River Spey Abstractions 2021
Water Resource Management Now and Implications for the Future

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EXECUTIVE SUMMARY

In 2008 the Spey Fishery Board published an independent report investigating the water abstractions in the River Spey catchment. It provided a valuable insight into the demand on water resources at that time, enabling a much more informed position to be adopted in decision making relating to the effective management of the fisheries and fish populations of the Spey.

This update to the 2008 report reviews the changes in demand on the water resources of the Spey. The changes in data availability are considered along with the most recently published future climatic trend forecasts to identify priority actions to help manage these challenges. The key findings are:

- A total of 51 sites have active water abstractions licenced by SEPA, with the two largest abstractions being for hydro-electric power generation that account for 91% of the entire consented abstraction volume on the Spey - the Fort William Aluminium Smelter and the Scottish and Southern Energy Tummel Valley hydro scheme.
- Actual annual abstractions vary between 5% to nearly 80% of the consented amount and are typically only 25% to 30% of the consented amount. Some consents transferred from historic abstraction rights are in excess of the available resources when assessed on an annual basis.
- The two main hydro schemes abstract and transfer water out of the Spey catchment from an area draining 390 km^2, or 13% of the catchment to Spey Bay. This reduces the natural mean flow in the Spey by up to 66% below the abstractions, by 39% – 61% at Kinrara, and by 17% - 24% at Boat o' Brig. This reduction in natural flow reduces the resilience of the river during low flow conditions.
- Analysis of the available water resources and the amount of water abstracted during a wetter year (2015) compared to a drier year (2018), shows that abstraction volumes increase when more water is available, with 20% more water being abstracted in 2015 compared to 2018.
- Opportunities to improve the amount of water released back into the Spey in the upper catchment will provide benefits that will extend downstream through the entire river. For example, if the mean annual flow rate of 0.302 m^3/s could be reinstated to the Allt an t-Sluie at Dalwhinnie, this would represent a similar flow to that abstracted by Scottish Water at the Dipple wellfield (0.313 m^3/s).
- The latest regional future climate projections indicate that annual average rainfall up to 2100 is not expected to change significantly, however changes to seasonal patterns are likely to result in wetter winters and autumns, and drier summers. The frequency of extreme events leading to floods and droughts are also expected to increase. There is a projected 20-40% regional decrease in winter mean snowfall by 2080, which will reduce meltwater flow through the spring.
- The upper Spey valley has extensive sand and gravel deposits that store less water than would naturally be expected due to the lower river levels where flows have been reduced by abstraction. This is often compounded by historic land management to limit flooding of agricultural land, which also limits the opportunity to recharge these groundwater resources from ponding floodwater.
- Initiatives to reduce the loss of water transferred out of the catchment along with the promotion of land management measures that can re-connect the rivers with their natural floodplains and allow floodwater to drain naturally back into the underlying sands and gravels can help improve the resilience of the river system to these low flow events, which are likely to become more common.
- The management of abstractions remains a key objective within the most recent 2016 Spey Catchment Management Plan and was a recommendation from the 2008 Abstraction Report. Although the available data on abstractions and river flows have become more accessible and general stakeholder communications have improved, there remains a lack of a holistic river basin approach by any agency to actively manage water abstractions and water resources in the Spey.

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1 INTRODUCTION

1.1 Terms of Reference

EnviroCentre Ltd. were commissioned by the Spey Fishery Board to undertake an update to the independent review of water abstractions from the River Spey catchment undertaken in 2008.

1.2 Scope of Report

It is over 11 years since the work contained in the 2008 abstractions report was produced. In this time there have been changes to the amount and distribution of abstractions within the catchment of the River Spey, an increased baseline dataset of river flows has been recorded and updates to the government's future climate change predictions have been published.

The scope of the update will be to examine how these changes may inform the understanding of the water resources within the River Spey from the perspective of the Spey Fishery Board. It will also review the progress in catchment management terms since the initial report in 2008 and consider what forward priorities are likely to be. The main focus is summarised as follows:

- Update and review the catchment abstraction information, flow data analysis and catchment water balance;
- Review the impact of abstractions at present and consider the implications of the most recent climate change;
- Consider the potential effect of future potential changes to the abstraction regime on the present river flow regime;
- Review how the above may alter the river conditions over time, in particular on salmon and freshwater pearl mussels.
- Gauge progress in catchment management terms since the previous report and consider forward recommendations to improve the management of the river, now and in the future.

1.3 Report Usage

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2 OVERVIEW OF 2008 SPEY ABSTRACTION REPORT

In 2007 the Spey Fishery Board was being consulted on various proposals for changes to existing water abstractions and creation of new water abstractions within the Spey. Through this, they had identified that there was a lack of a holistic river basin approach by any agency to assess the water abstractions and their potential impact on the fisheries within the Spey. As a consequence of this, the Spey Fishery Board commissioned EnviroCentre to undertake an independent review of the water abstractions from the River Spey catchment area and assess the impact of this in relation to their role in effectively managing the fisheries and fish populations.

The study was structured to initially examine and review the demand on water resources of the River Spey, and to detail the pressures on the Spey. A water balance for the River Spey was developed to characterise the magnitude of existing water abstractions and inter-basin transfers. The effect of these on the habitat of the river was considered and critical flow periods examined. It concluded with a series of recommendations for a suitable way forward to improve and better inform future decisions.

The main findings and outputs of the report produced in 2008 were as follows:

- There has historically been a lack of joined up thinking in the management of water resources on a holistic catchment wide basis. Such an assessment was one of the recommendations made in the 2003 Spey Catchment Management Plan.

- Water abstraction and transfer rights are set out in legislation, either through individual Acts or under the Controlled Activities Regulations.

- The major water abstractions within the Spey (distilleries, public water supply and fisheries) amount to a water demand of 2% of the mean annual flow flowing out into Spey Bay. The local impacts can be important, especially public water supply requirements during periods of low flows.

- Water is abstracted and transferred out of the catchment to hydro power schemes via Loch Laggan to the west and Loch Ericht to the south. There are no clear records detailing the amount of water transferred, however it has been estimated that it is between 19-49% of the mean annual flow at Kinrara or between 9-19% of the mean annual flow to Spey Bay.

- The effect of these abstractions and transfers on the River Spey and its tributaries is a reduced flow regime. Downstream of transfer points in the upper catchment where no compensation flows are released, channels can frequently run dry. Compensation flows where provided tend to produce a very constant flow regime which removes the majority of the high and low flow variation, changing what would naturally be a very dynamic habitat.

- Two proposals were reviewed that focused on increasing the demand on water resources before examining what improvements can be achieved using the existing resources. Measures should be put in place to maximise the management of these existing resources before increasing demand.

- The effect of the abstractions and transfers are most sensitive during low flows when the wetted habitat is reduced. In these conditions water abstractions that have little flexibility in their operational demand become the most critical activities, which include public water supplies.

- There is a clear opportunity provided by the Water Framework Directive and other legislation to improve the management of the existing regulated flows. Existing agreements should be reviewed to provide a new, more varied flow regime to encourage increased wetted habitat and improve the river habitat without altering the amount of water transferred.

3 RIVER SPEY ABSTRACTIONS AND WATER TRANSFERS

3.1 The River Spey as a Water Resource

The water resources of the River Spey are a highly valued resource. It is of importance for sustaining the natural resources, for which the River Spey has been designated a Special Area of Conservation (SAC), as well as being an important resource for providing a public water supply, power generation, agriculture and local industry especially the numerous distilleries. The benefits of these resources extend outwith the River Spey catchment boundary, with water transferred out of the natural river basin for public water supply, power generation and whisky production.

The importance of the water resources are core to the objectives of the Spey Catchment Management Plan, which was initially developed in 2003 and recently updated in 2016. The need to better understand and deal with the issues associated with river flows and abstraction regimes within the catchment is a key objective with the plan, while other objectives rely on this understanding to be successfully delivered.

The river flow regime is critical to the sustaining the surrounding morphology, ecology and biodiversity as highlighted in Figure 3.1.

- Flow regime is important in maintaining physical habitat in rivers.
- The occurrence of less frequent channel-forming flows (bankfull flow, flushing flows and floodplain flows) are important in natural river systems.
- Suitable hydraulic conditions that sustain aquatic life is of more interest than discharge alone.
- Reduced flows have indirect effects on aquatic life such as plant growth, temperature changes, water quality changes and effects on sediment erosion and deposition.
- Reduced depth and wetted area will lower the availability of suitable habitat, which may be severe for fish but less severe for invertebrates, provided that adverse conditions are not prolonged.
- Good diversity can still be found at low flows, provided that habitat heterogeneity is maintained.
- Atlantic salmon require specific flows at different stages of their life cycle: spawning and nursery areas need to be accessible, adequate holding areas are required to provide shelter for fish, and summer flows must be sufficient to maintain adequate depth and velocity in juvenile rearing areas.
- Sufficient flow must be provided for salmon to negotiate obstacles.
- The effect of flow on instream biota is important but may be masked by environmental factors.
- The crucial factor in the maintenance of stream integrity is the timing and nature of disturbance.

Figure 3.1: Summary of key ecological conditions driven by river flow regime

Water resources can be quantified in different ways depending upon the volumes or flow rates of interest, with some typical terms being cubic metres per second [m^3/s], mega litres per day [Ml/d], or litres per second [l/s]. For the purposes of this report, water resources will be expressed in terms of a flow rate in cubic metres per second, or cumecs.

3.2 Regulation of Abstractions

All existing and new abstractions are now regulated in accordance with The Water Environment Controlled Activities (Scotland) Regulations 2011 (as amended), which is commonly referred to as Controlled Activities Regulations (CAR). These regulations are implemented by the Scottish Environment Protection Agency (SEPA) and any abstractions greater than 50 m^3/day, (0.0006 m^3/s) require a licence to operate.

The present Controlled Activities Regulations first came into place in April 2006, before being subsequently updated in 2011, and amended in 2013 and 2017. These regulations provided the first framework for consistently consenting all abstractions from the water environment. Prior to this, formal consent to abstract was limited to large scale abstractions, which took the form of Acts of Parliament for the major hydro power schemes and Water Orders for large public water supplies, with the majority of abstractions being subject to local landowner agreements.

At the time of the 2008 Abstraction Report, the Controlled Activities Regulations were in the early stages of implementation, with existing consents being transposed into the required licences. The hydro power schemes did not have licences in place and many of the other abstractions were in the process of quantifying the amount of water they were abstracting.

Where existing abstractions have been identified as having adverse impacts, there is a programme of measures agreed within River Basin Management cycles to improve these conditions. Any new abstractions will have licence conditions agreed at the outset to protect the water environment.

3.3 Consented Abstractions

The consented abstractions from the Spey catchment active in 2018 have been provided by SEPA. These have been reviewed and compared to the previous information available on abstractions from 2008. The consented abstractions have been grouped into main types of use as listed below and detailed in Table 3.1 along with a summary of the main associated abstractions:

- Hydro Power;
- Distillery;
- Fisheries;
- Public Water Supply; and
- Agriculture.

A summary of the consented water abstractions in 2018 is presented in Table 3.2. This identifies a total of 51 sites with registered abstractions and a total of 74 individual abstraction locations within these sites. Abstraction consent is typically expressed as an annual volume of water, which can then be averaged out through the year as an annualised flow. The abstraction consent is shown as the annualised flow in Table 3.2. The largest consented abstractions are for hydro power, which although only have three sites, account for 92% of all the consented abstractions from the Spey catchment and are located in the upper Spey catchment. Distilleries are the next largest abstractor, accounting for 6% of the total consented resource, although with 33 sites, they represent 65% of all licenced abstraction sites, which tend to be more concentrated in the lower Spey catchment. The remaining abstractors comprising of fisheries, public water supply and agriculture, collectively account for the remaining 2% of consented abstractions within the Spey catchment.

In addition to these larger licenced abstractions, there will be smaller abstraction within the catchment, such as those for private water supplies which fall below the CAR licensing threshold (<50 m^3/day), although these will generally return a high proportion of the water back to the river following treatment.

Table 3.1: Main types of consented abstractions in the Spey

Abstraction Use	Description
Hydro Power	The headwaters in the west of the catchment are utilised for hydro-electric power generation by the Fort William Aluminium Smelter and the Scottish and Southern Energy (SSE) Tummel Valley hydro scheme. These two large hydro schemes had abstractions consented by Acts of Parliament, that have since been transposed into CAR licences. The flows abstracted from these two schemes are effectively water transfers out of the catchment as the water does not get returned to the Spey and is lost as a resource to the river. More recently another mini-hydro scheme has also been developed and the abstraction licensed. The flows from such mini-hydro schemes are returned to the river with no net loss, although there are depleted flow reaches between the abstraction and return points.
Distillery	Distilleries are major abstractors of water, both for the manufacture of whisky and to use as cooling water. The distilleries are generally concentrated in the Lower Spey and have recently come under regulation for their abstractions through the CAR licensing regime. The water used for cooling purposes will largely be returned to the Spey, reducing the net loss of water to the river, although there may be thermal impacts from the returning water temperature.
Fisheries	The Rothiemurchus Fisheries and Glenmore Hatchery have abstraction licences. Although these abstractions are relatively high, the water is generally all returned to the river, reducing any significant net loss in the quantity of water to the Spey, although not necessarily the quality.
Public Water Supply	Scottish Water provides a public water supply to serve the local population for domestic and commercial use. The population centres are served by six main supplies at Fochabers (Dipple), Aviemore, Tomnavoulin, Blairnamarrow, Laggan and Dalwhinnie. The largest single supply is the wellfield at Dipple, near Fochabers, which is largely transferred out of the catchment for use elsewhere. The other supplies will eventually return water to the Spey after passing through wastewater treatment works, reducing the net loss of water to the river.
Agriculture	Abstractions for agriculture tend to be in the lower reaches of the catchment and overall have a relatively low demand, although the timing of that demand can also coincide with when resources may be most constrained.

Table 3.2: Consented abstractions in the Spey (2018)

Type	Sites	Locations	Abstraction Consent (m^3/s)	% of Total Abstraction Consent
Hydro Power	3	4	46.799	92%
Distillery	33	51	2.969	6%
Fisheries	2	2	0.738	1%
Public Water Supply	6	6	0.409	1%
Agriculture	7	11	0.003	0%
Total	**51**	**74**	**50.918**	**100%**

The majority of the abstraction sites result in a proportion of flow being lost to the Spey, however a proportion of the abstracted flow will be returned to the Spey, and associated impacts will include reaches that have depleted flows or local alterations to water quality and/or temperature. The proportion of flow returned will depend on the use of the abstracted flow.

There are three main sites that involve abstraction where the entire abstraction volume is then transferred out of the Spey catchment and entirely lost as a resource to the river. These comprise of two hydro power schemes abstracting direct from rivers for the Fort William Aluminium Smelter and the Scottish and Southern Energy Tummel Valley hydro scheme, with the third being the public water supply abstracted from the riverbank sands and gravels at the Dipple wellfield. The two hydro schemes represent 91% of the entire consented abstraction from the Spey, and 99% of the consented abstraction transferred out of the catchment. These water transfer abstractions have a significant impact on the local water resources available as none of the water is returned to the Spey.

The details of the abstractions that part-return a proportion of flows to the Spey and those that transfer water entirely out of the Spey are provided in Table 3.3.

Table 3.3: Details of consented abstractions retained in the Spey and transferred out (2018)

Type	Sites	Locations	Abstraction Consent (m^3/s)	% of Total Abstraction Consent
Abstraction Part-Returned to the Spey				
Hydro Power	1	1	0.650	15%
Distillery	33	51	2.969	67%
Fisheries	2	2	0.738	16%
Public Water Supply	5	5	0.096	2%
Agriculture	7	11	0.003	0%
Total	**48**	**70**	**4.456**	**100%**
Water Transferred Out of the Spey				
Hydro Power	2	3	46.149	99%
Public Water Supply	1	1	0.313	1%
Total	**3**	**4**	**46.462**	**100%**

A comparison of the consented abstractions in 2018 is made with those consented in 2008 as shown in Table 3.4. The main changes have been the inclusion of the large hydro power schemes within the CAR licensing regime, along with an increase in the number of consented abstractions for distilleries which has doubled the overall distillery abstraction volumes. The inclusion of the hydro power schemes do not represent new abstraction activities, but a transfer of the abstraction consenting regime from a site specific Act of Parliament to the CAR regime.

The range in abstraction volumes across the 2018 consented sites is provided in Table 3.5 and is compared to the consents in place in 2008. This shows an increase at the larger end of consents, again reflecting the inclusion of the larger hydro power schemes, although there is a trend for a general increase across all bandings shown.

The top ten largest abstraction consents are provided in Table 3.6, which includes hydro power, distilleries, fisheries and public water supply. The abstractions that involve water transfers out of the catchment are present within this list and represent the top three largest consented abstractions.

Table 3.4: Changes in CAR consented abstractions in the Spey between 2008 and 2018

Type	2008 Sites	2018 Sites	Change	2008 Consent (m^3/s)	2018 Consent (m^3/s)	Change (m^3/s)
Hydro Power	0	3	+3	0.000	46.799	+46.799
Distillery	24	33	+9	1.504	2.969	+1.465
Fisheries	2	2	0	0.703	0.738	+0.035
Public Water Supply	6	6	0	0.399	0.409	0.010
Agriculture	11	7	-4	0.097	0.003	-0.094
Grand Total	**43**	**51**	**+8**	**2.703**	**50.918**	**+48.215**
Abstraction Part-Returned to the Spey	42	48	+6	2.390	4.456	+2.066
Water Transferred Out of the Spey	1	3	+2	0.313	46.462	+46.149

Table 3.5: Comparison in the range of licensed abstractions in the Spey between 2008 and 2018

Abstraction Range (m^3/s)	Number of Licensed Abstractions		
	2008	2018	
		Sites	Locations
>0.5	1	5	6
0.1-0.5	4	5	4
0.05-0.1	8	9	10
0.025-0.05	10	12	14
0.005-0.025	11	7	18
<0.005	9	13	22
Total	**43**	**51**	**74**

Table 3.6: Largest consented water abstractions in the Spey (2018)

Abstraction	Consent (m^3/s)
Lochaber Smelter - Spey Dam Tunnel	21.991
Tummel Hydro, Cuaich Power Station, Abstraction from Loch Cuaich	12.700
Lochaber Smelter, Mashie and Pattack Division	11.458
Wm Grant & Sons Ltd, Balvenie Distillery, Abstraction from River Fiddich	1.111
Rothiemurchus Fisheries, Aviemore, Abstraction from River Druie	0.729
Kingussie Micro Hydro, Abstraction from Gynack Burn	0.650
Dipple Wellfield, Fochabers	0.313
Macallan Distillery, Abstraction from River Spey @ Spey Pumps	0.191
Aberlour Distillery, Charlestown of Aberlour, Abstraction from Burn of Aberlour	0.111
Wm Grant & Sons Ltd, Glenfiddich Distillery, Abstraction from River Fiddich	0.111

3.4 Actual Abstractions

The CAR licensing regime requires operators of abstraction activities to record the quantities of water abstracted and provide annual returns to SEPA to confirm they are compliant with their licenced operating conditions. The returns for 2018 have been provided by SEPA and reviewed in relation to the consented totals by type of abstraction (Table 3.7), and also by the largest abstractions (Table 3.8).

This review and comparison identifies that the actual abstractions were all much lower than the consented totals, being typically 25% to 30% of the total, with the exception of the fisheries which was 60%. When the individual largest abstractors were reviewed, the range in amount abstracted compared to the consent was much greater, ranging from 5% to nearly 80%. This single year presents a snapshot, and it is recognised that 2018 was a drier than average year. A comparison between actual recorded abstractions between 2018 and a wetter than average year (2015), indicates that the total actual abstractions during the wetter year were 18% higher, reflecting the greater availability of flows throughout the year, which still remained within all the consented amounts.

Table 3.7: Comparison between consented and actual abstractions in 2018 by abstraction type

Type	Consented Abstraction (m^3/s)	Actual 2018 Abstraction (m^3/s)	% of Consent Abstracted
Hydro Power	46.799	11.680	25%
Distillery	2.969	0.796	27%
Fisheries	0.738	0.426	58%
Public Water Supply*	*	n/a	*
Agriculture	0.003	0.000	13%
Grand Total	50.509	12.902	26%
Total Abstraction (Retained in Catchment)	4.360	1.400	32%
Transfers Out of Catchment	46.149	11.503	25%

* The SEPA 2018 data returns reviewed do not confirm the consented and actual abstractions.

Table 3.8: Comparison between consented and actual abstraction in 2018 by largest abstractors

Abstraction	Consented Abstraction (m^3/s)	Actual 2018 Abstraction (m^3/s)	% of Consent Abstracted
Lochaber Smelter - Spey Dam Tunnel	21.991	8.123	37%
Tummel Hydro, Cuaich Power Station	12.700	2.811	22%
Lochaber Smelter, Mashie and Pattack Division	11.458	0.569	5%
Wm Grant & Sons Ltd, Balvenie Distillery	1.111	0.116	10%
Rothiemurchus Fisheries, Aviemore	0.729	0.426	58%
Kingussie Micro Hydro	0.650	0.178	27%
Dipple Wellfield, Fochabers*			
Macallan Distillery	0.191	0.087	45%
Aberlour Distillery, Charlestown of Aberlour	0.111	0.061	55%
Wm Grant & Sons Ltd, Glenfiddich Distillery	0.111	0.085	77%

* The SEPA 2018 data returns reviewed do not confirm the consented and actual abstractions.

4 WATER RESOURCE OF THE SPEY

4.1 Flows in the River Spey

The River Spey drains a catchment area of 2,948 km^2 to Spey Bay, while the River Spey District fisheries management area is slightly larger at 3,172 km^2 as shown in Figure 4.1, with the inclusion of some smaller coastal tributaries.

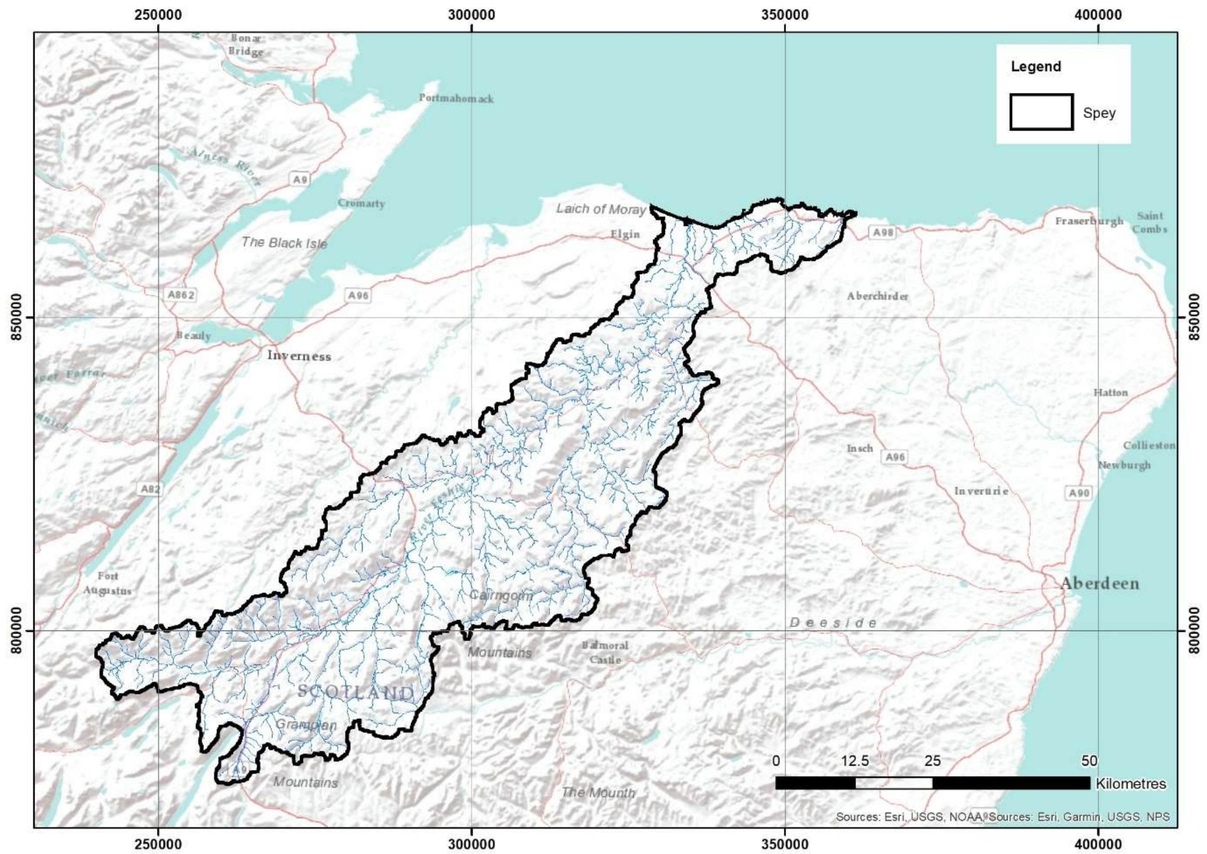


Figure 4.1: Catchment of the River Spey

A network of river gauges is operated by SEPA throughout the catchment, many of which date back to the early 1950s. This coincides with the implementation of the major hydro power abstractions / water transfers. As a result, these flow gauges which provide such a good resource for characterising flows within the main stem of the River Spey record a flow regime that is already altered by these water transfers, and therefore not the natural flow regime. Aberlour is the only gauging station which has a dataset preceding 1951, having records over the period 1938-1974.

A total of seven gauging stations have been examined in this investigation with daily flow records where available being provided by SEPA. These gauging stations along with the period of record examined are summarised in Table 4.1, and their locations shown in Figure 4.2.

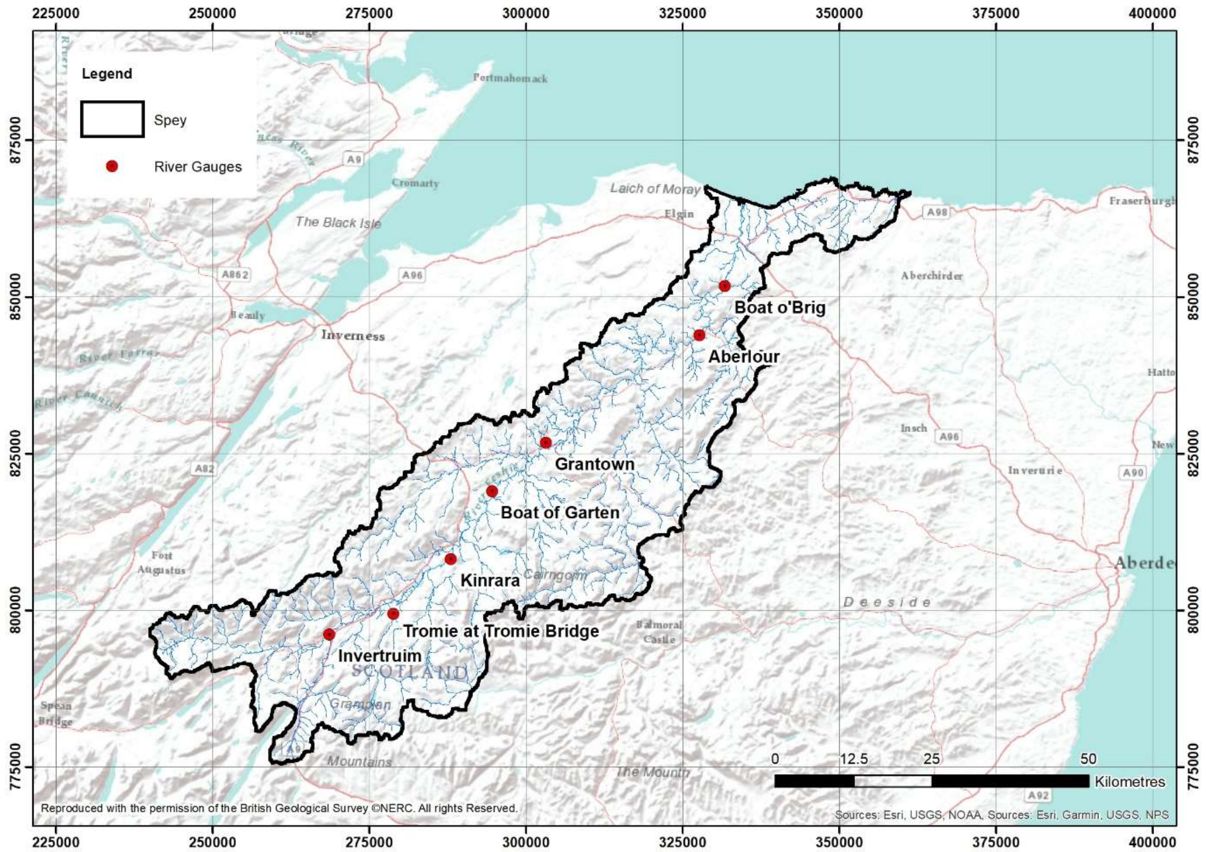


Figure 4.2: SEPA gauging stations

Table 4.1: River Spey flow gauging stations

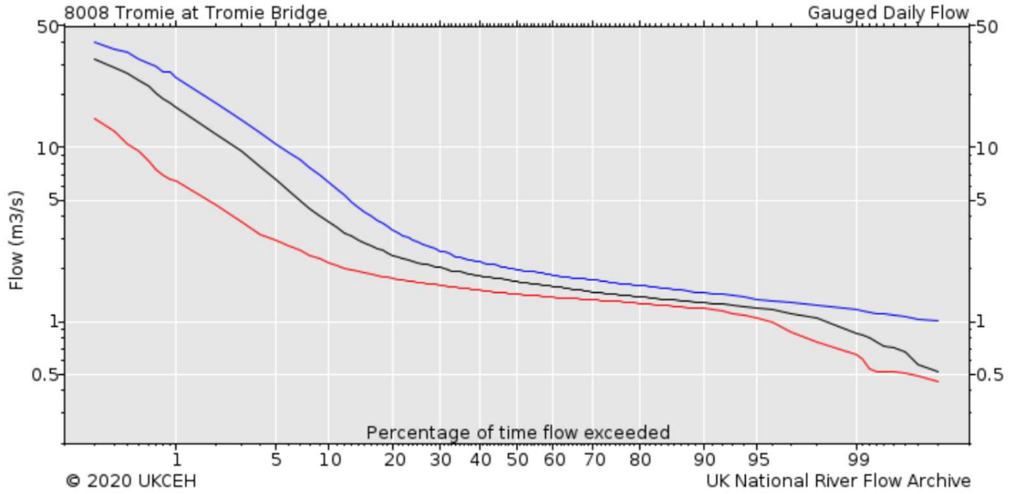
Gauging Station	Period of Record	Years
Tromie*	1952 – present	68
Invertruim	1952 – present	68
Kinrara	1951 – present	69
Boat of Garten	1951 – present	69
Grantown	1953 – present	67
Aberlour	1938 – 1974	36
Boat o’Brig	1952 – present	68

‘* The Tromie is a tributary of the Spey that is directly influenced by hydro power abstractions

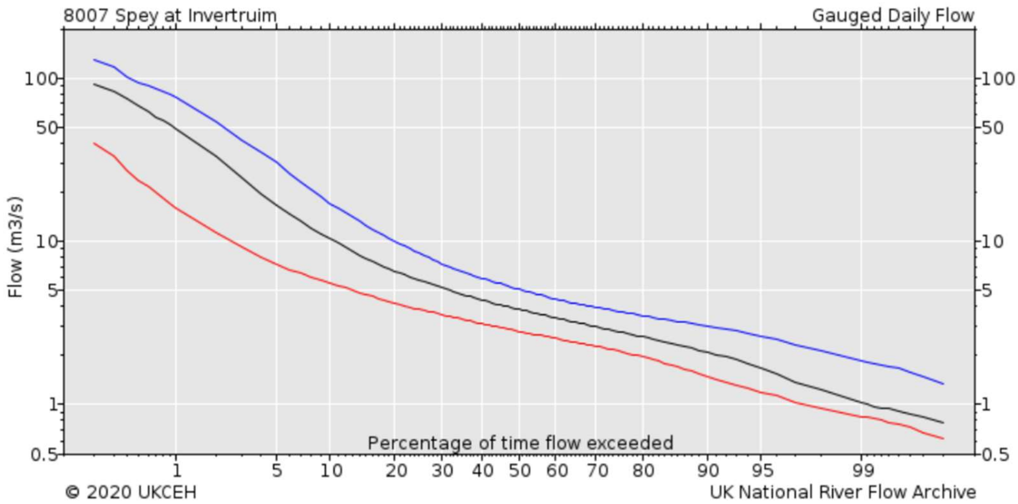
4.2 Gauged Flows on the Spey

The long term flow records for the gauges on the Tromie, and the main Spey at Invertruim and Boat o’ Brig are provided in Figure 4.3 as flow duration curves. These curves show the percent of time that river flows were exceeded during the long term dataset. For example, a flow exceeded for 95% of the time, represents a low flow condition. The scales used are not linear in order to improve the detail provided at the lower and higher end of flows, and for naturally varying flow conditions, a relatively straight, sloping line would be expected through the central section of the plot.

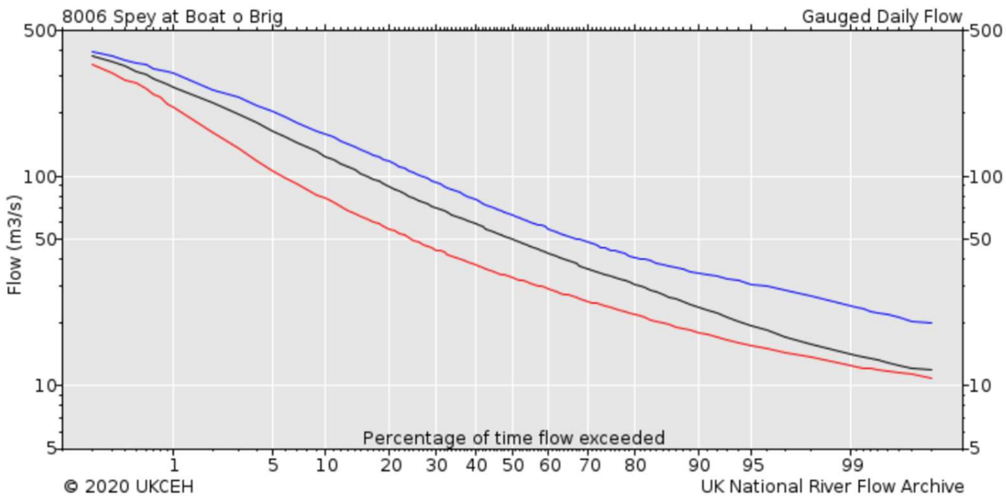
The flow duration curves for Tromie and Invertrium are closest to the main hydro water transfers, while the Boat o’ Brig gauge is furthest downstream on the Spey. The curves for the Tromie and Invertruim clearly do not demonstrate the typical curve shape expected for natural conditions due to the influence of abstractions, while at Boat o’ Brig, this influence is less apparent, however can still be detected.



Key: Black line - annual; blue line - December to March; red line - June to September.



Key: Black line - annual; blue line - December to March; red line - June to September.



Key: Black line - annual; blue line - December to March; red line - June to September.

Figure 4.3: Gauging station flow duration curves

The effect of the regulation of flows at the water transfer locations is to decrease natural flows to a near constant level for the majority of the time, in order to maximise the storage and abstraction, while allowing for spilling during high flows. The result of this is that the majority of the time, flows are artificially low, while the very lowest flows tend to be kept artificially higher due to compensation flows being released, only returning to more natural conditions when the compensation flow cannot be met. Higher flows are less influenced as any abstraction is generally small by comparison. These effects can be clearly seen on the Tromie flow duration curve where the compensation flow is 1.263 m^3/s and this flow is maintained for a large proportion of the time.

4.3 High Level Water Resource Information

The UK Water Resource Portal is operated by the Centre for Ecology and Hydrology. It provides access to hydrological information with a graphical user interface. The data available is useful in understanding hydrological trends and this can be provided in terms or rainfall and to a more limited extent, river flow data.

With regards to the Spey, there are four hydrological units modelled as shown in Figure 4.4, comprising of:

- the upper Spey to Inverdruie;
- Inverdruie to the Avon confluence;
- the River Avon; and
- the Avon to Spey Bay.

The past 20 years of monthly rainfall data is shown in Figure 4.4 for these hydrological units expressed in terms of a Standard Precipitation Index (SPI), which benchmarks the monthly rainfall against the long term average, and in this case, the accumulation period to each month is set to 12 months to smooth out shorter term monthly variations. Wetter than average periods are shown as blue and drier than average periods are shown as red. An SPI of greater than +2 or less than -2 is considered to represent an extreme event. When comparing the four hydrological units, it can be seen that the trends are similar, however the magnitude and phasing are different which highlights the differences in available water resources over this period within the individual catchments. This also reflects the challenges in managing varying pressures across such a large catchment as the Spey.

A similar output is provided in Figure 4.5 which shows the SPI over the past five years with a one month accumulation period to highlight the monthly variations more than the longer term trends. Again this shows similar overall trends, with local variations in the magnitude and phasing of the rainfall across the catchment throughout the year.

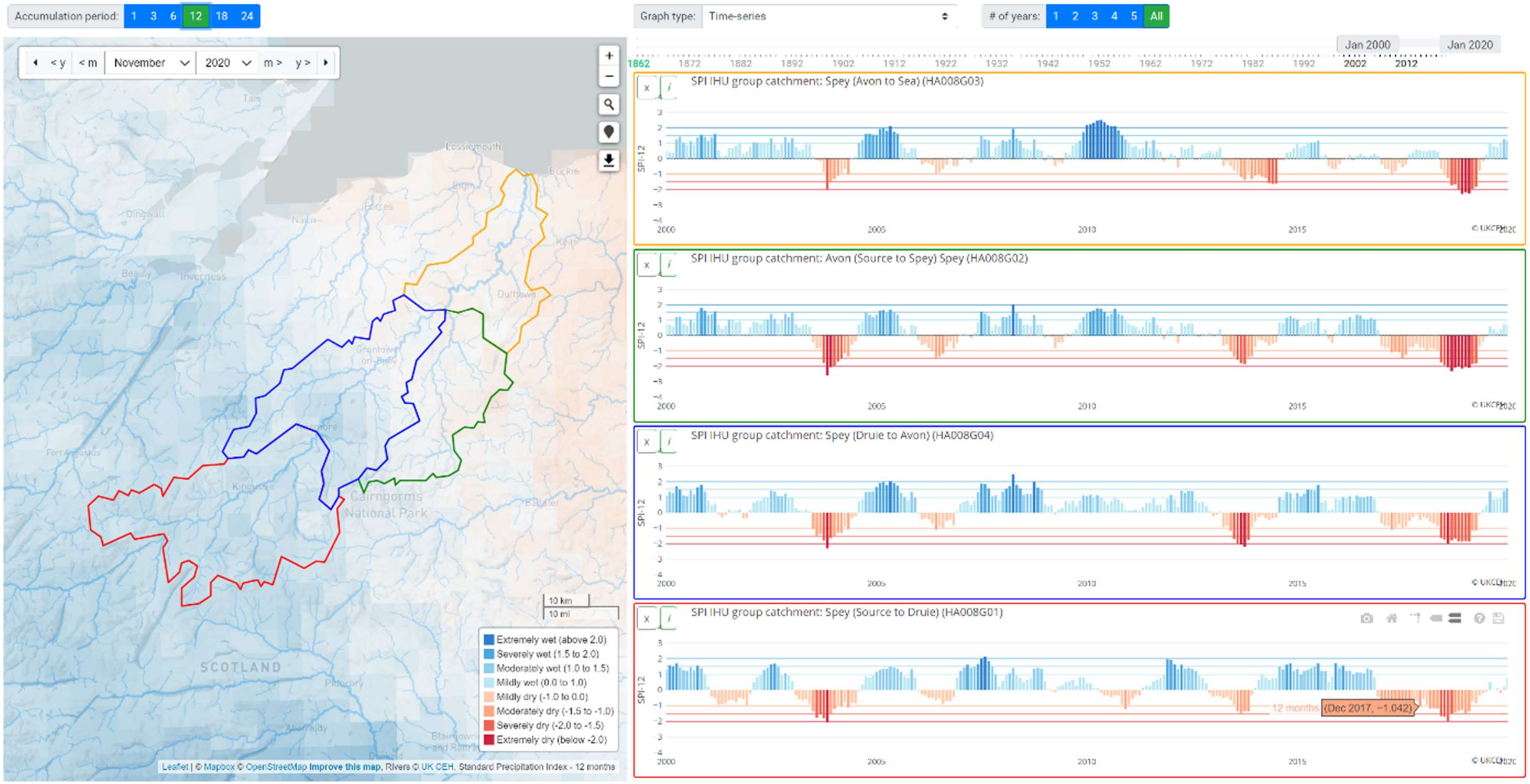


Figure 4.4: Standard Precipitation Index across the Spey (2000-2020) – 12 month accumulation

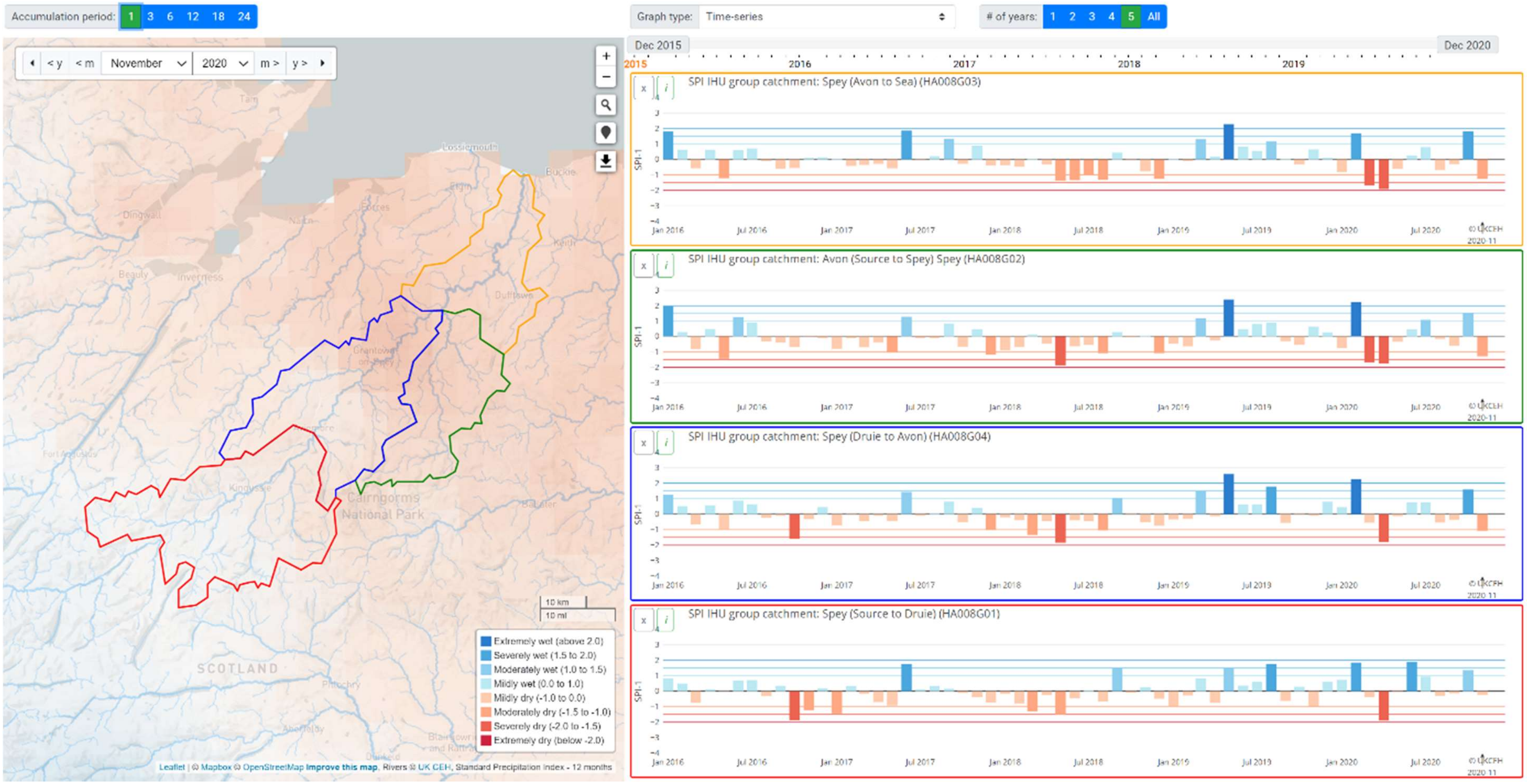


Figure 4.5: Standard Precipitation Index across the Spey (2015-2020) – 1 month accumulation

4.4 Water Transfers from Major Hydro Power Schemes

The headwaters in the west of the Spey catchment have been utilised for hydro-electric power generation by the Fort William Aluminium Smelter and the Scottish and Southern Energy (SSE) Tummel Valley hydro scheme. This regulated area extends to 390 km^2, or 13% of the entire catchment to Spey Bay, as shown in Figure 4.6. The influence of this is greater in the upper reaches of the main catchment being 54% to the Spey/Tromie confluence and 39% to Kinrara.

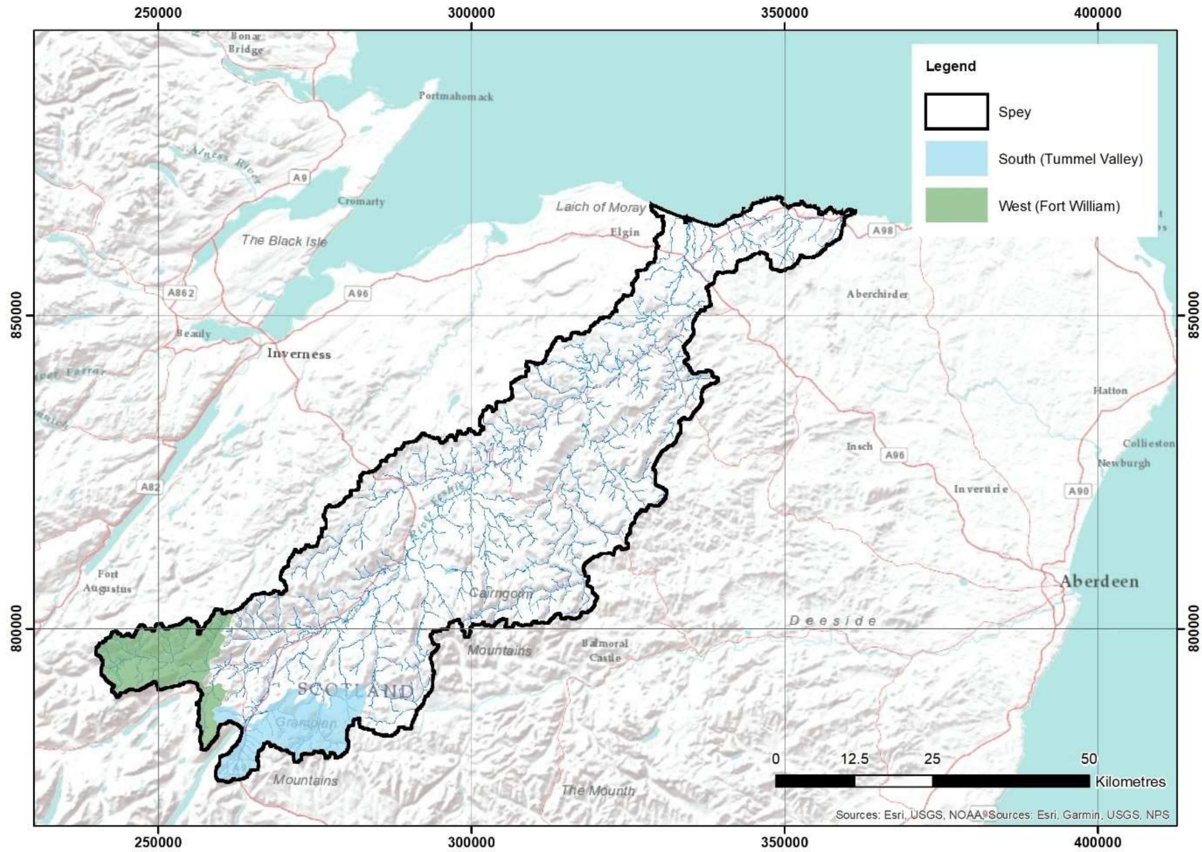


Figure 4.6: Major hydro scheme water transfers from the Spey catchment

Flows from the north-western extents of the Spey catchment are diverted and transferred out of the catchment to west into Loch Laggan in the River Spean catchment, eventually being used to generate electricity at the aluminium smelter in Fort William before being discharged to Loch Linnhe. While flows from the south-western extents of the catchment are transferred south west by SSE to Loch Ericht in the Tay catchment and into the Tummel Valley hydro-electric scheme, before discharging into the Firth of Tay at Perth.

The background to the development of these two major hydro schemes is provided in the following sections, while the technical details of these two main transfers are summarised in Table 4.2, along with a more detailed view of the regulated catchment from which abstractions are made in Figure 4.7.

Table 4.2: Major hydro scheme water transfer details

Hydro Scheme	Abstration for Water Transfer Details
Fort William Aluminium Smelter	Abstraction originally authorised through the Lochaber Water Power Order Confirmation Act 1940. There are two abstraction points that abstract flows from a catchment of 205 km^2 (Spey Dam 176 km^2 and River Mashie 29 km^2). The flow regulation was agreed as follows: • No abstraction to be made if the daily flow was less than 1.420 m^3/s. • The balance of the previously agreed flow (1.504 m^3/s) to be made available as freshet flows. • These freshets to be delivered through 22 freshets of 1.420 m^3/s delivered in 22 days from August to November.
Tummel Valley hydro scheme	There are five main control features operated by SSE in the Spey catchment that abstract water from an area extending to 185 km^2: **Loch an t-Seilich (Tromie Dam – capacity 4.5 million m^3)** The catchment of Loch an t-Seilich is increased by an aqueduct intake on the Allt Bhran, which along with the aqueduct intake on the Allt na Fearna increases the regulated catchment area on the River Tromie to 100 km^2. A compensation flow of 1.263 m^3/s is released through the fish pass on the dam whenever available. Above this flow, water is diverted to Loch Cuaich or spilled. **Loch Cuaich (Cuaich Dam – capacity 1.68 million m^3)** The Loch Cuaich catchment is increased by the aqueduct from Loch an t-Seilich and smaller aqueducts from Allt a'Choire Chais and Allt a'Choire Chaim, providing a catchment of 39km^2 (excluding that of Loch an t-Seilich). This flow passes through Cuaich power station and is then diverted via the Allt Cuaich weir into an open aqueduct and pipeline to Loch Ericht, with no compensation flow requirement to the Allt Cuaich. **Cuaich Aqueduct** The aqueduct and intakes that form the control structures diverting water towards the Tay, only release water back into the Spey when they spill. The general rule used during the design of these structures was that they could convey approximately five times the average daily flows. **Truim Intake** The catchment of the River Truim to the intake is 36.3 km^2 and a flow of 0.684 m^3/s is released continuously down through the fish pass on the intake. If the flow drops below this, a valve is opened on the pipeline that feeds water from Allt Cuaich into Loch Ericht. However as there are occasions when this pipe is empty for various operational reasons, this flow in the Truim is not guaranteed. **Alt an t-Sluie Intake** This intake and small aqueduct drains an area of around 10 km^2 and does not have any compensation arrangements.

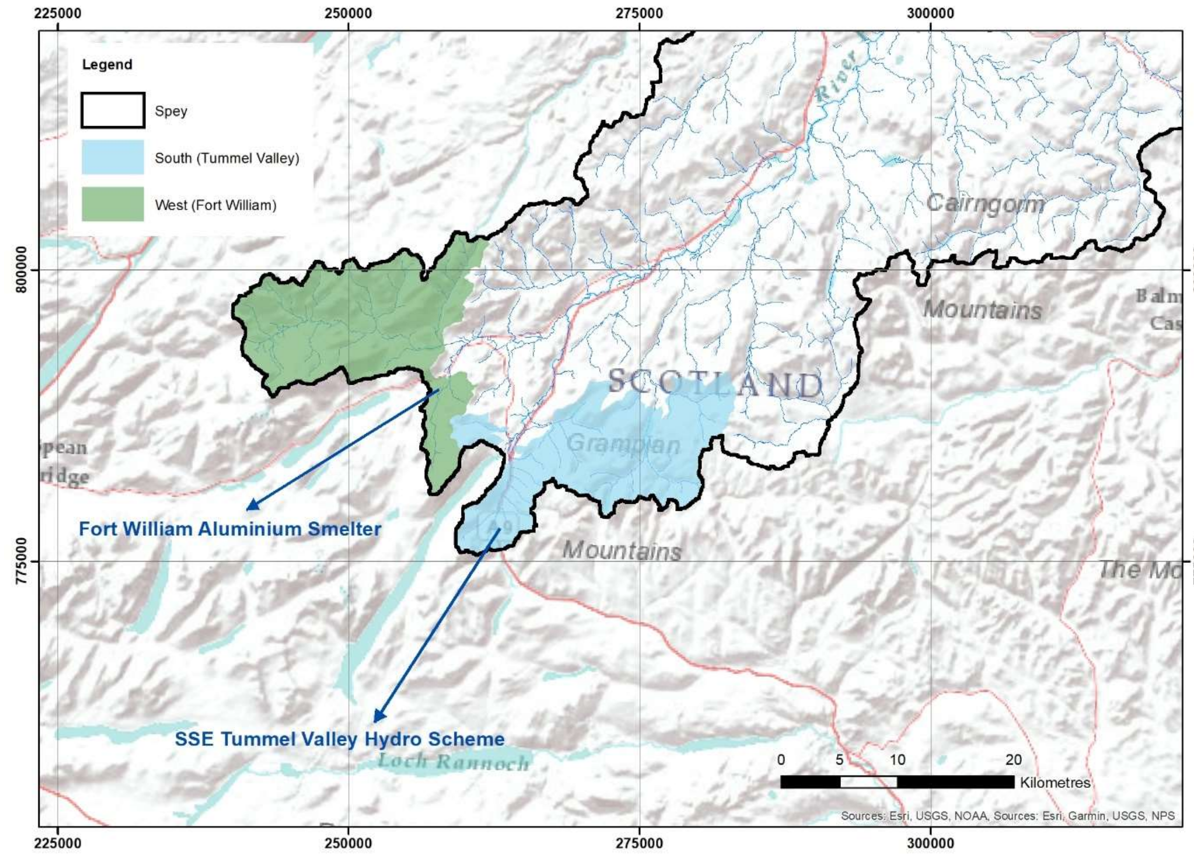


Figure 4.7: Regulated catchment areas for major hydro scheme water transfers from the Spey

4.4.1 Fort William Aluminium Smelter

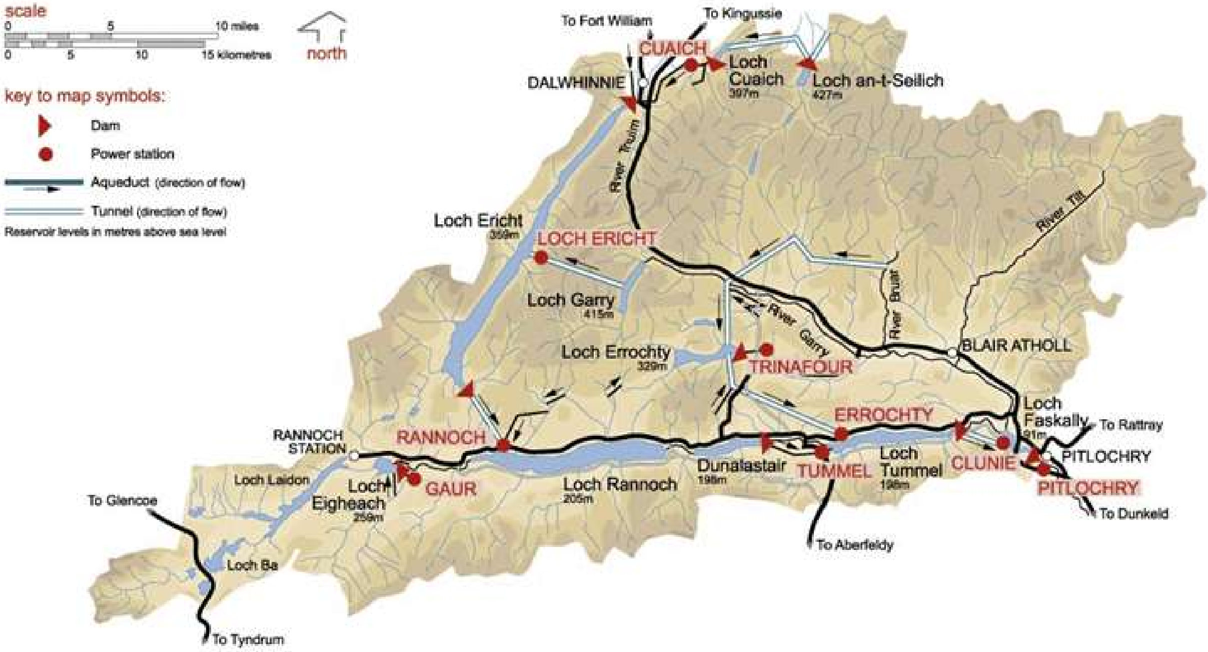
GFG Alliance is the company that now operates the aluminium smelter at Fort William. A hydro power scheme was developed to power the smelter in the early 20th century which harnessed water from the River Spean and used it to generate electricity at Fort William before discharging into Loch Linnhe. These initial works were progressed following the Lochaber Water Power Act 1921. This legislation was followed by a further Act of Parliament in 1930 and subsequently by the Lochaber Water Power Order Confirmation Act 1940, which enabled the head waters of the River Spey to be diverted to the west and into the River Spean catchment. This set out that no abstraction was to be made if the recorded flow at Laggan Bridge was less than 40 million gallons per day (2.104 m^3/s), based on a projected flow of 28.6 million gallons per day (1.504 m^3/s) at Spey Dam. The 1940 Act was the first of these three Acts to include a compensation flow from Spey Dam; the previous two Acts were solely concerned with diverting water away.

The water was controlled by constructing the Spey Dam across the upper River Spey approximately 3.5 km west of Laggan. The catchment area draining to the dam extended to 176 km^2, and the reservoir created allowed the water to back up to Loch Crunachdan, where an intake tunnel was excavated to channel the water into Loch Laggan at Kinloch Laggan. From there it would eventually flow to the sea at Loch Linnhe to the west. An additional smaller intake draining 28.8 km^2 was also created on the River Mashie, a tributary of the Spey, which diverted water along an open aqueduct to the River Pattack and into Loch Laggan.

This original flow regulation was revised through a Minute of Agreement between The Lochaber Power Company Ltd and The Spey District Board in 1954. This used the flow recorded at the Spey Dam, as Laggan Bridge was a distance from the dam for operational control and was prone to variations in the rating curve due to mobile gravels. Under this 1954 Agreement it was agreed that: no abstraction was to be made if the daily flow was less than 27 million gallons per day (1.420 m^3/s); and that the balance of the previously agreed flow (1.504 m^3/s) would be made available as freshets (planned increased releases of water from the dam) delivered over 22 days.

4.4.2 Scottish & Southern Energy

The Tummel Valley scheme was initiated in the 1930’s when the Grampian Electricity Supply Company constructed power stations at Rannoch and Tummel Bridge. The scheme was extended to the north and into the Spey in the 1940-50’s, with the full extent shown in Figure 4.8. The water draining from the Spey catchment is very valuable to SSE as it provides ‘green’ renewable energy each time it flows through either four or five hydro power stations before flowing out to the sea at Perth.



Source: Scottish & Southern Energy

Figure 4.8: The Tummel Valley hydro electric scheme

There are five main control features operated by SSE in the Spey catchment that abstract water from an area extending to 185 km^2, as detailed in Table 4.2. Of these, only Loch an t-Seilich has a compensation flow agreement. A flow of 1.263 m^3/s is released continuously down through the fish pass on the dam. Above this flow, water is diverted to Loch Cuaich or spilled. The catchment of Loch an t-Seilich is increased by an aqueduct with an intake on the Allt Bhran, which along with the aqueduct intake on the Allt na Fearna, give a catchment area within the River Tromie of 100 km^2 that is regulated by abstractions.

The catchment draining to Loch Cuaich is increased by the aqueduct from Loch an t-Seilich and smaller aqueducts from Allt a’Choire Chais and Allt a’Choire Chaim. This water then passes through Cuaich power station and the outflow is then diverted at the Allt Cuaich weir into an open aqueduct and pipeline to Loch Ericht, picking up some smaller tributaries along its length. The additional catchment area above that of Loch an t-Seilich is around 39 km^2.

The intake on the River Truim has a flow that is constantly released, although it is not a true compensation flow. A flow of 0.684 m^3/s is released continuously down through the fish pass on the intake. The flow is measured downstream of the intake on the River Truim at Dalwhinnie and if the flow drops below 0.684 m^3/s, a valve is opened on the pipeline that feeds water from Allt Cuaich into Loch Ericht. However as there are occasions when this pipe is empty for various operational reasons, this flow in the Truim is not guaranteed. The catchment of the River Truim to the intake is 36.3 km^2.

There is also a small aqueduct with an intake on the Allt an t-Sluie to the north of Dalwhinnie. This does not have any compensation arrangements and drains an area of around 10 km^2. It is abstracted by the distillery for use as cooling water, after which it is pumped back up to enable SSE to divert it into Loch Ericht.

The aqueducts and intakes that form the control structures diverting water towards the Tay only release water back into the Spey when they spill. No design checks have been undertaken to establish at what level they spill, however, a general rule used during the design of these structures was that they could convey approximately five times the average daily flows.

4.5 Naturalised Flows in the River Spey

The gauged flows downstream of the hydro scheme transfers reflect the impacted nature of the flow regime after the flows have been diverted. In order to estimate the amount of water diverted out of the catchment, an estimate has to be made of the naturalised flows.

In the absence of flow records at the points where water is transferred from the upper tributaries of the Spey into the hydro schemes, hydrological methods for predicting flow regimes in ungauged catchments have been used. The 2008 Abstraction Report adopted the Institute of Hydrology Report No. 108: Low Flow Estimation in the United Kingdom, while in this update the hydrological modelling software LowFlows2 is adopted. This software is founded on the techniques used within the 2008 abstraction report, and has developed the predictions using refinements to the techniques used, along with adapting to use more spatially varied ground model data sets now available.

This approach has been used to generate naturalised flow duration curves to fixed points. The fixed points selected include flow gauging stations to allow comparison between predicted flows and actual gauged flows, and at abstraction points to understand how much resource may be being transferred. Modelling has been undertaken to estimate the mean annual flow (MAF), median flow (Q_{50}) and low flow condition (Q_{95}). These have been calculated for each of the transfer locations and also checked at each of the gauging stations with actual recorded values of mean flow, Q_{50} and Q_{95}.

The results show that a mean annual flow contribution of up to 15 m^3/s is under the influence of regulated abstractions for water transfer, as summarised in Table 4.3. This approach has been compared to that used in the 2008 Abstraction Report and it is generally in good agreement, with the updated predictions generally predicting naturalised flows slightly higher than the previous assessment technique (mean annual flow +2%, Q_{50} +6%, and Q_{95} +21%).

To put these flows into context with the only other main water transfer out of the Spey, the consented abstraction at Dipple for public water supply is 0.313 m^3/s, which is equivalent to the mean annual flow from the Allt an t-Sluie (0.302 m^3/s) near Dalwhinnie, which is entirely diverted to Loch Ericht.

Table 4.3: Predicted flow regimes at flow transfer intakes

River	Sub-Catchment	Area (km^2)	Flow (m^3/s)		
			MAF	Q_{95}	Q_{50}
Spey	Mashie A	1.96	0.054	0.009	0.032
	Mashie B	26.82	0.958	0.144	0.558
	Spey	175.95	6.760	0.837	3.638
	Total	***204.73***	***7.772***	***0.990***	***4.228***
Tromie	Allt Bhran	29.46	1.038	0.171	0.617
	Loch an t-Seilich	62.08	2.526	0.489	1.565
	Allt na Fearna	7.74	0.293	0.054	0.183
	Total	***99.28***	***3.857***	***0.714***	***2.365***
Truim	Allt Cuaich Weir	33.81	1.245	0.173	0.683
	Leacainn Burn	0.59	0.018	0.002	0.010
	Allt Coire Bhathaich	5.02	0.191	0.014	0.093
	Truim	36.31	1.579	0.135	0.783
	Dalwhinnie Burn	1.23	0.039	0.005	0.023
	Allt an t-Sluie	8.85	0.302	0.049	0.189
	Total	***85.81***	***3.374***	***0.379***	***1.781***
	Overall Totals	**389.82**	**15.00**	**2.08**	**8.37**

Note: MAF - Mean Annual Flow; Q95 - low flow; Q50 - median flow.

4.6 Modelled Losses from Water Transfers in the Upper Spey

The two gauging stations most affected by the flow transfers are Invertruim (Spey Dam, Loch Cuaich and Truim Intake) and Tromie (Loch an t-Seilich). Adopting a similar approach to the 2008 Abstraction Report, to predict the abstraction losses in the upper catchment, the mean annual flow was predicted to the flow transfer intakes and the gauging station, then the predicted mean flow at the intake was replaced by the compensation flow, and predicted mean flow at the gauging station revised. This prediction was then compared to the recorded mean flow at the gauging station. The predicted results came to within 5% of the gauged value for the Tromie and 1% for Invertruim as shown in Table 4.4.

As a check on this approach, the predicted Q_{50} for the Aberlour gauging station was calculated and compared to the recorded data, with the difference being 1%. This can be considered a reasonable prediction, considering the uncertainties within the data.

Using this method, the mean annual flow expected to be abstracted and transferred from the upper Spey catchment is 9.95 m^3/s, or approximately 66% of the mean annual flow reaching the intakes. This estimate is similar to the 11.08 m^3/s predicted in the 2008 Abstraction Report.

Table 4.4: Predicted flows and water transfer losses

Gauging Station	Predicted MAF (m^3/s)	Revised MAF Prediction (m^3/s)	Gauged MAF (m^3/s)	Difference (%)	Loss in MAF (m^3/s)
Tromie Bridge	4.665	2.374	2.504	-5%	2.29
Invertruim	13.86	6.203	6.12	1%	7.66
Aberlour	65.85	55.90	56.354	-1%	**9.95**

MAF – Mean Annual Flow
Revised MAF Prediction replaces predicted flow to intake with compensation flow.
Difference and loss in MAF is expressed between the gauged MAF and the revised MAF prediction.

4.7 SEPA Abstraction Consents and Returns

The CAR licensing regime regulated by SEPA requires annual returns to be provided detailing the amount of flow abstracted under licence. This data has been provided by SEPA for the years 2014 – 2018 for the licenced abstractions on the Spey, with the exception of the public water supplies.

The consented and actual abstraction rates for the main abstraction categories identified are detailed in Table 4.5 for the years 2018 (most recent data and a dry year) and 2015 (a wet year). These show that the actual abstractions recorded are only in the order of 25% - 30% of the consented amounts, however the relative split between uses remains similar, with the large scale hydro power water transfers representing around 90% of the abstraction amount. The differences between the two years show that there can be up to a 20% year to year variation based on the resources available.

The annual average loss of flow from the Spey comprises of the water transfer amount, plus the losses from the remaining abstractions that return flows to the Spey. The transfer flow from 2015 and 2018 provides a range of between 11.8 – 14.3 m^3/s, while the total abstraction from the remainder of the licenced consents was 1.5 m^3/s, which with an assumed average loss of 10% would provide a loss of 0.15 m^3/s. This would equate to an annual loss in the range of 12 – 15 m^3/s on average each year, 99% of which would be experienced in the upper catchment.

Table 4.5: Consented and actual abstraction rates in 2015 and 2018

Type	**2018 (drier year)**				**2015 (wetter year)**	
	Consent (m^3/s)	Actual (m^3/s)	% Consent	% Total Actual	Actual (m^3/s)	% Total Actual
Agriculture	0.003	0.000	13%	0%	0.000	0%
Distillery	2.969	0.796	27%	6%	0.661	4%
Fisheries	0.738	0.426	58%	3%	0.688	4%
Hydro	46.799	11.681	25%	88%	13.974	89%
Public Water Supply*	0.409	0.409*	100%*	3%	0.409*	3%
Grand Total	**50.918**	**13.312**		**100%**	**15.732**	**100%**
Transfers	46.462	11.816		89%	14.29	91%
Balance	4.456	1.496		11%	1.45	9%

* Actual abstractions not provided, so assumed to be 100%.

The consented abstractions have been reviewed in relation to the available water resources based on the gauged flow data. The consented abstractions for water transfer in the upper catchment are reviewed in Table 4.6 along with the actual abstraction flows recorded for 2018, which was a dry year, and 2015, which was a wet year.

It can be seen that the level of abstraction consent exceeds the available resources in the upper catchment, with the consented abstraction being equivalent to 151% of the long term average flow recorded at Kinrara. Even allowing for the assumptions made in approximating annual abstractions and resources in terms of an average annual flow, this is expected to be the case. It is however recognised that these consented values will have been derived through the transposing of previous pre-CAR abstraction consents, and that the actual consented flows may not be realistic to achieve. This is supported by the actual level of abstractions recorded in 2018 and 2015, which are only 30% and 40% respectively of the consented total.

The actual proportion of the long term average flows transferred out of the catchment in a drier year (2018) was 48% at Kinrara, reducing to 17% by Boat o' Brig, while these increased to 61% and 21% respectively for a wetter year (2015).

When these water transfers are considered in terms of the mean river flow within those respective years, to take into account averaging of flows, the drier year resulted in transfers of 57% at Kinrara, reducing to 24% at Boat o' Brig, while the wetter year resulted in transfers of 39% and 18% respectively. This demonstrates that during the drier year, although the abstraction was less, the proportion of the flow abstracted from what was available through the year was a greater proportion of the available flow than that of a wet year.

Table 4.6: Consented and actual water abstractions for water transfers

Water Transfers	Flow (m^3/s)	Flow Gauging Station		
		Kinrara	Grantown	Boat o Brig
Consented (2018)	34.691			
% of LTA mean flow		151%	91%	53%
Actual Transfers (2018) [Dry Year]	10.934			
% of LTA mean flow		48%	29%	17%
% of 2018 mean flow		57%	36%	24%
Actual Transfers (2015) [Wet Year]	13.974			
Relative increase compared to 2018:	28%			
% of LTA mean flow		61%	36%	21%
% of 2015 mean flow		39%	26%	18%
Range of LTA mean flow to transfers		**39% - 61%**	**26% - 36%**	**17% - 24%**

LTA – Long Term Average

5 FUTURE MANAGEMENT AND CLIMATE PROJECTIONS

5.1 Water Resource Management Tools

There are a number of useful datasets, publications and analysis tools that have become available since the 2008 Abstractions Report. Some of those directly relevant to the management of water resources include:

- Real time water levels and rainfall data, managed and made available by SEPA;
- Monthly reviews of hydrological conditions, provided by the Centre for Ecology and Hydrology;
- Monthly reviews of precipitation and weather conditions, provided by the Met Office;
- Regular updates on regional water resources / water scarcity, published by SEPA;
- UK Water Resources Portal for accessing rainfall and river flow data, hosted by the Centre for Ecology and Hydrology; and
- Forward forecasting for contingency planning, provided by the Met Office.

In relation to the River Spey, the above resources provide useful and relevant information for individual abstractors to manage what they are doing, and will supplement direct monitoring systems that they have in place already. These tools can be used more proactively to suit particular circumstances when pressures on resources may occur, such as during drought conditions.

Although there are the noted data resources, there is not as yet an active means to readily access the water resource usage within the Spey catchment, nor is there an easily accessible resource to quantify available resources specific to the active usage within the catchment. This could be critical where short term planning is required and would greatly benefit from near real-time data. The significant loss of flow to the Spey already makes the river less resilient to extended periods of low flows.

Existing management measures tend to be informed by review and interpretation of the historic data, such as the review of spate flow conditions undertaken by the Spey Fishery Board in February 2015 after the large flood resulting from Storm Bertha in August 2014. The type of information that can be gained from such reviews includes longer term trends. As an example, the 66 year long term flow record (1952-2018) at Boat o' Brig has been reviewed to identify the annual number of days in each year where high flows (>Q5) and low flows (<Q95) have been recorded, and a 20 year moving average trendline added to investigate trends as shown in Figure 5.1. These display an increasing trend for the number of higher flow events, while the low flow conditions do not display a significant trend. This type of analysis is useful for informing strategic management decisions.

What is missing for the River Spey is the strategic overview and appropriate management agreements to manage the available resources on a catchment scale, or on an active basis, such as during an extended period of low flows. Responding to and managing such scenarios require active involvement to ensure appropriate management actions can be identified and initiated in advance of more sensitive conditions arising. This will require the engagement and active participation of all key stakeholders to collectively manage resources as effectively as possible. Examples of measures during projected drought conditions would include potentially reducing abstraction volumes, or compensation flows, beyond normal operating procedures.

Many of the organisations involved in the major abstractions will have corporate Environmental, Social and Governance (ESG) standards that will set out the values they aim to meet. The environmental standards are of particular relevance to the Spey, whereby as a result of the active and historic abstractions, the resilience of the river to climate extremes, in particular low flows, has a known impact. This may provide opportunities for developing targeted measures to mitigate this in the future.

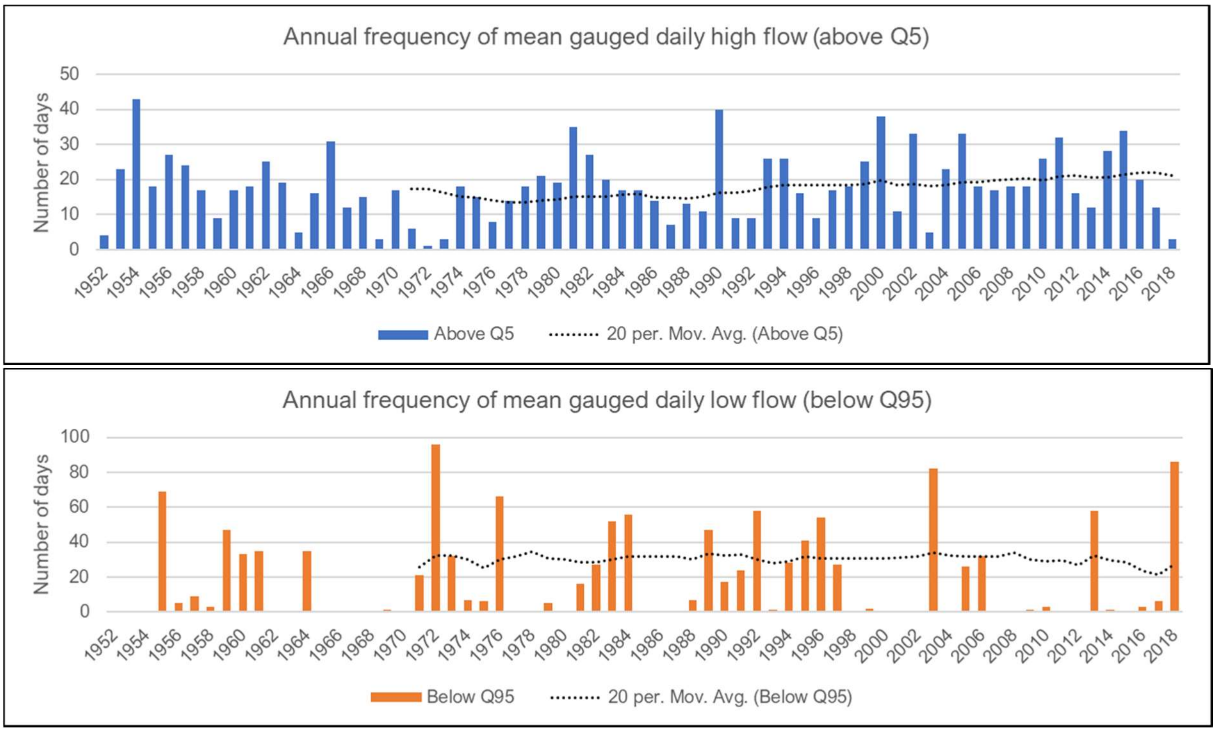


Figure 5.1: Frequency of daily high (>Q5) and low (<Q95) flows recorded at Boat o' Brig

5.2 UK Future Climate Projections

The UK updated the forward climate projections in 2018 (UKCP18) for the first time since 2009. This data can be accessed to enable users to run specific scenarios for different climatic indicators of interest down to a regional and local levels. The projections are based on different future scenarios which are based on assumptions on future economic, social and physical changes to environment, which are referred to as Representative Concentration Pathways (RCPs). There are three RCPs as summarised in Figure 5.2, with RCP2.6 having the least change from present conditions and RCP8.5 representing a high emissions scenario having the largest change.

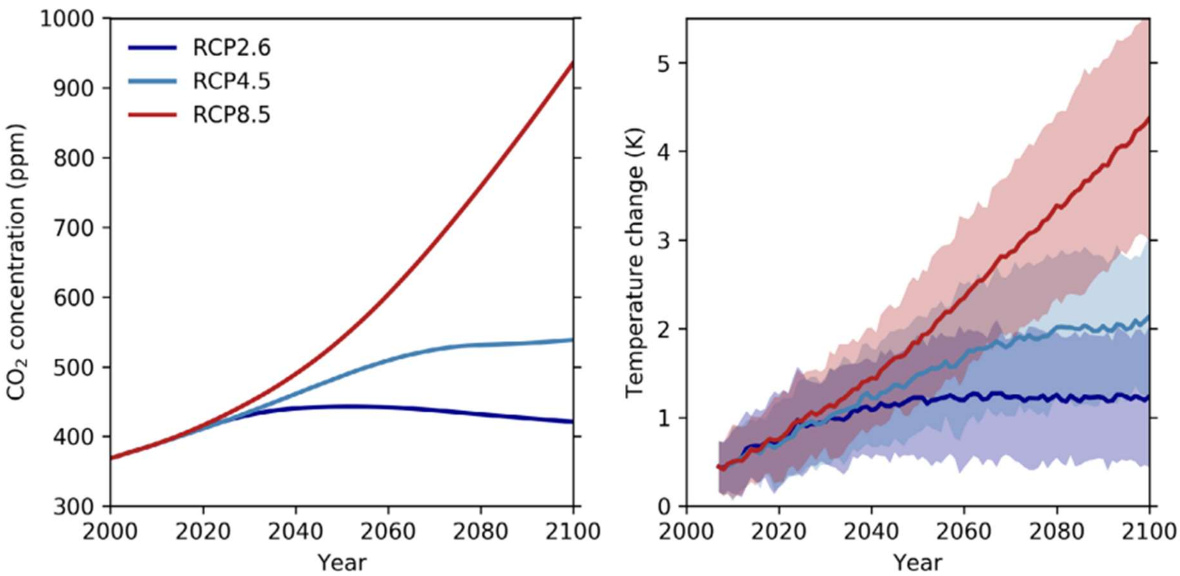


Figure 5.2: Representative Concentration Pathways (RCPs) for future UKCP18 climate scenarios

The climate projections are made at a national scale, such as shown in Figure 5.3, where the actual observed conditions are shown as a solid black line against the coloured modelled projections. At the national scale, it can be observed that the future trends are expected to result in slightly wetter winters and drier summers than we experience on average at present. These changes are more pronounced for the more extreme high emmissions scenario (RCP8.5).

There are also regional projections available and the Spey catchment is contained within the North East Scotland region of the model predictions. When looking at the projected annual average rainfall anomaly charts up to 2100 for both the high emissions scenario (RCP8.5) as shown in Figure 5.4 and also the less extreme RCP2.6, it can be seen that the overall annual change is small, although the range of the anomaly rate increases into the future. Positive anomalies indicate a higher risk of floods, while negative anomalies indicate a higher risk of droughts.

When the seasonal regional projections are examined for the high emissions scenario (RCP8.5) up to 2100, more pronounced changes can be observed. These seasonal projects show much clearer differences, with wetter winters (Figure 5.5) and drier summers (Figure 5.6). The anomaly rates also increase over time, with increases in the likelihood of extreme high flows in autumn and winter, and increases in the likelihood of extreme low flows during the summer.

The future projections for snow cover based on the high emmissions (RCP8.5) scenario show decreases in winter mean snowfall for the period 2061-80 of between 20% to 60% compared to that of the period 1981-2000, as shown in Figure 5.7. There are differences between the results from local and regional model predictions, however the trend is similar.

In general, the high emmission scenarios are more extreme, however the projected trends remain similar, with less rainfall in the summer and a reduced snowpack in the winter. These will result in a trend of reductions in the available water resources of the Spey during the spring and summer on average.

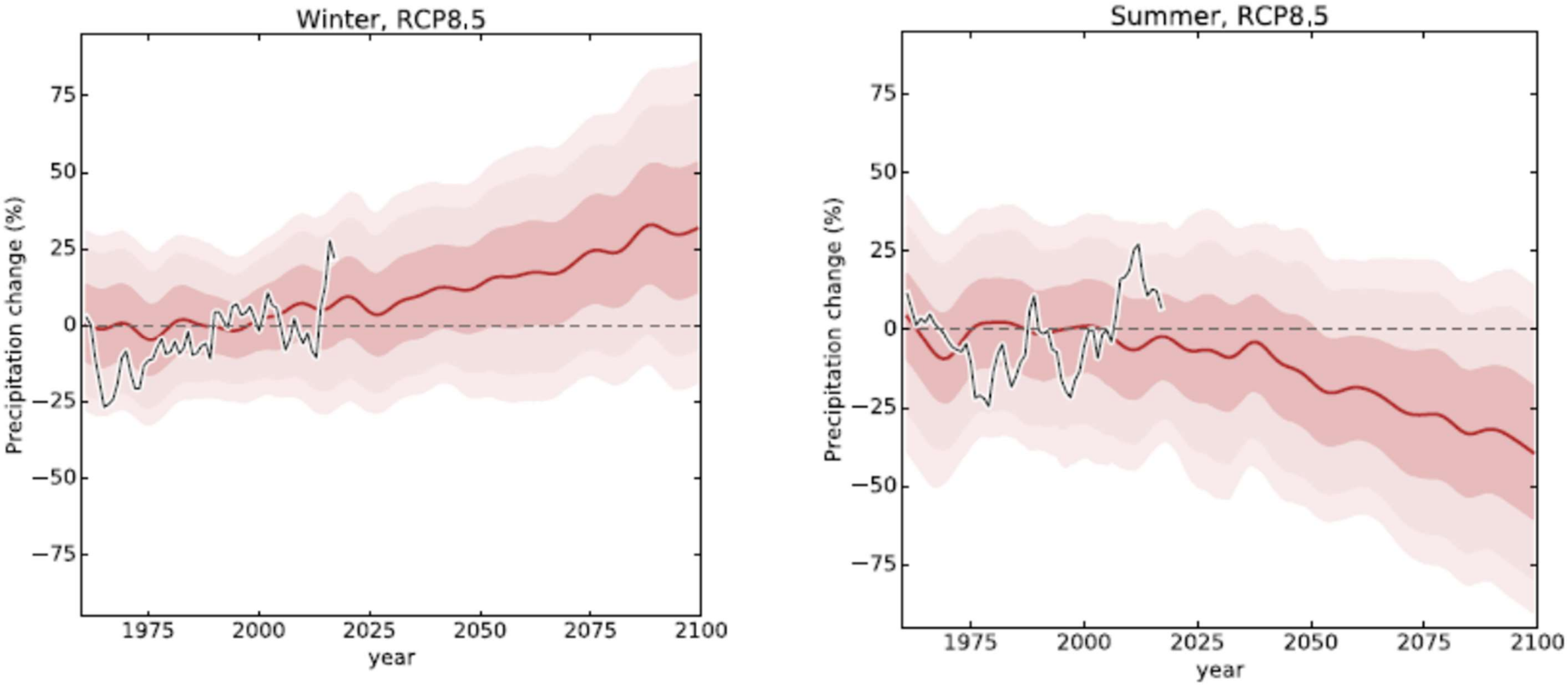


Figure 5.3: UK seasonal precipitation change from 1981-2000 average – winter and summer

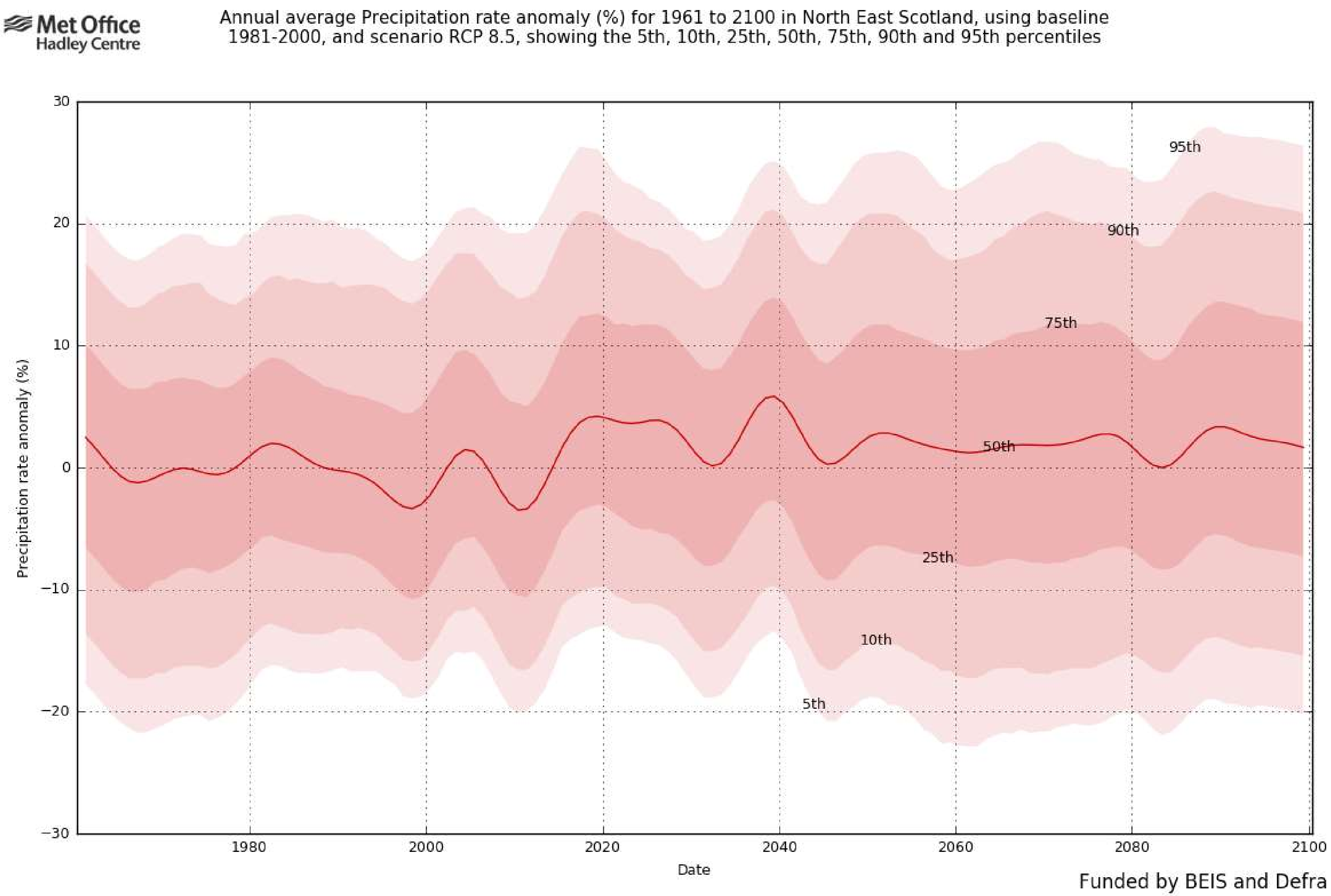


Figure 5.4: Annual average rainfall rate anomaly to 2100 for North East Scotland – RCP8.5

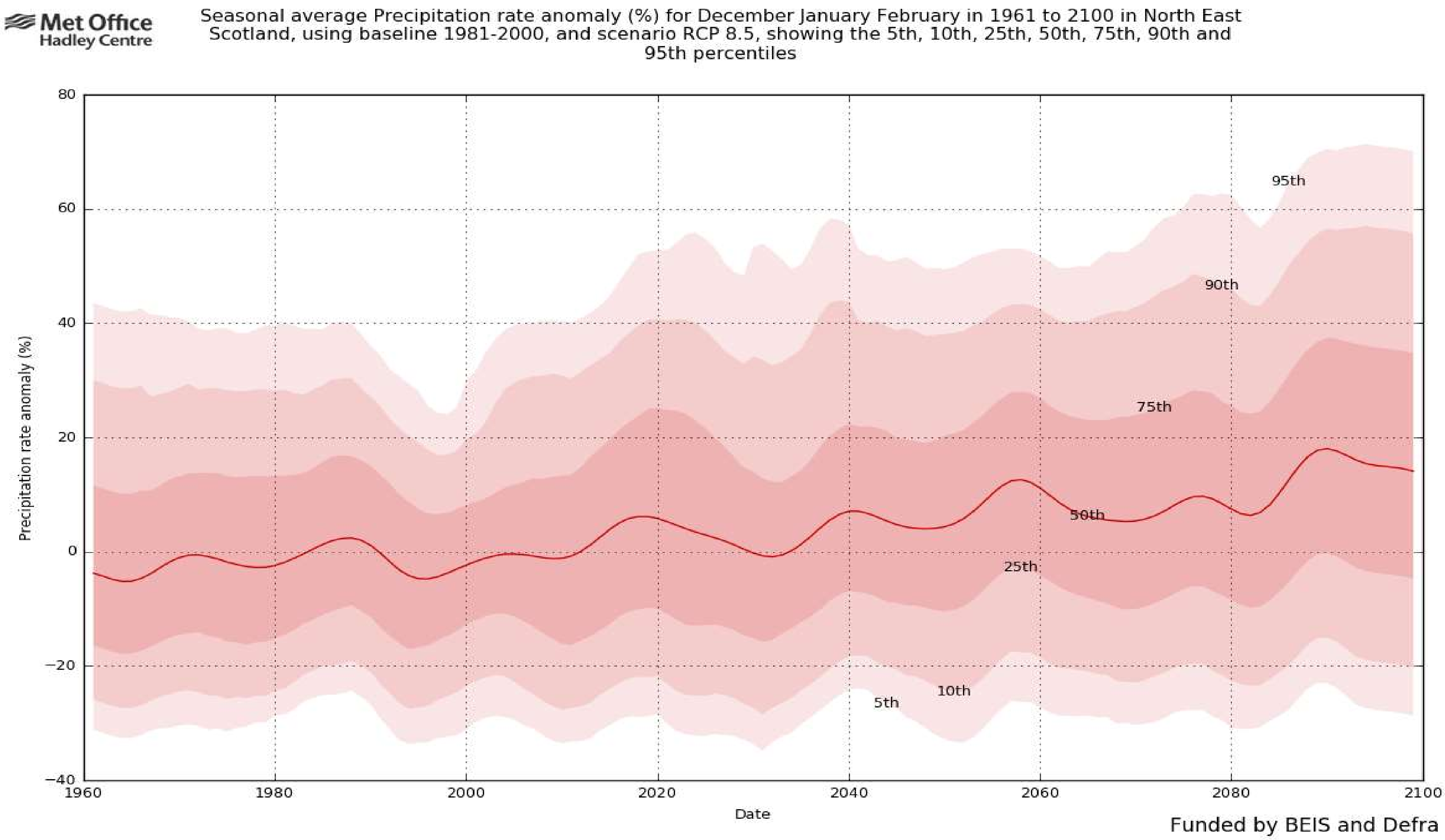


Figure 5.5: Winter average rainfall anomaly 1961-2100 for North East Scotland – RCP8.5

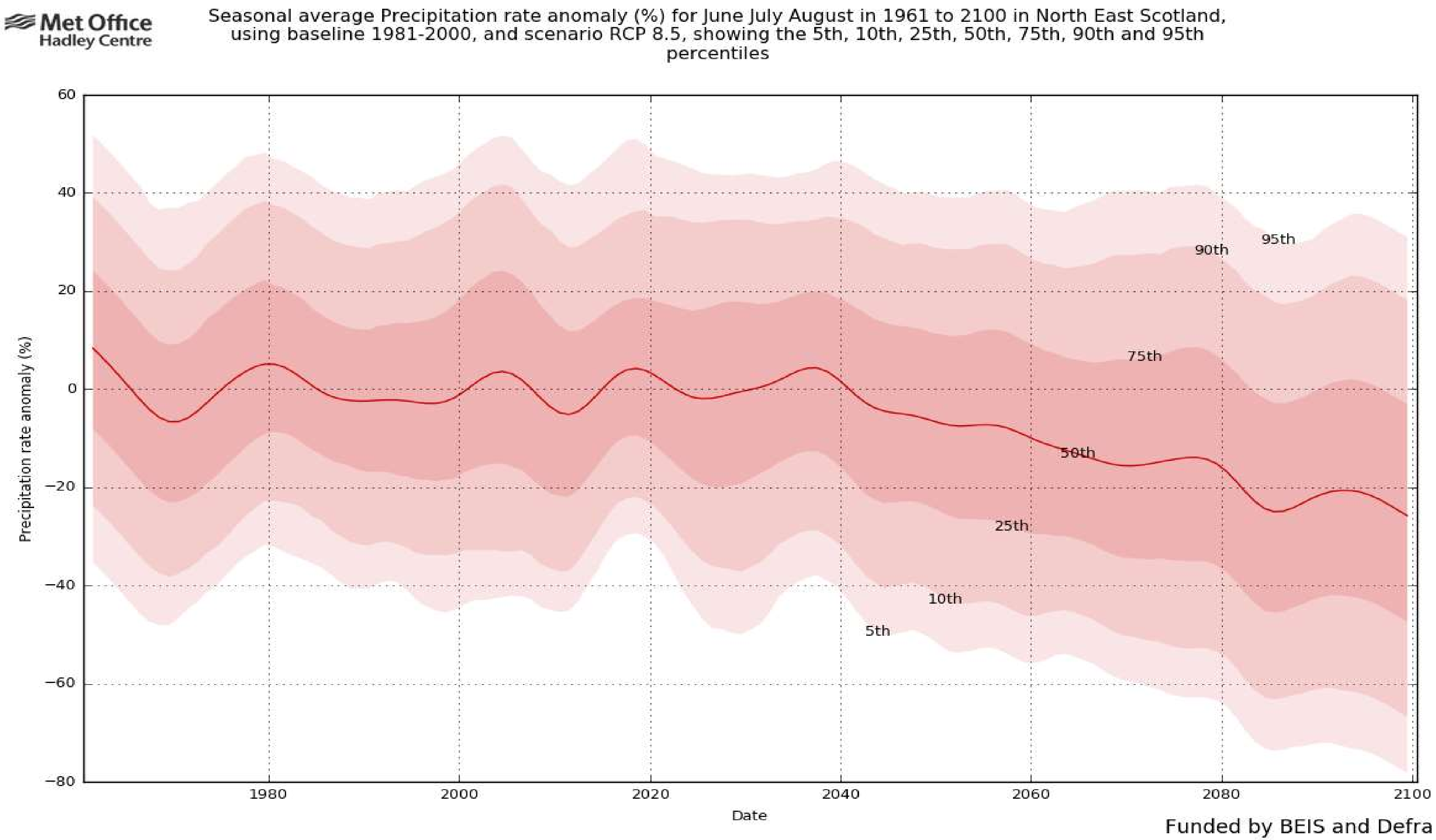
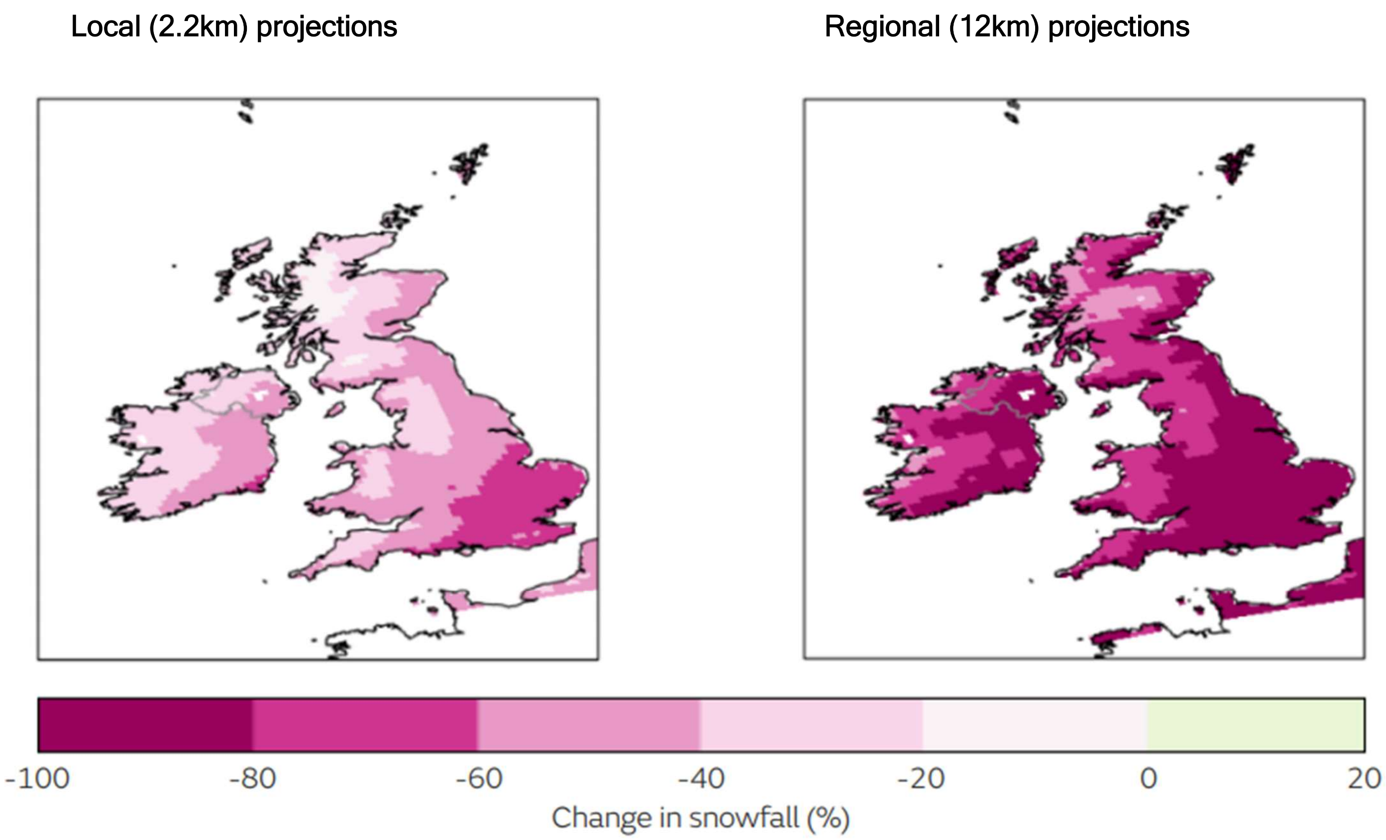


Figure 5.6: Summer average rainfall anomaly 1961-2100 for North East Scotland – RCP8.5



Source: UKCP18 Snow Factsheet

Figure 5.7: Winter mean snowfall change for 2061-2080 compared to 1981-2000– RCP8.5

5.3 Restoring Hydrological Resilience to the Spey

The water balance for the Spey, and in particular the upper Spey highlights that the mean flows are lower than they would naturally be, and in some instances, the flows are absent below intakes. There tends to be less change to the higher flows and the lower flows further downstream in the catchment as they are sustained to an extent by release of compensations flows. The loss of flow does however result in a reduction in the amount of water that would naturally be available for storage in the alluvial and glacial sand and gravel deposits within the Spey river valley downstream of the abstractions. A reduction in the mean flow, results in a reduction in water level, which will tend to lower the surrounding groundwater level and reduce the ability for the river to recharge the groundwater in the sand and gravel aquifers along the river valley, as shown schematically in Figure 5.8.

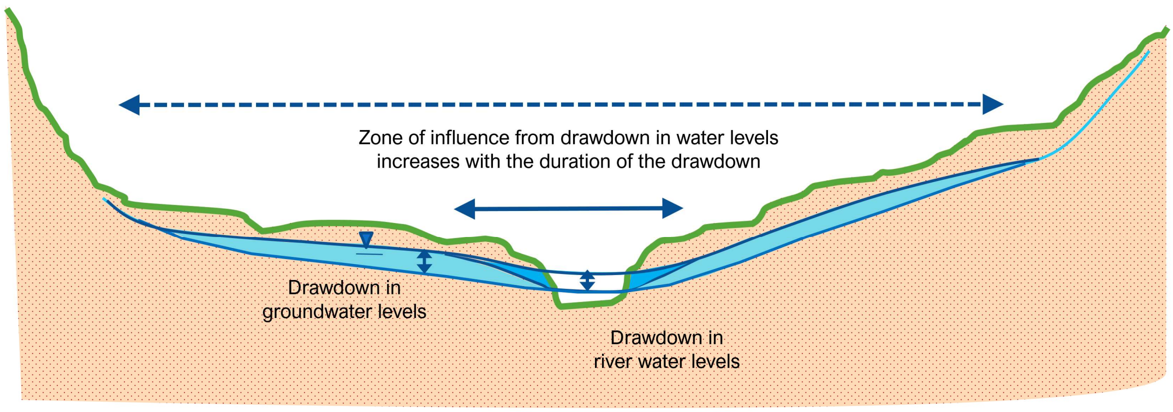


Figure 5.8: Schematic section through river valley showing loss in groundwater storage

In addition to the depleted flow regime, historically the land management priorities were often to prevent high flows coming out of the river channels and ponding on the land, which has led to many locations throughout the Spey having a reduced connectivity between the river and the floodplain. The reduced amount of water ponding on the floodplain further reduces opportunities to provide recharge to the underlying groundwater levels. As a result, during low flows the river is less resilient to falling water levels as the surrounding groundwater storage is less and can only supply a reduced baseflow to the river.

There is an opportunity to restore this river and floodplain connectivity, and potentially restore more opportunities for floodplain ponding, with the aim to improve the amount of recharge that is provided to these depleted groundwater storage zones within the sands and gravels. With increased groundwater storage provision, the resilience during low flows increases as higher baseflows are maintained. This approach is consistent with the aims of natural flood management measures promoted at a national level.

The extents of these alluvial and glacial deposits along the Spey are shown in Figure 5.9, and a closer view of the conditions in the upper Spey where the greatest impact on flows are experienced is provided in Figure 5.10. These demonstrate the extent of these deposits, especially in the upper Spey, and subsequently show the loss in resilience to more extreme flow conditions as a result of depleted natural flow conditions.

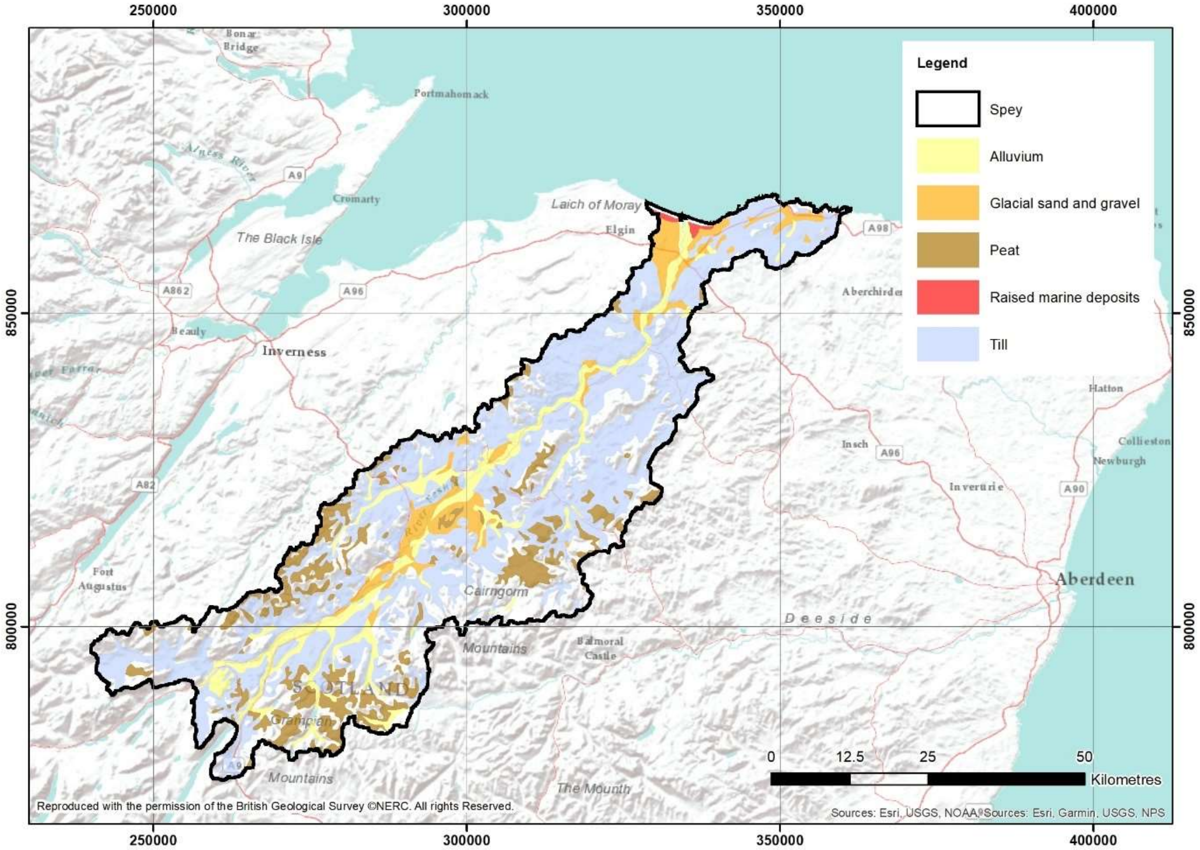


Figure 5.9: Superficial geology deposits within the Spey catchment

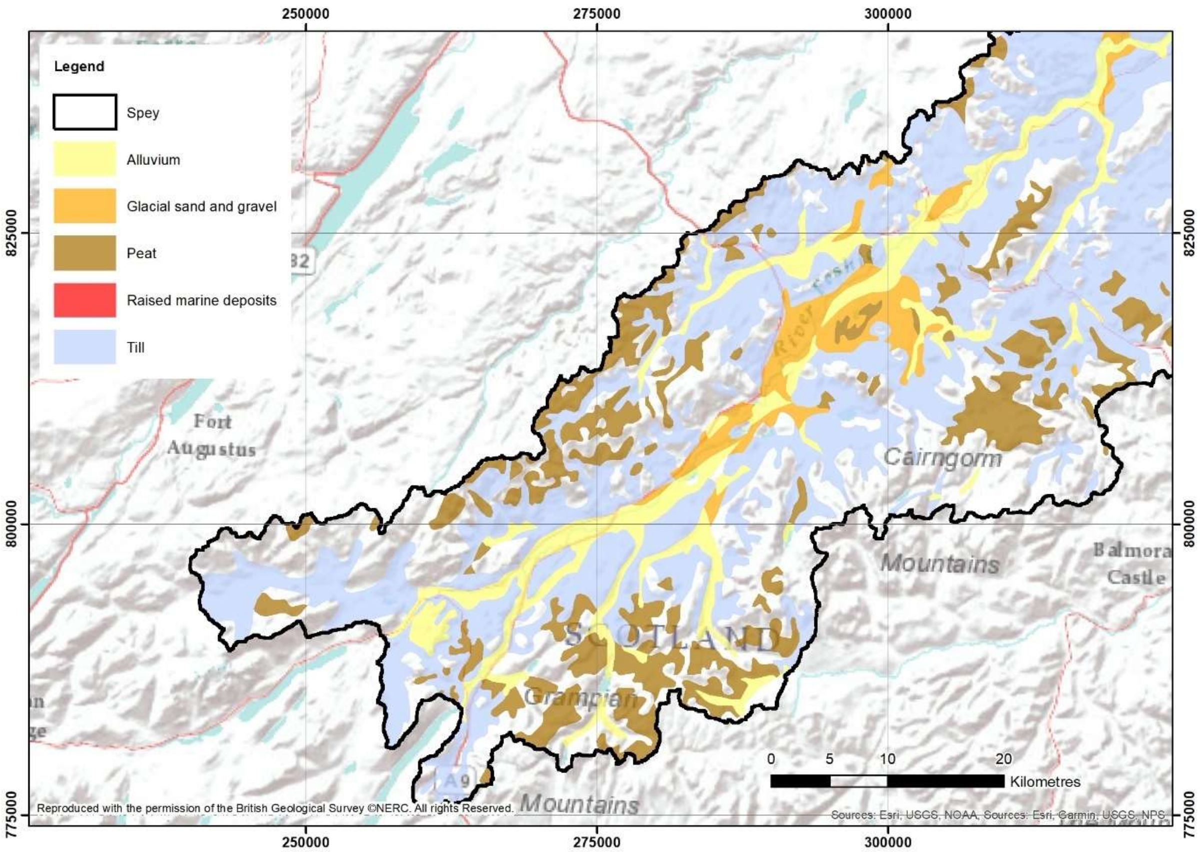


Figure 5.10: Extent of alluvial and glacial deposits within the river valleys of the upper Spey

A high level assessment has identified that these sand and gravel deposits along the main River Spey from Spey Dam to Boat o' Brig cover approximately 175 km^2, and if an additional 0.1 m depth of flood water or runoff was able to infiltrate into this area, it would provide the equivalent storage of nearly four times the maximum 4.5 million m^3 capacity that SSE have at Loch an t-Seilich, behind the Tromie Dam. This highlights that significant benefits could be achieved on a much wider catchment scale.

There are similar approaches that could be considered in tributaries that are impacted by upstream abstractions, where an increased release of flows below the abstraction, or a more varied flow release would help improve the river habitat and provide increased local recharge that can be released naturally as an improved baseflow over time. As identified earlier, an example is the Allt an t-Sluie at Dalwhinnie, which has no compensation flow below the abstraction intake, and if the mean annual flow of 0.302 m^3/s could be reinstated, this would represent a very similar flow to that abstracted by Scottish Water at the Dipple wellfield (0.313 m^3/s). The reinstatement of flows in the upper catchment will provide a benefit along nearly the full length of the Spey valley.

Longer term changes in land management and vegetation cover could also improve the hydrological resilience through reducing the surface water runoff rate by providing increased opportunities for slowing down and storing flows for a more gradual release.

There are catchment scale measures that can be explored further to better quantify the impact, and to engage with others involved in the management of the water resources to plan what could feasibly be done to help improve the resilience of the river during more extreme weather windows in future. This represents a long term issue that is not going to change or improve without changes to how the water resources and interactions with land management are presently managed.

5.4 Implications for River and Fisheries Management

The flows in the Spey are impacted by the abstractions that take place, however the major abstractions have been in place for nearly 70 years, so the most significant impacts on the river and in particular on salmon and freshwater pearl mussels will have already occurred.

The legacy is a river system that has an artificially lowered average flow condition, and while lower flows are sustained to a degree by compensation flow releases from dams, there is a reduced baseflow contribution downstream of the abstractions due to the regulated flow releases. This makes the river less resilient to extended periods of low flows. However, the impoundments in the headwaters will provide some attenuation to high flow events.

The recent trend in the frequency of high flows within the Spey shows a slight increase which can have implications for washout of redds and also freshwater pearl mussels in more extreme flows. There is no clear recent trend in the frequency of low flow events, although an extended low flow event occurred recently in 2018. During these conditions, the available habitat decreases and as the wetted perimeter of the river shrinks, leading to increased stress and potential mortality of salmon of all age classes and freshwater pearl mussels.

Future climate projections indicate increased frequency of extreme events of both higher flows and lower flows, along with a reduction in winter snowpack that typically provides a spring baseflow from the release of meltwater. The lower flow conditions are potentially of greater concern given the reduced resilience of the Spey due to natural flows being depleted through water transfers. However, the more effective management measures have the potential to both attenuate the magnitude of high flows, while increasing baseflow within the catchment to provide improved resilience to extended periods of low flows.

6 CONCLUSIONS

Progress since 2008 Abstraction Report

Since the 2008 Spey Abstraction Report was published, there have been a number of positive advances in terms of the awareness and profile of water resources within the Spey catchment. The 2008 report commissioned by the Spey Fishery Board has been a key driver in enabling this to happen. There has been continued positive engagement with SEPA and the main water users to ensure that water use and management can be tailored to benefit the river as far as possible.

The availability of annual abstraction volumes is a significant step forward in being able to confirm the quantity of the water resources that are being utilised. Although as yet, these are not readily accessible, or in a suitable format to allow an active catchment scale water balance to be developed. The benefit of such an active system would allow the impacts of different management actions on water resource use to be assessed for short or longer term strategies.

Updated hydrological assessment

The update to the analysis undertaken originally in the 2008 report has confirmed that the predictions made at that time remain in relatively good agreement with the updated predictions. The hydrological analysis indicates that the predicted mean flows are in good agreement, while the low flow conditions may have been previously under-estimated in the 2008 report. The previous water use figures compare well with the actual water abstraction returns detailing annual water use volumes.

Abstraction licences

Since 2008, the number of licenced abstractions has increased, although the overall consented level of abstractions has not increased significantly. The two major hydro schemes are now regulated under CAR and account for 91% of the consented abstractions, all of which is transferred out of the catchment and lost to the Spey. Distillery abstractions have increased, although a doubling of the abstraction has only resulted in a 3% increase in the total abstraction within the Spey catchment.

Actual abstraction rates for the different types of abstractions vary between 5% to nearly 80% of the consented rate, and are typically 25% to 30% of the overall consented abstraction. The level of consented abstractions in in the upper catchment are in excess of the annual average resources available, and represent the transfer of legacy arrangements directly onto the new CAR licences.

Impact of abstractions

The annual average loss of flow from the Spey comprises of the water transfers, plus the losses from the remaining abstractions that return flows to the Spey. This is predicted to be in the range of 12 – 15 m^3/s on average each year, based on the limited dataset to date, and 99% of these losses are due to the hydro scheme transfers in the upper catchment. A comparison of abstractions during wetter and drier years indicates that during wetter years, annual average abstraction rates can be 20% higher.

These two main hydro schemes abstract and transfer water out of the Spey catchment from an area draining 390 km^2, or 13% of the entire catchment to Spey Bay. The impact of this is a reduction in the natural mean flow rate by an average 66% below the abstractions, although some smaller tributaries with no compensation flows can run dry. This loss reduces down through the catchment, however it still remains significant, with mean flows being reduced by 39% – 61% at Kinrara and by 17% - 24% at Boat o' Brig in the lower Spey. This reduction in the natural flow reduces the resilience of the river during prolonged low flow conditions.

Future climate projections

The latest regional future climate projections indicate that annual average rainfall up to 2100 is not expected to change significantly, however changes to seasonal patterns are likely to result in wetter winters and autumns, and drier summers. The frequency of extreme events leading to floods and droughts are also expected to increase. There is a projected 20-40% regional decrease in winter mean snowfall by 2080, which will reduce meltwater flow through the spring.

Forward water management actions

The Spey has an artificially lowered average flow condition that has been depleted through water transfers, and while lower flows are sustained to a degree by compensation flow releases from dams, there is a reduced baseflow contribution downstream of the abstractions due to the regulated flow releases. This makes the river less resilient to extended periods of low flows, and future climate projections are likely to increase the likelihood of these conditions occurring.

The management of abstractions remains a key objective within the most recent 2016 Spey Catchment Management Plan and was a recommendation from the 2008 Abstraction Report. Although the available data on abstractions and river flows have become more accessible and general stakeholder communications have improved, there remains a lack of a holistic river basin approach by any agency to actively manage water abstractions and water resources in the Spey. The development of a Water Resource Strategy Plan can be used to inform strategic management decisions.

Restoring hydrological resilience should be actively progressed as this will provide the most sustainable long term approach to help manage the impacts of extreme events on the river along with the salmon and freshwater pearl mussels that it sustains. Measures to consider include:

- Identifying opportunities to reduce or redistribute water transfers and retain them within the Spey. For example, if the mean annual flow rate of 0.302 m^3/s could be reinstated to the Allt an t-Sluie at Dalwhinnie, this would represent a similar flow to that abstracted by Scottish Water at the Dipple wellfield (0.313 m^3/s) and have the benefit of being able to flow through the entire Spey Valley.

- The upper Spey valley has extensive sand and gravel deposits that store less water than would naturally be expected due to the lower river levels where flows have depleted by abstraction. Initiatives to promote land management measures that can re-connect the rivers with their natural floodplains and allow floodwater to drain naturally back into the underlying sands and gravels can help improve the resilience of the river system to low flow events, which are likely to become more common.

- Other land management measures to consider can be supporting changes to land use and/or vegetation cover to provide conditions where water runoff is decreased and storage increased.

- The organisations involved in the major abstractions will have corporate Environmental, Social and Governance (ESG) standards that may provide opportunities for developing targeted resilience restoration measures to mitigate against historic impacts and/or future extreme events.