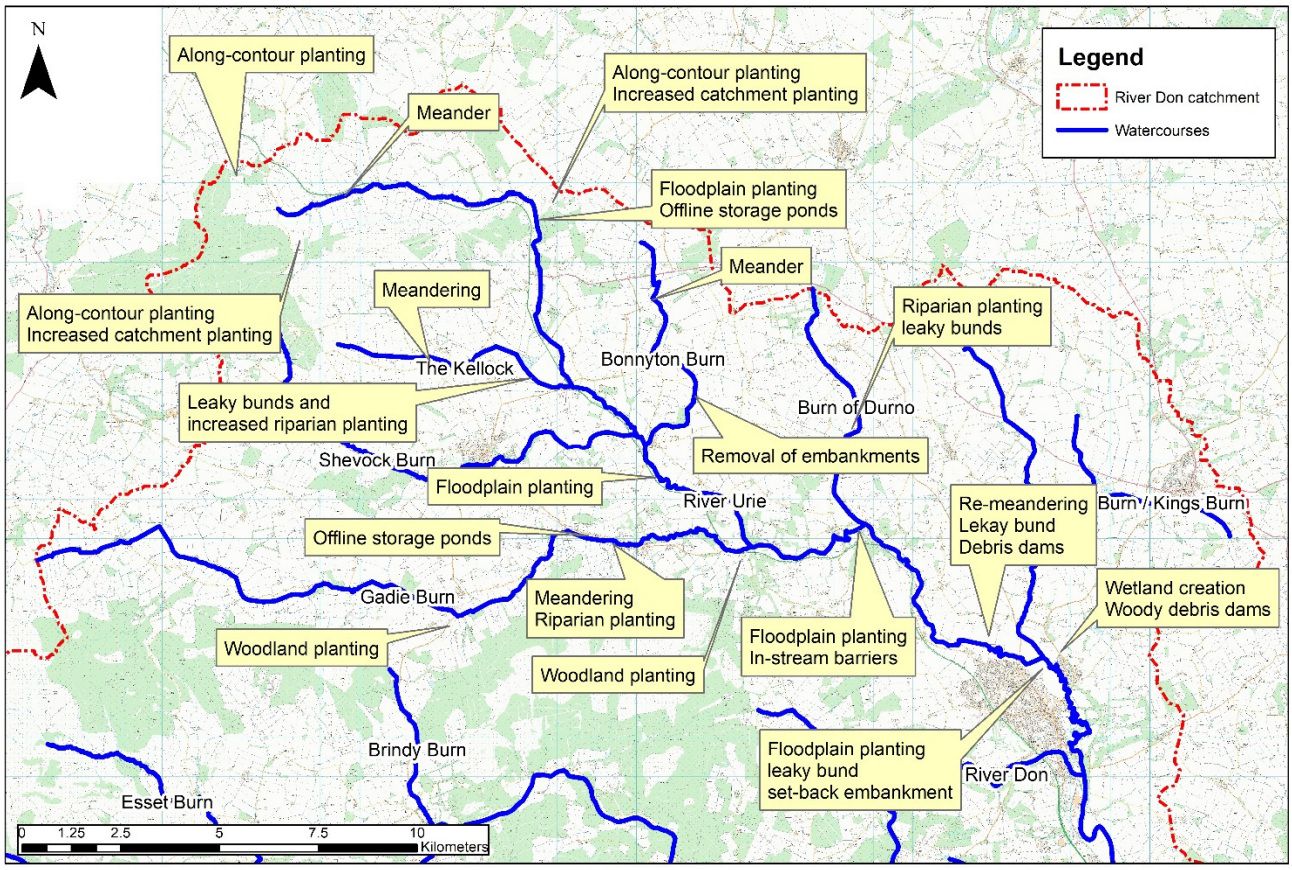
In contrast, a number of the Urie tributaries including the Bonnyton Burn, The Kellock, Burn of Durno and Lochter Burn (which discharges into the Urie at Inverurie, discussed in further detail in Section 9) are classified as being in 'Moderate' physical condition. Realignment and embankments are the primary physical constraints but there is ample opportunity to improve their physical condition and thus RBMP status. For example, the Bonnyton Burn could be meandered near Freefield Cottages and near Bonnyton itself; The Kellock meandered near Upper Boddam and embankments set back and/ or removed at several locations. Additionally, leaky bunds, buffer strips and hedgerows at field boundaries would improve water quality as it reduces sediment in the watercourse.

NFM opportunities within the scheme extent are greatest at and west of Uryside. The fields west of Uryside Housing Estate and west of the B9001 bridge are ploughed agricultural land. The creation of leaky bunds, increasing buffer strip areas, ideally to 6 m in width and planting hedgerows along field boundaries would reduce sediment flow and excess runoff into the Urie and Lochter watercourses. Preventing grazing to the river edge will reduce soil compaction and stabilise the banks. Floodplain storage is suggested south of the Lochter Burn confluence in the form of a wetland which would provide educational benefits to the nearby school, as well as having ecological benefits in the form of increased biodiversity. Large debris dams are also suggested in this area to increase floodplain connectivity by encouraging out-of-bank flow and floodplain storage. Increasing the sinuosity of the watercourse may be possible near the B9001 bridge as well as the field drains. Outwith the scheme extent further upstream in the catchment, opportunities for runoff reduction arise, particularly within the Gadie Burn sub-catchment which contributes a high proportional flow and in the upper Urie catchment near Hill of Tillymorgan. Along contour shelter belts are suggested near Dummuies and on Gartly Moor. Floodplain storage near Old Rayne may be an option in the form of planting and an offline storage pond.

Key recommendations based on the site visits and for the River Urie catchment as a whole include:

- Increase floodplain woodland planting at various points along the watercourse including at the confluence with the Lochter Burn, west of Uryside housing estate (Figure 8-2, F) and at the confluence with River Don.
- Meander the river in the upper catchment as well as highly straightened tributaries to slow flow and increase storage in the upper catchment (Figure 8-2, B).
- Implement debris dams in the field drain near the B9001 bridge (Figure 8-2, D; E).
- Set back existing embankments to allow for increased floodplain and riparian planting (Figure 8-2, D).
- Create bunds to reduce sediment runoff from ploughed fields, including along the Kellock and the Burn of Durno (Figure 8-2, B).
- Catchment and along-contour woodland planting on Gartly moor, Hill of Tillymorgan and near Auchleven.
- Implement offline storage ponds along the Gadie west of Oyne and near Colpy.

Figure 8-3: Suggested NFM measures for the River Urie catchment



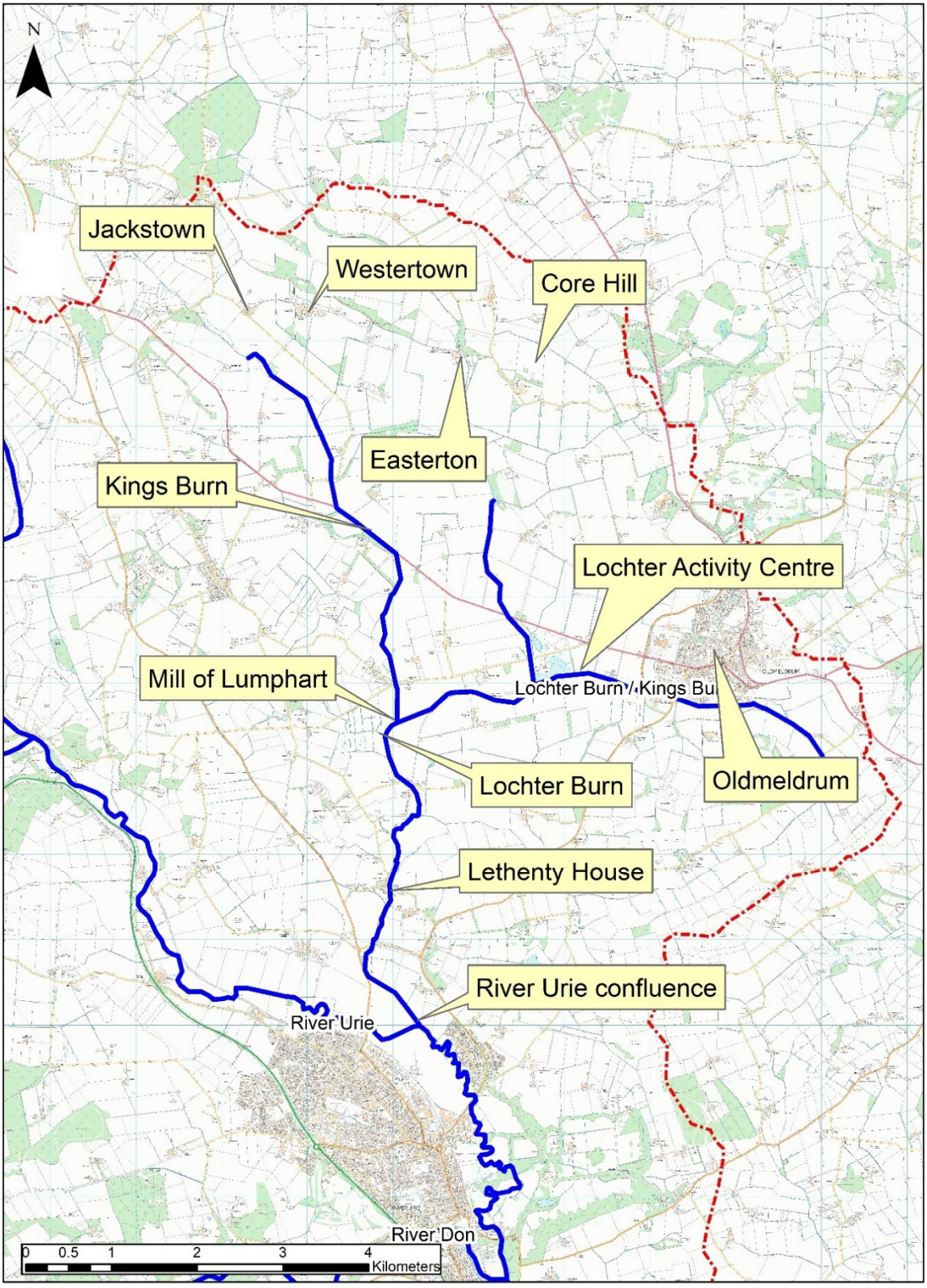
9 Lochter Burn

9.1 Catchment summary

The Lochter Burn is a sub-catchment of the River Urie and covers an area of approximately 61 km^2. The burn originates to the northwest of Old Meldrum flowing through areas of open agricultural land towards Inverurie where it discharges into the River Urie. Elevations are greatest in the north reaching approximately 245 mAOD at the top of Core Hill and decrease to circa 60 mAOD at Inverurie. Land use is predominantly agricultural with Oldmeldrum being the only urban extent and forest cover is also limited with the main area north and south of Oldmeldrum. The upper Lochter Burn is composed of the Kings Burn which originates near Jackstown and flows west past Oldmeldrum, and the main stem of the Lochter Burn which flows south from Westertown.

The Lochter Burn is classified in the RBMP as being in 'Moderate' physical condition due to the large number of physical constraints along its length. The SEPA NFM datasets indicate potential for floodplain storage along much of the watercourse however very limited runoff reduction potential is indicated within the catchment.

Figure 9-1: Lochter Burn key locations



9.2 NFM and RBMP Site Walkover Findings

The findings and recommendations based on the site visit are presented in the following sections. The site visit took place 18 April 2018 and weather conditions on the day of the walkover were bright and dry with sunny intervals. Conditions in the week prior to the visit had been mixed with periods of rain throughout the week.

The Lochter Burn was observed at the following locations: (i) the confluence with the River Urie at approximate OS NGR NJ 77300 23000, (ii) Lethenty House near Lethenty Mill at OS NGR NJ 77071 24937, (iii) near Mill of Lumphart north of the confluence with Kings Burn at OS NGR NJ 77050 27000 and (iv) the upper Lochter Burn beside the Lochter Activity Centre at OS NGR NJ 78775 27239. A map showing the location of photos taken in the Lochter catchment is included in Appendix B.4.

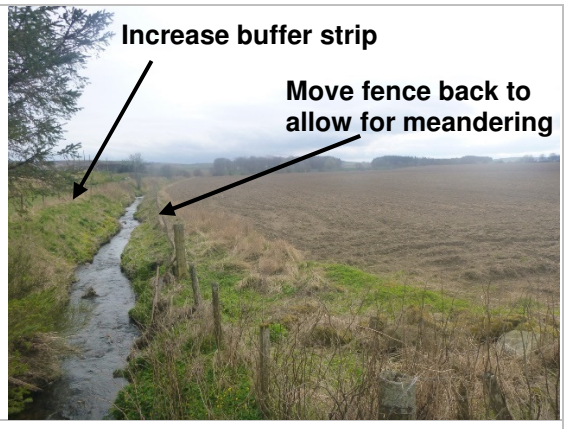
9.2.1 Lochter Burn upper catchment

This area is defined as the area north of the confluence with the Kings Burn. The predominant land use is arable land and pastures with very small areas of tree planting. The Lochter Burn tributary was accessed west of the Lochter Activity Centre. The channel is narrow and straightened but erosion is occurring to restore sinuosity (Figure 9-2, B). Arable land is present on both sides of the watercourse and it is suggested the buffer strips along both banks be increased to reduce pluvial and sediment runoff from the nearby fields. Upstream of the road bridge new trees have been planted along the left bank which will increase infiltration rates along the bank (Figure 9-2, A). On the right bank, there is a ploughed field which had been ploughed along the contour of the land, parallel to the watercourse. Continued good land management practices in this area will reduce sediment and runoff from fields into the watercourse. Downstream of the road bridge, the fence on the right bank could be set-back to allow re-meandering of the tributary into the uncultivated floodplain (Figure 9-2, B).

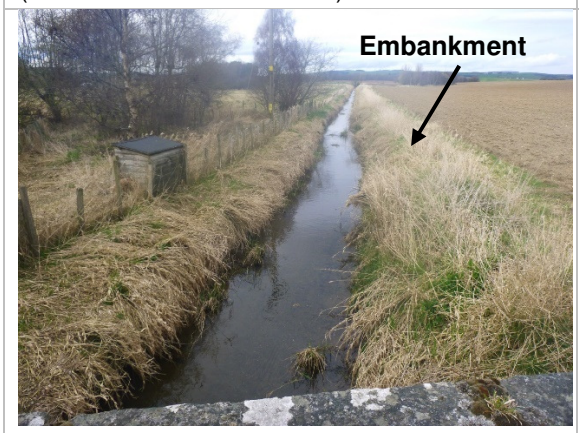
At the Mill of Lumphart the Lochter Burn is indicated in the pressures dataset as having undergone high impact realignment as well as being constrained by a right bank embankment which was clearly evident during the site visit (Figure 9-2, C). Between the Mill Lade channel and Lochter Burn an area of apparently uncultivated land (Figure 9-2, D) could be used for woodland planting, meandering of the straightened Lochter Burn, as well as in-channel debris dams within the watercourse to slow and reduce flows. Re-meandering of the watercourse would release channel capacity by 12%. The old mill lade runs through/ adjacent to the Mill of Lumphart properties restricting NFM and RBMP opportunities due to the channel being more constrained and culverted with several small bridges (Figure 9-2, G). Downstream of the minor road south of Mill of Lumphart there is clear evidence of sediment runoff and water flow paths from the field into the river and the right bank of the Lochter Burn is eroding (Figure 9-2, E). Creation of a leaky bund in the corner of the field would reduce the inflow of sediments and slow water runoff to the main channel. Fencing off the watercourse from livestock would reduce poaching and help with sediment management. Additionally, roadside runoff was evident (Figure 9-2, F) with road pollutants entering the watercourse at this location.

Figure 9-2: Upper Lochter Burn and Kings Burn characteristics and features

A: Looking upstream along the Lochter Burn tributary near the Activity Centre. Arable land with new planting visible on left bank. Limited riparian planting on both banks. Recommended increasing area of buffer strip. (OS NGR NJ 78595 27273)



B: Looking downstream along the tributary near Lochter Activity Centre. Increase buffer strip on both banks suggested and the fence on the right bank could be moved back to allow for re-meandering of the watercourse. (OS NGR NJ 78595 27273)



C: Looking upstream along the Lochter Burn from minor road by Mill of Lumphart. Highly straightened watercourse with left embankment. (OS NGR NJ 77027 26995)

D: Area of land between the Mill Lade and Lochter Burn east of Mill of Lumphart where meandering of the watercourse and woodland planting suggested. (OS NGR NJ 76962 27061)

E: Downstream of Mill of Lumphart - sediment and runoff flow path from field. (OS NGR NJ 77033 26981)

F: Roadside runoff flow path near Mill of Lumphart. (OS NGR NJ 77033 26981)

G: Constrained mill lade with high sediment input through the Mill of Lumphart gardens. (OS NGR NJ 76802 27141)

9.2.2 Lochter Burn lower catchment

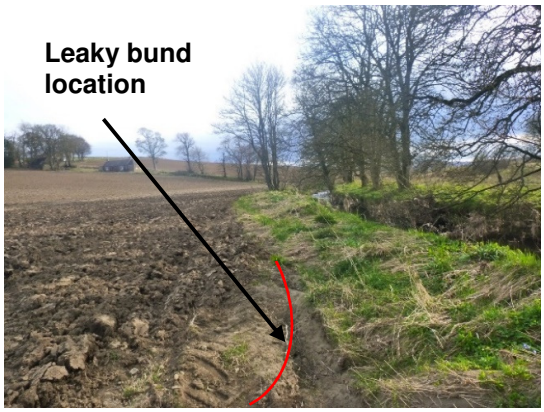
The lower catchment is defined as the area south of the Kings Burn confluence to the Lochter Burn confluence with the River Urie. There are several physical pressures along this stretch of the Lochter Burn, namely embankments, culverts and realignment. At Lethenty House the channel upstream and downstream was eroding despite the presence of embankments, some of which were not present on the SEPA dataset (Figure 9-3, A and B). Downstream of Lethenty House, there was evidence of runoff from road and field (Figure 9-3, C) on the left bank, which could be reduced by the creation of a leaky bund along with bank stabilisation. Ploughing along the contour of the field should be encouraged as this naturally manages sediment and water runoff from the fields, reducing the inflow to the watercourse. On the right bank there is a former railway embankment constraining the channels morphology. The watercourse is quite incised and so complete connection with the floodplain is unlikely (Figure 9-3, D). Upstream of the Lethenty area, active floodplain storage was visible in the form of a pond at the bottom of a field (Figure 9-3, E). By planting more trees and shrubs in the area, this would enhance infiltration rates in the soil, making the storage pond more effective.

At the confluence with the Urie, the Lochter Burn was highly straightened with no buffer strip on its left bank (Figure 9-3, F). Riparian planting and/or the creation of sediment traps would greatly reduce the sediment and water runoff from the field entering the watercourse. The Lochter Burn has potential to be re-meandered through the left bank and wetland encouraged to store runoff and out-of-bank fluvial flow, increasing channel capacity by 18%. These could co-exist with a set-back leaky bund on the left bank and floodplain planting to allow the floodplain to naturally flood in times of peak flows, whilst protecting the watercourse from sediment runoff from the land behind it. The buffer strip on the right bank could also be increased and floodplain woodland planted.

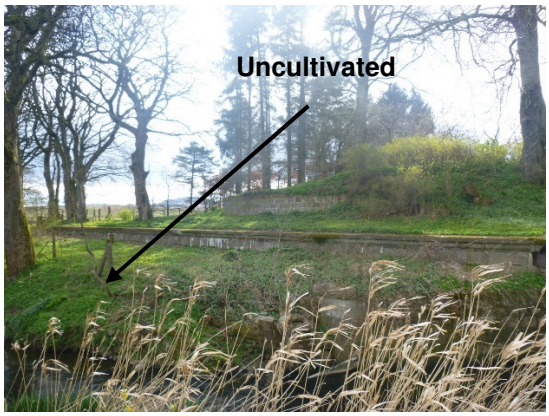
Figure 9-3: Lower Lochter Burn characteristics and features

A: Upstream from Lethenty House, showing grey bank embankments. (OS NGR NJ 76978 24680)

B: Downstream from Lethenty House, erosion visible on left bank near an outlet pipe. (OS NGR NJ 76958 24629)



C: Road and field runoff channels on left bank. Leaky bund would reduce inflow of sediments from field and road. Good agricultural management practices such as along contour ploughing would also reduce sediment inflow. (OS NGR NJ 76986 24530)



D: Former railway embankment on right bank constraining the burn which is moderately incised. (OS NGR NJ 76954 24557)

E: Pond on the left floodplain storing pluvial runoff from the cultivated land. (OS NGR NJ 77047 24812)

F: Looking upstream from the Lochter Burn confluence with the River Urie. Left bank could be used for re-meandering and floodplain planting. (OS NGR NJ 77314 22991)

9.3 Summary

The Lochter Burn is classified as being in 'Moderate' overall and 'Moderate' physical condition due to the abundance of physical pressures along its length. Significant morphological pressures indicated in the SEPA dataset include high impact realignment and embankments, both of which were visible along all sections of watercourse that were visited. The highly straightened channel near the confluence with the River Urie could be meandered into the left bank, improving the RBMP status of the watercourse. The embankment north of Lethenty House could be removed to make the watercourse less constrained and increase floodplain connection and could coincide with the re-meandering of the watercourse into the available floodplain on the left bank. At the Lochter Activity Centre, both the straightened main Lochter channel and tributary field drains, could be meandered south of the road on the right bank to improve channel morphology.

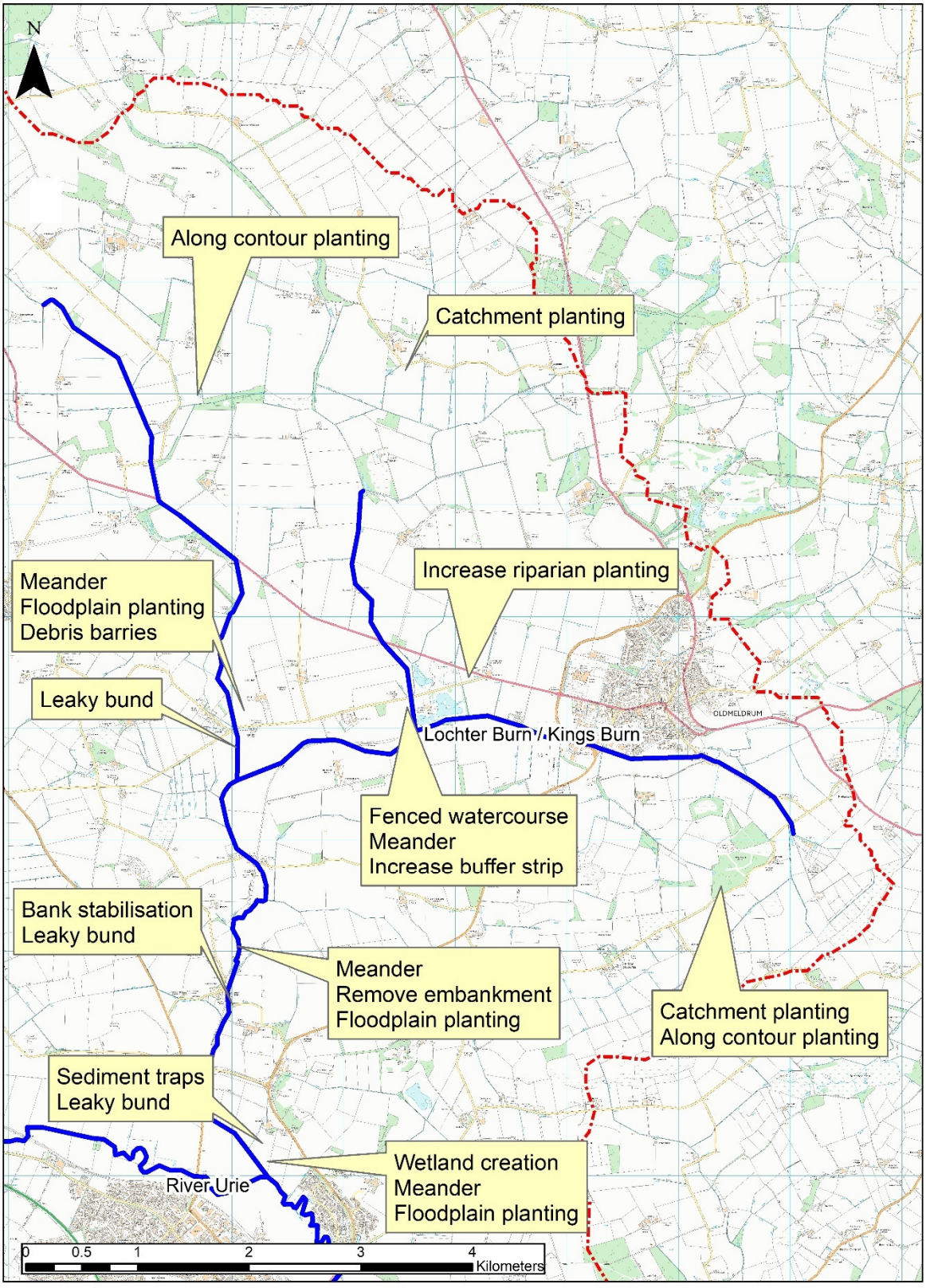
NFM opportunities within the lower catchment include riparian planting and meandering of the watercourse near the confluence with the Urie as well as increased floodplain planting. There is also potential for wetland creation. Further upstream the opportunity for leaky bunds and bank stabilisation arise near Lethenty House to manage sediment influx to the watercourse. Enhancement of the natural ponding that already exists in this area would help increase infiltration rates. Areas of uncultivated land, such as the area beside Mill of Lumphart, are suitable for meandering the watercourse through, along with floodplain planting and in-stream barriers to encourage out-of-bank flows and floodplain connection. Increased riparian planting near the Lochter Activity Centre would aid infiltration and limit runoff from the cultivated land reducing flood risk

further downstream. Management of sediment and runoff through leaky bunds was identified at several locations at field boundaries where runoff pathways were present. Land management practices such as ploughing fields along contours instead of cross contour are recommended to reduce sediment and pluvial runoff into the watercourse. Along contour planting is also suggested in the wider catchment near Oldmeldrum and to the north near Eastertown and Westertown. The hill south of Oldmeldrum is highlighted as having runoff reduction potential which could be achieved by woodland planting.

Key recommendations based on the site visit and for the Lochter Burn catchment as a whole include:

- Increase the area of riparian vegetation and buffer strips, ideally to 6 m in width[17], which could be implemented along the majority of the watercourse.
- Create leaky bunds at field edges to hold back and store sediment and water runoff to the channel (Figure 9-2, E, Figure 9-3, C and D).
- Meander the burn near the River Urie confluence; north of Lethenty House and beside Lochter Activity Centre (Figure 9-2, B, Figure 9-3, F).
- Woodland planting near the confluence with the River Urie, on the island between the two channels at Mill of Lumphart (Figure 9-2, D) and further into the upper catchment near Oldmeldrum.
- Along contour woodland planting near Westertown and Eastertown.
- Wetland creation near the confluence with the River Urie.
- In-stream debris barriers to encourage out-of-bank flow and floodplain connection.
- Good agricultural practices e.g. along contour ploughing.

Figure 9-4: Suggested NFM measures for the Lochter Burn catchment



10 Conclusions

10.1 NFM

There are abundant NFM opportunities across the River Don catchment and its tributaries. Within the scheme extent NFM opportunities along the River Don include floodplain storage opportunities upstream of the A96 road bridge including offline storage ponds and floodplain woodland planting. The River Urie within the scheme extent has greater NFM potential due to the banks being far less urbanised and constrained. Options include wetland creation, storage ponds, large debris dams and increased floodplain woodland planting, all of which would increase floodplain connection and storage upstream of Inverurie and Port Elphinstone.

Outwith the scheme extent, NFM within key sub-catchments will have the greatest impact on flood risk from the River Don and River Urie through reducing runoff and increasing tributary sub-catchment storage. The Ton Burn (a tributary of the Don) and the Lochter Burn (a tributary of the Urie) were visited as example catchments. NFM recommendations within these catchments following the site visits, and applicable to others in the wider Don catchment, include opportunities for increased riparian planting, buffer strips, re-meandering straightened reaches, in-stream debris barriers and improved land management practices such as along contour ploughing. The upper Don catchment to the west of Inverurie, where land use is less agricultural, is indicated in the SEPA NFM potential datasets to have the greatest potential for runoff reduction. It is suggested increased upland woodland planting, gully planting in the tributary watercourses and upland habitat restoration would improve infiltration and reduce runoff to the River Don.

10.2 RBMP

The watercourses within the River Don catchment range from 'Good' to 'Poor' overall condition based on SEPA's 2016 classifications. The River Don within the scheme extent is classified as being in 'Good' physical condition although a number of embankments constrain the watercourse and excessive bank erosion parallel to Port Elphinstone was observed. There are few options to further improve the physical condition of the watercourse within the scheme extent as it is assumed at this stage that the embankments cannot be removed as they are protecting key infrastructure for example the Scottish Water embankment. Although currently classified as being in 'Good' physical condition, if these embankments could be set-back this would maintain the 'Good' status of the Don in this reach as well as improving floodplain connectivity. Riparian planting through Inverurie to stabilise the highly eroding sections of bank, and particularly bank stabilisation measures to the heavily eroding bankside footpath along the Don opposite Port Elphinstone are recommended. The River Urie within the scheme extent is also classified as being in 'Good' physical condition and is far less constrained with a highly sinuous morphology. Any flood protection works should ensure this is maintained to prevent downgrading of the watercourse.

In contrast many of the Don/ Urie tributaries are classified as being in 'Moderate' physical condition including the Lochter Burn which flows into the Urie at Inverurie. These watercourses have undergone high impact realignment which is the primary reason for the downgrade, but many are also constrained by a series of embankments. The site visits indicated a number of Urie and Lochter embankments could be set back or removed with minimal impact on productive land. By setting back embankments channel capacity is released and floodplain connectivity is improved. In the Ton Burn catchment removal of embankments near Bilbo Bridge would link the watercourse with the wooded floodplain creating wet-woodland storage within the catchment upstream of the River Don confluence. Meandering of many of these tributary watercourses would have the greatest improvement in RBMP status with additional NFM benefits as increasing sinuosity slows flow towards the River Don. Potential for re-meandering was identified in several areas during the site visits for example along the Lochter Burn at Lethenty House.

10.3 Economic, social and environmental benefits and disbenefits

A high-level consideration of the economic, social and environmental benefits and disbenefits have been considered in the table below.

Table 10-1: Economic, social and environmental assessment

Criteria	River Don	River Urie	Lochter Burn	Ton Burn
Interventions	Floodplain planting, riparian planting, upland drain blocking, catchment planting, wetland/ washland creation.	Floodplain storage, catchment planting, riparian planting, meandering, leaky bunds, debris dams, wetland creation.	Riparian planting, catchment planting, floodplain storage, meandering, debris dams, leaky bunds, sediment traps.	Riparian planting, debris dams, leaky bunds, floodplain storage, wet woodland, catchment and gully planting.
Morphology (including WFD objectives)	Benefit: Stabilisation of banks and improved connection with floodplain. Disbenefit: Stabilisation in some areas may involve grey/ green bank protection which impacts RBMP status.	Benefit: Meandering of straightened reaches to slow flow; stabilisation of banks. Disbenefit: Potential loss of productive agricultural land.	Benefit: Meandering of straightened reaches to slow flow; stabilisation of banks. Disbenefit: Limited areas suitable for meandering.	Benefit: Stabilisation of banks through riparian planting. Disbenefit: Potential loss of productive agricultural land.
Water quality (including WFD objectives)	Benefit: Improve runoff water quality from farmland. Wetlands store nutrients improving soil. Disbenefit: Impact on productive agricultural land.	Benefit: Improve runoff water quality from farmland; Wetlands store nutrients improving soil. Disbenefit: Impact on productive agricultural land.	Benefit: Improve runoff water quality from farmland. Disbenefit: Impact on productive agricultural land.	Benefit: Improve runoff water quality from farmland. Disbenefit: Impact on productive agricultural land.
Natural processes (soils, geomorphology, geology)	Benefit: Reduce soil loss from upper catchment and farmland. Disbenefit: Potential loss of productive agricultural land.	Benefit: Natural geomorphic process restored; reduce soil loss. Disbenefit: Potential loss of productive agricultural land.	Benefit: Natural geomorphic process restored; reduce soil loss. Disbenefit: Potential loss of productive agricultural land.	Benefit: Reduction of soil loss throughout catchment. Disbenefit: Potential loss of productive agricultural land.
Climate change impact	Benefit: Improving floodplain connectivity allows the watercourse to better adapt to climate change; carbon sequestration benefits of wetlands and	Benefit: Improving floodplain connectivity allows the watercourse to better adapt to climate change; carbon sequestration benefits of wetlands and	Benefit: Improving floodplain connectivity allows the watercourse to better adapt to climate change; carbon sequestration benefits of woodland	Benefit: Improving floodplain connectivity allows the watercourse to better adapt to climate change; carbon sequestration benefits of wetlands and

	woodland planting. Disbenefit: Limited ability to future proof.	woodland. planting Disbenefit: Limited ability to future proof; woodland takes time to establish.	planting. Disbenefit: Limited ability to future proof; woodland takes time to establish.	woodland planting. Disbenefit: Limited ability to future proof; woodland takes time to establish.
Habitats and species	Benefit: Upland habitat restoration Disbenefit: Upper catchment is within the Cairngorm National Park, and there are many SSSIs present.	Benefit: Upland habitat restoration; wetland habitat creation; limit sedimentation of waters Disbenefit: Wetlands may impact grazing habitats.	Benefit: Upland habitat restoration; wetland creation; limit sedimentation of waters Disbenefit: Wetlands may impact grazing habitats.	Benefit: Upland habitat restoration; wet woodland creation; limit sedimentation of waters Disbenefit: Wetlands and woodlands may impact grazing habitat.
Recreation, tourism and education	Benefit: Visual improvements within the Cairngorm National park, Bennachie and near Craigievar Castle Disbenefit: Current access is limited and constrained by active agriculture.	Benefit: Educational opportunities - Uryside Primary School close by; catchment improvements along The Gordon Way Disbenefit: Current access is limited and constrained by active agriculture.	Benefit: Educational benefits - close to Uryside Primary School Disbenefit: Historical buildings/sites may limit NFM in some areas.	Benefit: General catchment improvements near Cluny Castle and local core plan paths Disbenefit: Current access is limited and constrained by active agriculture; Historical buildings/sites may limit NFM in some areas.
Landscape	Benefit: Rural catchment: improve visual impacts. Disbenefit: Some loss of productive land; elements limited by urban infrastructure.	Benefit: Rural catchment: improve visual impacts. Disbenefit: Some loss of productive land; public walking in areas of habitat restoration.	Benefit: Upper catchment visual improvements. Disbenefit: Some loss of productive land; public walking in areas of habitat restoration.	Benefit: Visual improvements to catchment. Disbenefit: Some loss of productive land.
Perceived multiple benefits	Improved morphology, runoff reduction, water quality improvement, positive impact on biodiversity.	Educational benefits, improved morphology, water quality improvements, new habitats.	Educational benefits, runoff reduction, improved water quality and morphology, new habitats, climate change benefits.	Improved catchment storage, runoff reduction, water quality improvements, habitat creation.

10.4 Recommendations and proposed mechanisms to develop NFM and RBMP

Without detailed modelling the interventions discussed within this report have not been quantified in terms of economic, social or environmental benefits. The way in which the council may wish to take the recommendations for environmental improvement forward will depend on a number of factors including the scale of opportunities and the funding available. We propose that the recommendations could be undertaken as follows:

- **Incorporation of NFM within a proposed FPS either as a separate option** (particularly for the River Urie upstream of Inverurie for example), or to supplement other more structural options to provide future adaptation against climate change. Additional modelling may help to quantify the benefits of such measures and facilitate inclusion within the wider appraisal studies.
- **Inclusion within any wider Aberdeenshire NFM funding mechanism to deliver NFM** and river restoration when specific funds become available on an ad-hoc basis (e.g. a pick list of measures to implement with land owner consent, but without further appraisal). This would lend itself to a separate catchment or sub-catchment study and would suit the recommendations made for the Lochter Burn as these would benefit both Inverurie and the wider risk communities including Oldmeldrum. This catchment is also ranked poorly under RBMP categories which could be tackled alongside the NFM options. Such studies may present many multiple benefits including environmental improvements by reviewing opportunities and success would rely on favourable landowners.
- **Delivery of measures via an FPS as a percentage uplift included within the total FPS costs set aside for local NFM and RBMP measures**. For example, 10% of the total FPS costs could be set aside for wider environmental improvements and NFM delivery. Once again, this could help to achieve the adaptation and wider environmental benefits without the need for wider appraisal and modelling. This would be suited to the Urie catchment, where a number of NFM measures have been recommend and would reduce flood risk within Inverurie. Early discussions with landowner and legal department may also be beneficial.

10.5 Future works

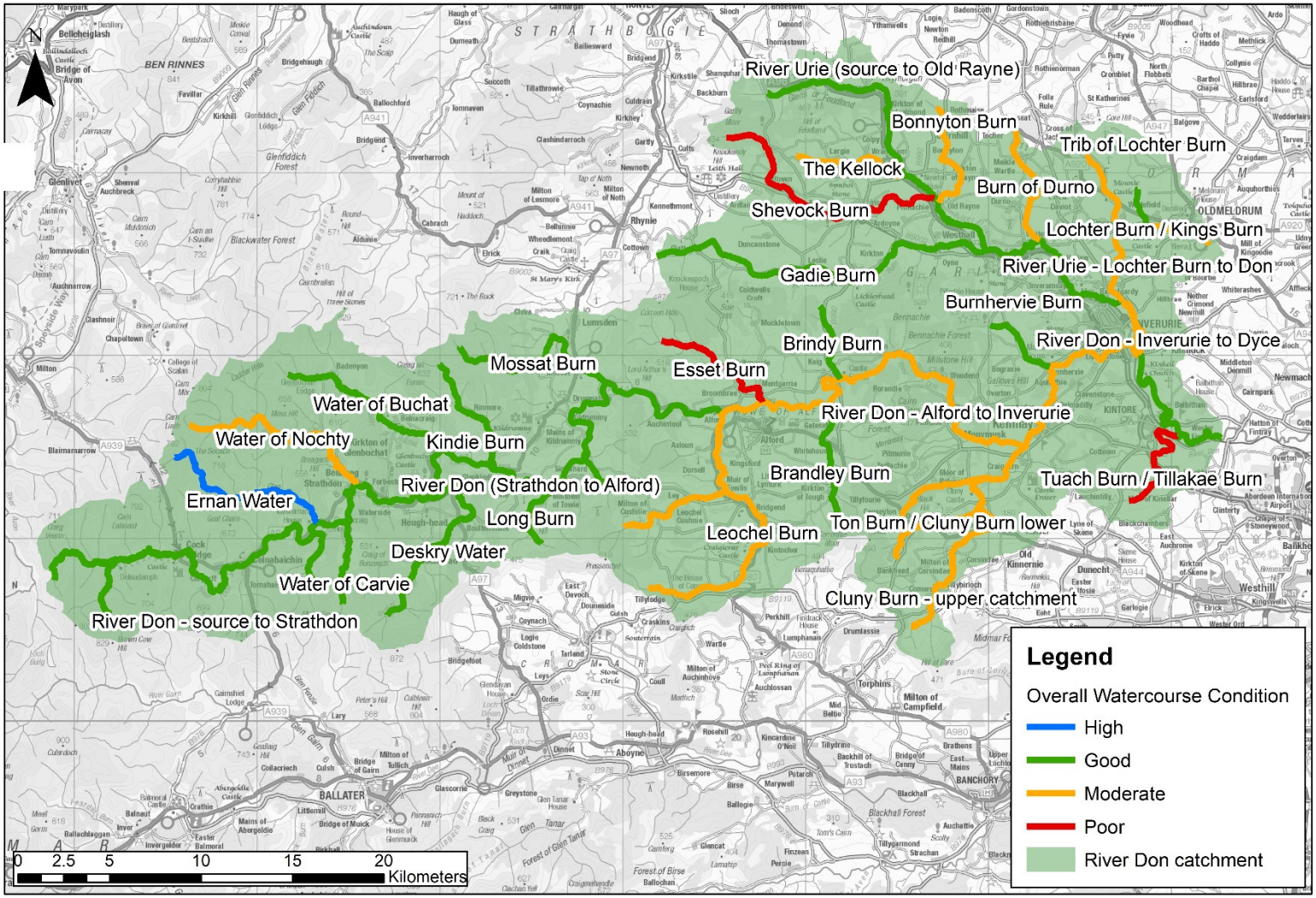
To enable future implementation of RBMP improvements and NFM interventions, the following may be required:

- Raise awareness
- Early landowner awareness and consultation
- Public awareness raising event
- Further investigation
- Ground investigations (including infiltration testing and contamination testing)
- Utilities search and review
- Detailed topographic survey
- Ecological survey
- Detailed hydraulic modelling
- Set up pre-works monitoring
- Outline design
- Early contractor involvement
- Public engagement
- Detailed design
- Produce bill of quantities and contract documents
- Tender for contractor
- Planning application including CAR licence
- Construction
- Post-works monitoring.

Appendices

A RBMP Watercourse Classifications

A.1 Map of overall waterbody conditions within the Don catchment



A.2 Table of current overall waterbody status

			Reason for Downgrade (2016)				
Watercourse	**RBMP ID**	**Present Overall Condition (2016)**	**Overall ecology**	**Physico-chem**	**Biological elements**	**Specific pollutants**	**Hydromorphology**
INVERURIE							
River Don - source to Strathdon	23295	Good	Good	High	Good	Pass	Good
Ernan Water	23577	High	High	High	High	High	High
Water of Carvie	23297	Good	Good	High	High	_	Good
River Don (Strathdon to Alford)	23294	Good	Good	High	High	Pass	Good
Deskry Water	23298	Good	Good	High	High	_	Good
Water of Nochty	23578	Moderate	Moderate	high	Moderate	_	Good
Water of Buchat	23299	Good	Good	High	High	_	Good
Kindie Burn	23300	Good	Good	High	High	_	Good
Long Burn	23301	Good	Good	High	High	_	Good
Loanend Burn	23302	Good	Good	High	High	_	Good
Mossat Burn	23303	Good	Good	High	High	_	Good
Leochel Burn	23304	Moderate	Moderate	High	Moderate		Good
River Don - Alford to Inverurie	23293	Moderate	Moderate	High	Moderate	Pass	Good
Esset Burn	23305	Poor	Poor	High	Poor	_	Good
Brindy Burn	23307	Good	Good	High	High	_	Good
Bandley Burn	23306	Good	Good	High	High	_	Good
Ton Burn / Cluny Burn lower	23310	Moderate	Moderate	High	Moderate	Pass	Moderate
Cluny Burn - upper catchment	23309	Moderate	Moderate	High	Moderate	_	Good
Burnhervie Burn	23308	Good	Good	High	High	_	Good
River Urie (source to Old Rayne)	23369	Good	Good	Good	Good	_	Good
The Kellock	23292	Moderate	Moderate	Good	Good	_	Moderate
River Urie (Old Rayne to Pitcaple)	23288	Good	Good	Good	Good	_	Good
River Urie (Pitcaple to Lochter Burn)	23283	Good	Good	Good	Good	Pass	Good
River Urie - Lochter Burn to Don	23282	Moderate	Moderate	Good	Moderate	Pass	Good
Bonnyton Burn	23289	Moderate	Moderate	_	High		Moderate
Shevock Burn	23291	Poor	Poor	Good	Poor		Good
Gadie Burn	23290	Good	Good	_	High		Good
Burn of Durno	23287	Moderate	Moderate	Good	Good	_	Moderate
Trib of Lochter Burn	23285	Good	Good	Good	Good	_	Good
Lochter Burn / Kings Burn	23284	Moderate	Moderate	Moderate	Good	Pass	Moderate
River Don - Inverurie to Dyce	23269	Good	Good	High	Good	Pass	Good
Tuach Burn / Tillakae Burn	23272	Poor	Poor	Good	Poor	_	Poor

A.3 Morphological Impact Assessment

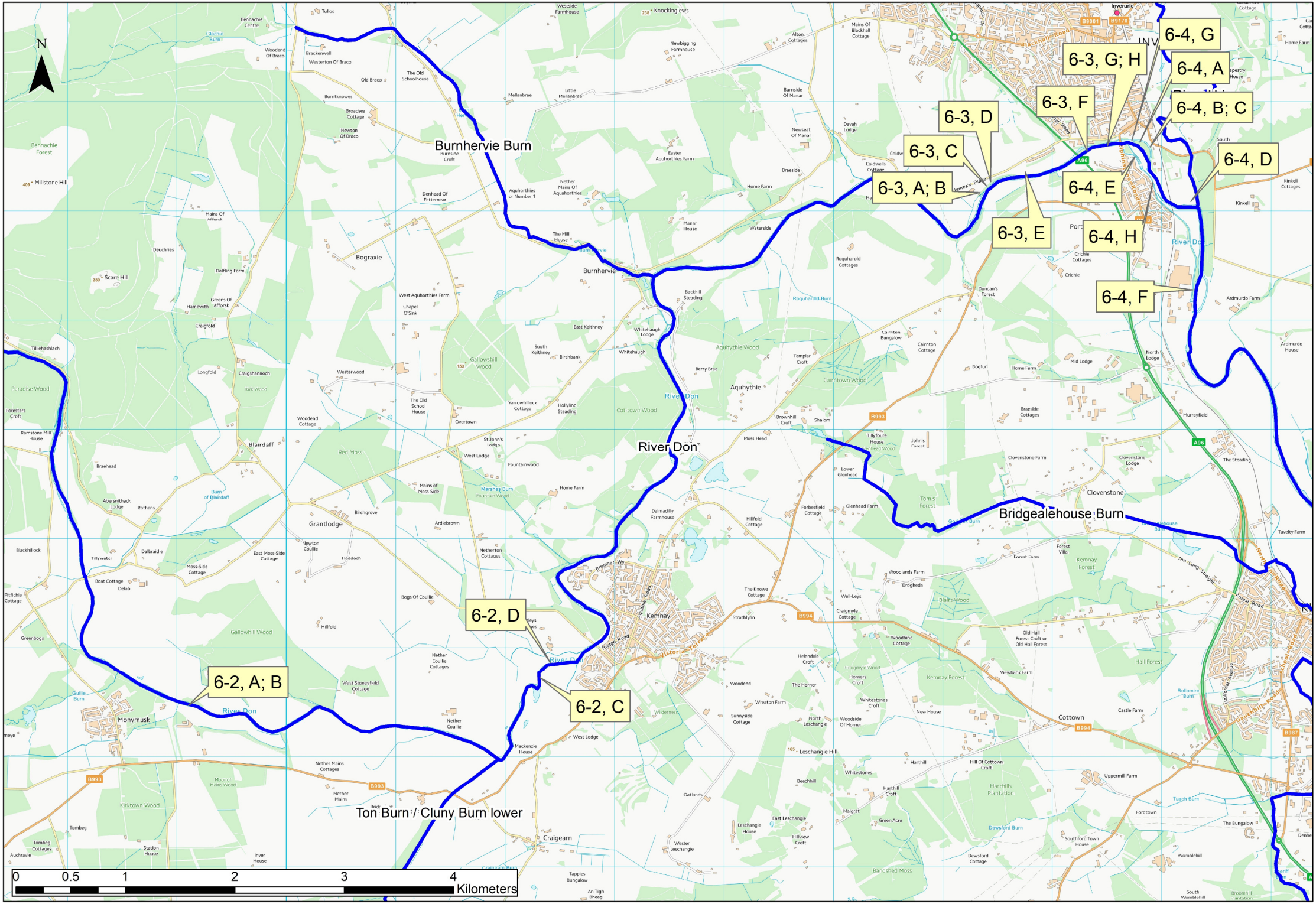
Pressure	Impoundments	Set Back Embankments	Embankments with no Reinforcements	Embankment Bank Reinforcement	Green Bank Reinforcement	Grey Bank Reinforcement	High Impact Realignment	Low Impact Realignment	Culverts
	Ton Burn / Cluny Burn lower								
Pressure Length (m)	20	119	8289	0	182	4959	13024	2057	187
Channel Capacity Used	0.16%	0.04%	33.33%	0.00%	2.63%	8.96%	104.74%	3.07%	1.67%
Bank Capacity Used	0.06%	0.00%	14.97%	0.00%	0.14%	8.96%	62.72%	1.88%	0.90%
Total Capacity Used	0.23%	0.04%	48.30%	0.00%	2.76%	17.91%	167.46%	4.95%	2.57%
	Cluny Burn - upper catchment								
Pressure Length (m)	0	0	1928	0	0	251	4365	1486	13
Channel Capacity Used	0.00%	0.00%	13.93%	0.00%	0.24%	0.81%	63.07%	3.99%	0.21%
Bank Capacity Used	0.00%	0.00%	6.26%	0.00%	0.00%	0.81%	37.77%	2.44%	0.11%
Total Capacity Used	0.00%	0.00%	20.19%	0.00%	0.24%	1.63%	100.84%	6.43%	0.32%
	Bonnyton Burn								
Pressure Length (m)	10	125	1459	0	0	198	7013	965	71

Channel Capacity Used	0.21%	0.10%	15.44%	0.00%	0.28%	0.94%	148.40%	3.79%	1.66%
Bank Capacity Used	0.08%	0.00%	6.93%	0.00%	0.00%	0.94%	88.86%	2.32%	0.90%
Total Capacity Used	0.30%	0.10%	22.37%	0.00%	0.28%	1.88%	237.26%	6.11%	2.56%
	Burn of Durno								
Pressure Length (m)	0	1150	453	0	108	90	6602	417	87
Channel Capacity Used	0.00%	1.10%	5.56%	0.00%	0.15%	0.50%	162.14%	1.90%	2.37%
Bank Capacity Used	0.00%	0.00%	2.50%	0.00%	0.25%	0.50%	97.09%	1.17%	1.28%
Total Capacity Used	0.00%	1.10%	8.06%	0.00%	0.39%	0.99%	259.23%	3.07%	3.65%
	Lochter Burn/ Kings Burn								
Pressure Length (m)	58	192	5713	0	307	572	17985	0	320
Channel Capacity Used	0.55%	0.07%	27.03%	0.00%	0.36%	1.22%	170.20%	0.00%	3.35%
Bank Capacity Used	0.22%	0.00%	12.14%	0.00%	0.27%	1.22%	101.92%	0.00%	1.81%

Total Capacity Used	0.77%	0.07%	39.17%	0.00%	0.63%	2.43%	272.11%	0.00%	5.17%
	The Kellock								
Pressure Length (m)	25	0	865	0	0	222	6399	499	50
Channel Capacity Used	0.25%	0.00%	4.36%	0.00%	0.27%	0.52%	160.91%	1.65%	0.61%
Bank Capacity Used	0.12%	0.00%	2.47%	0.00%	0.00%	0.64%	96.36%	0.98%	0.38%
Total Capacity Used	0.38%	0.00%	6.84%	0.00%	0.27%	1.15%	257.27%	2.63%	0.99%

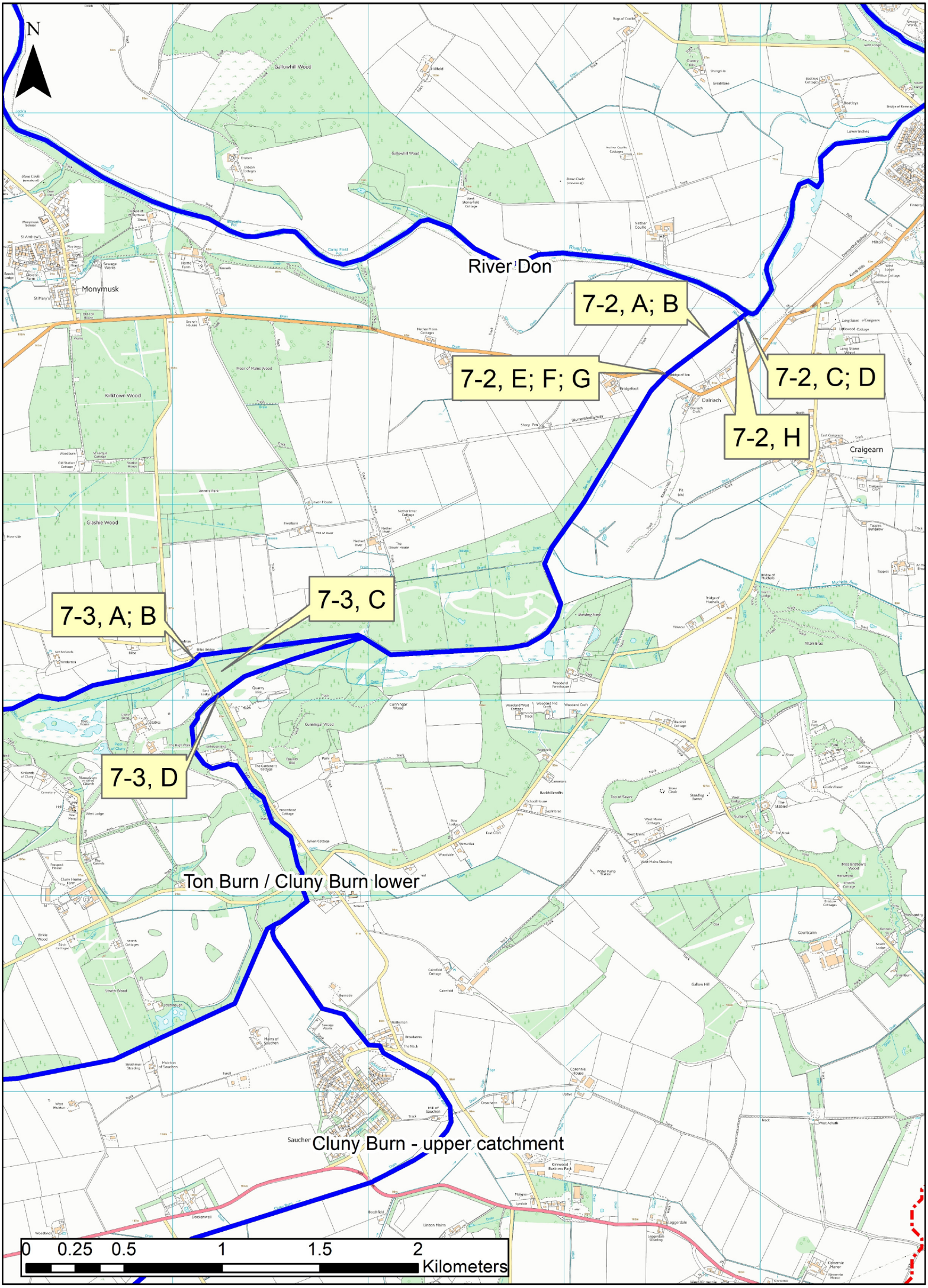
B Site Visit Photo Maps

B.1 River Don



0 0.5 1 2 3 4 Kilometers

B.2 Ton Burn



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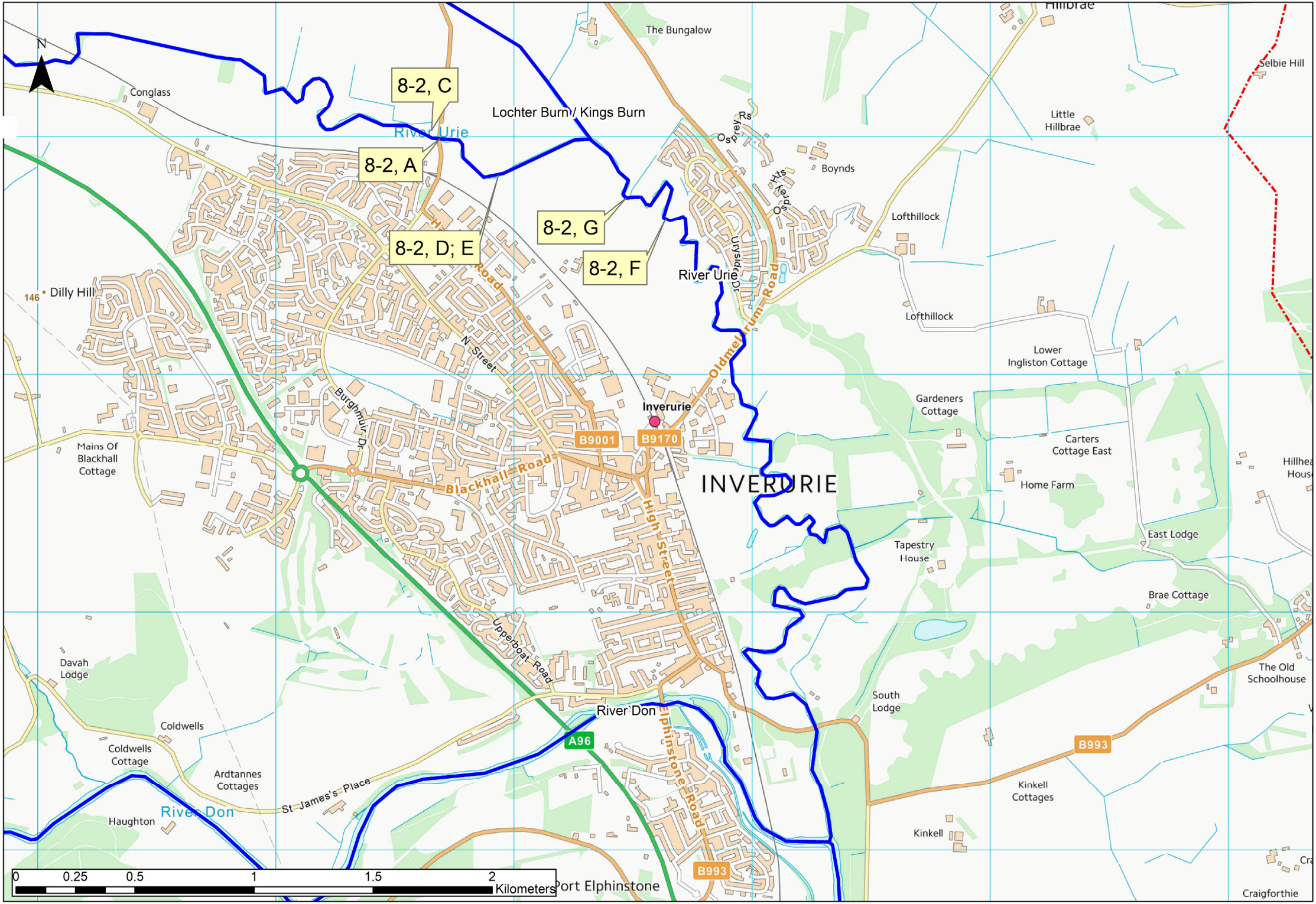
Kilometers

B.3 River Urie



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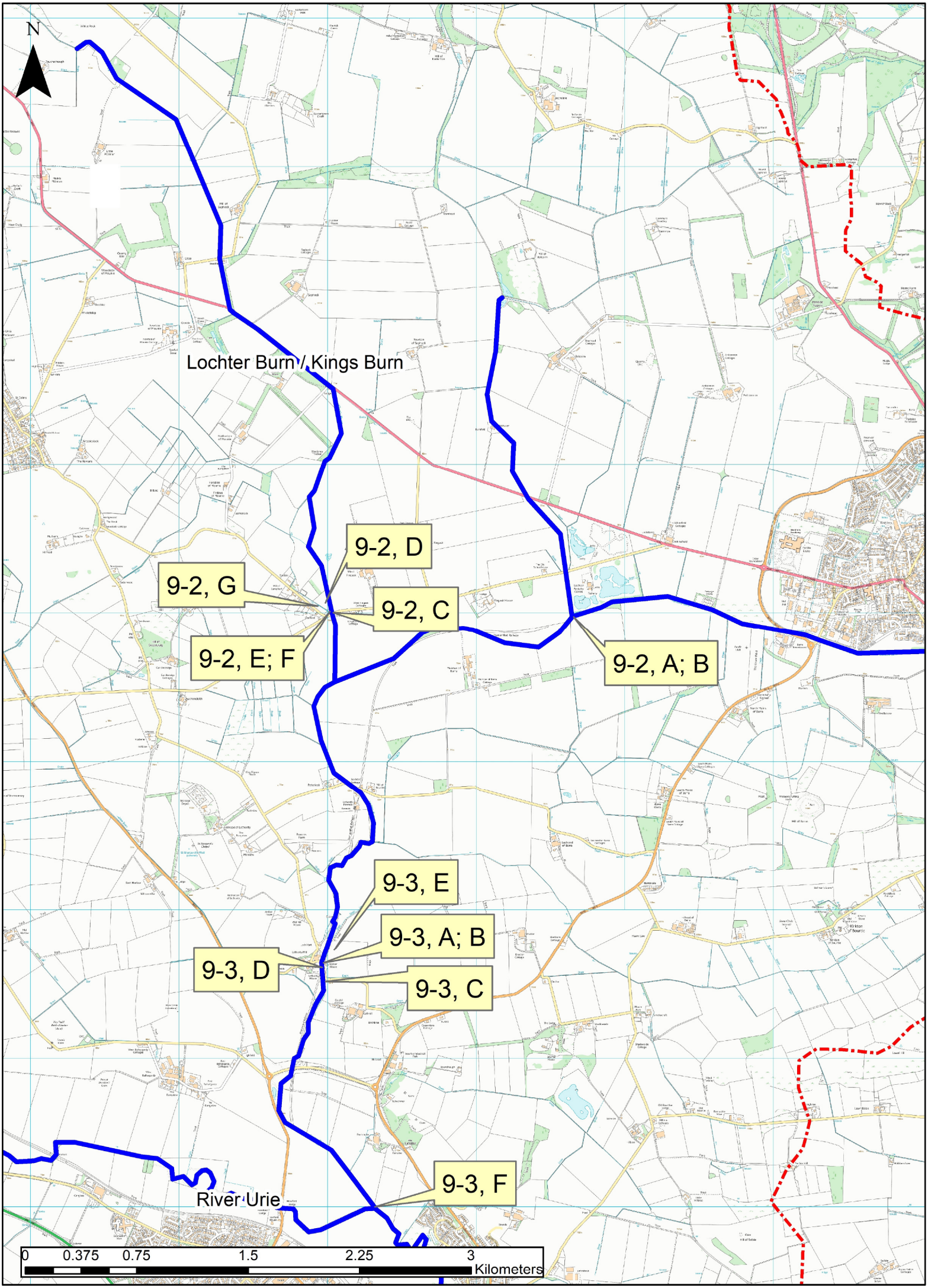
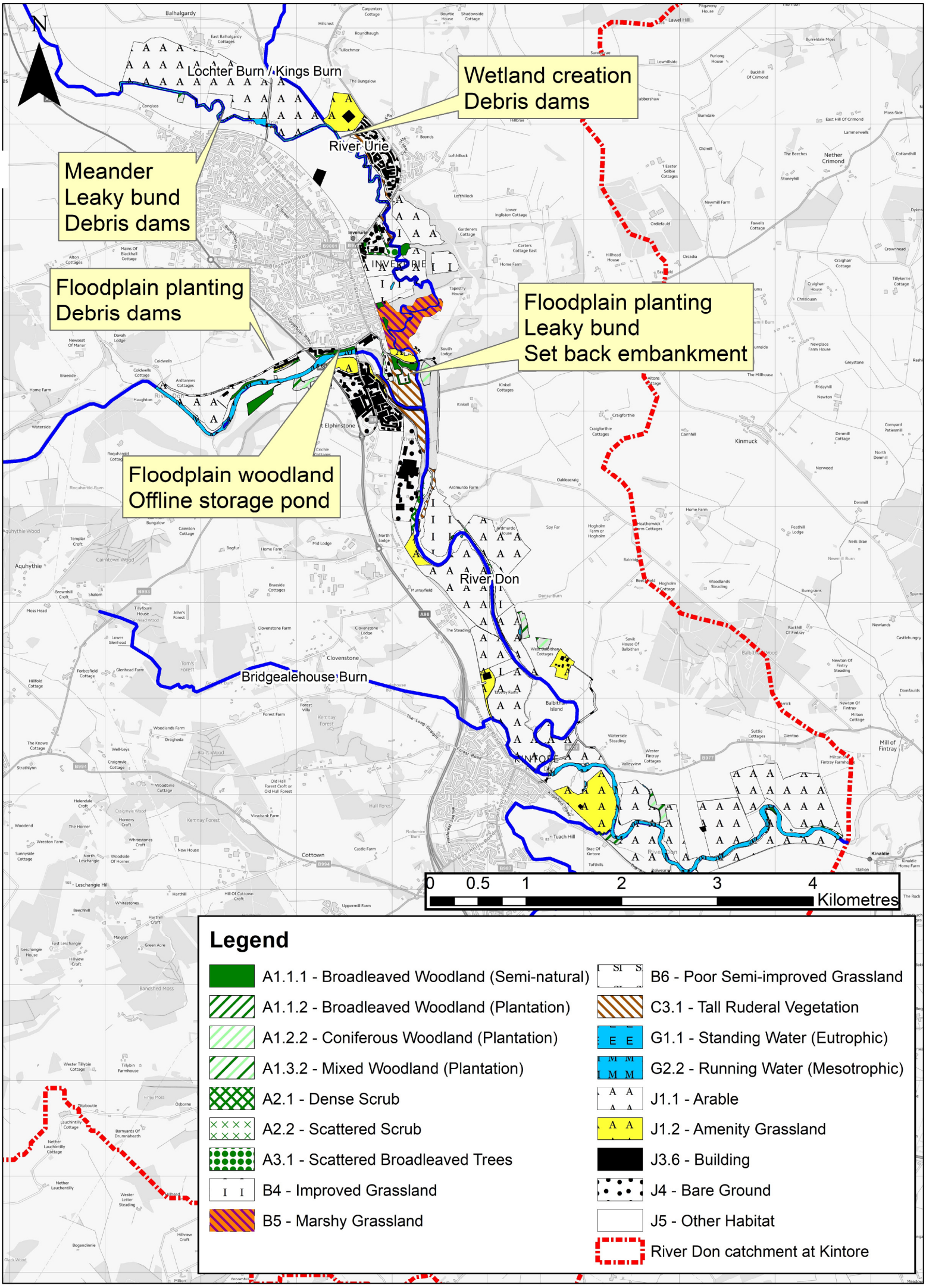
B.4 Lochter Burn



0 0.25 0.5 1 1.5 2 Kilometers

C Ecology within the Scheme Extent



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