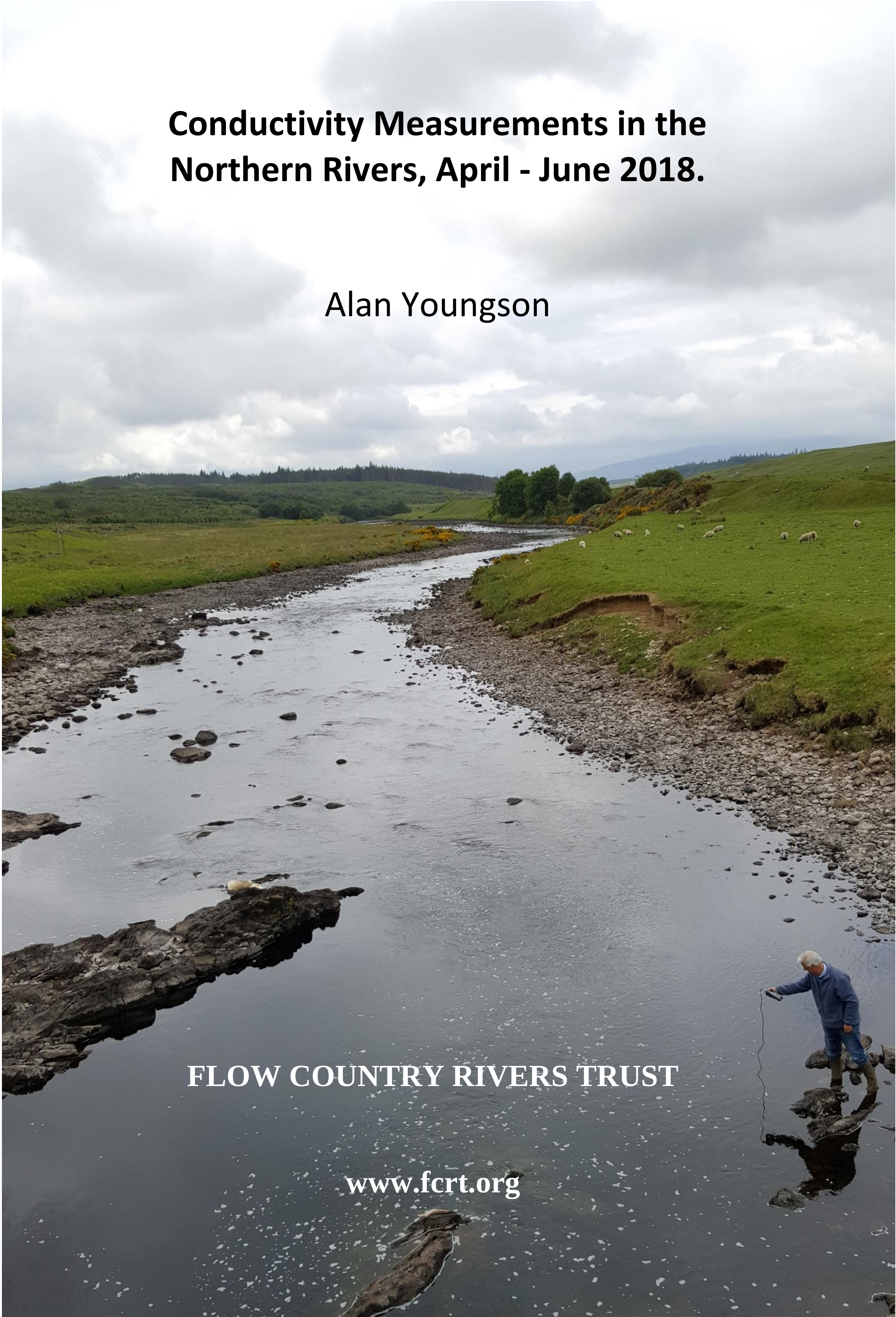
Conductivity Measurements in the Northern Rivers, April - June 2018.

Alan Youngson



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Background

The electrical conductivity of stream water is a measure of the quantity of dissolved material (ions) that the water contains. The dissolved material is a complex and variable mixture of many substances but conductivity provides a single measure of their overall concentration. The concentration of solutes partly determines the capacity of streams to support any of the wide range of organisms that salmon and trout depend on - directly or indirectly - for growth and survival. Conductivity values, considered together with temperature and physical habitat quality, make it possible to gauge the productivity of streams and their capacity to support young fish.

All stream water originates as snow or rain. The original precipitation is low in dissolved material because it is derived from water vapour. Extraneous material may be stripped from the atmosphere as rain falls in areas affected by urbanisation and industry but this is not a major issue in Caithness and Sutherland. Precipitation is therefore generally of low conductivity when it hits the ground. Notable changes take place subsequently as soluble material is picked up by the original rainwater percolating through river catchments towards the sea.

The visible surface water in streams and rivers forms only a small part of all the water that is present in catchments. Much greater volumes are tied up in the peat cover and in the underlying soils and gravels and in some catchments also in lochs. Rain or snow-melt reaches surface streams and rivers by moving down-slope at varying speeds via a range of pathways, visible and invisible. The pathways are of different lengths and they also pass through a range of different mineral substrates derived from a variable mixture of imported glacial material and weathered local bedrock.

The amount of dissolved material that water picks up as it transits a catchment depends on the nature and availability of the minerals to which the water is exposed and also on the length of time for which contact with soils and gravels occurs. At one extreme, heavy or prolonged rainfall is delivered rapidly to streams or rivers via shallow pathways. In this case interaction between water and soils or other substrates is minimal and conductivity remains low. At the other extreme, transit times for shallow groundwaters in soil or gravel layers (there are no deep groundwaters in the northern catchments) extend for weeks or months. Close and prolonged contact between water in transit and mineral substrates promotes the accumulation of solutes by the passing water and therefore increases its conductivity.

During "normal" river conditions stream water is a complex mixture of original rainfall delivered to the stream by shallow or deep and by fast or slow transit routes. The balance between these routes differs according to the characteristics of the catchment and also according to local patterns of rainfall. At times of drought, the shallow and fast routes for water delivery become depleted and the conductivity of stream water then reflects a simpler mixture of waters being delivered only by slower and deeper routes. Under these more stable circumstances it becomes possible to make comparisons of conductivity between locations and between rivers and also to examine the intrinsic hydrochemical characteristics of catchments.

The northern river catchments suffered a prolonged drought in 2018 from April onwards. This rare opportunity was taken to survey stream conductivity values in all the river catchments of the Northern, Caithness and Helmsdale DSFB areas under unusually uniform conditions of extreme low flow, between late April and June.

Results.

The rivers were surveyed between 21st April and 26th June using a portable conductivity meter (Hanna Instruments). The stability of the electrode was tested periodically using a single batch of bottled water from Highland Spring (350 µS/cm) and a single batch of de-ionised battery water (7 µS/cm). Values proved stable throughout. All the survey sites were accessed from the public road or from estate roads. Where measurements were obtained near the roadside they were made on the upstream side of the road to eliminate the potential effects of roadwash on conductivity values.

The Appendix shows all the data that was collected. The lowest conductivity value (53µS/cm) was measured at Allt na Sroine near Loch Choire Lodge on the Naver. The lowest mainstem value (58 µS/cm) was also observed on the River Naver, below Loch Naver itself. The highest value (580 µS/cm) was measured near Hastigrow on the River Wester, north of Wick.

Figure 1 shows the raw data for the main rivers and major tributaries. Conductivity values have been categorised and plotted on a map of the northern river network. Given that the survey was carried out after a prolonged period of near-zero rainfall, the conductivity values are probably near to the maximum levels that are likely to be observed at any time.

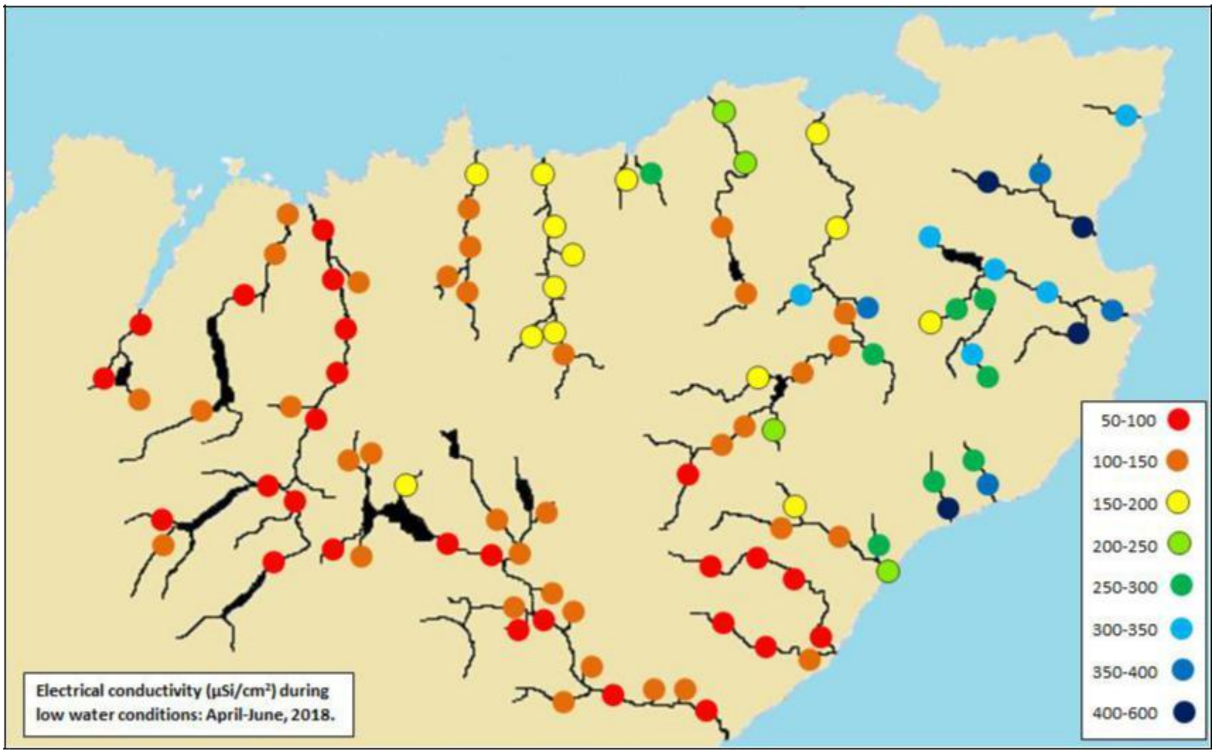

Figure 1. Map of conductivity values (µS/cm) for mainstem sites and major tributaries in the Northern rivers. The values are colour-coded by conductivity categories as per the inset key.

The raw data are shown in Figure 1 but this is not most informative form of presentation if comparisons are to be made between rivers across the whole area. In order to increase comparability, two adjustments to the data were carried out taking account of (1) differences in survey date between river catchments and (2) the conductivity of original rainfall.

The effect of survey date.

Survey of each separate catchment was carried out over a brief period. However, the Berriedale/ Langwell and Dunbeath rivers were surveyed at the very start of the survey sequence as part of a separate investigation. The survey series was extended to all the other rivers when it became evident that the period of low rainfall was going to be sufficiently prolonged to make it possible to attempt a comprehensive study.

Therefore, towards the end of the survey period, conductivity measurements were again obtained for main river sites on the Berriedale/ Langwell and Dunbeath. These showed that, as expected, conductivity values had continued to increase as the 2018 drought developed. Values for Langwell, Berriedale and Dunbeath Rivers had increased by 39%, 23% and 26%, respectively. The values obtained in the original survey were therefore increased by this amount in order to compensate for the passage of time and to make all the separate river surveys fully comparable.

The conductivity of original rainfall.

The effects of the conductivity of original rainfall on the values observed during the survey were investigated using data obtained for 2017 at the Forsinard weather station, near the centre of the survey area. The amount of rainfall and the conductivity of the rainfall are measured over 2-weekly periods.

Figure 2 shows that the conductivity of rainwater varied substantially. The average conductivity value over the whole year was 46.1 µS/cm including a single atypically high value of 250 µS/cm observed for Weeks 49-51.

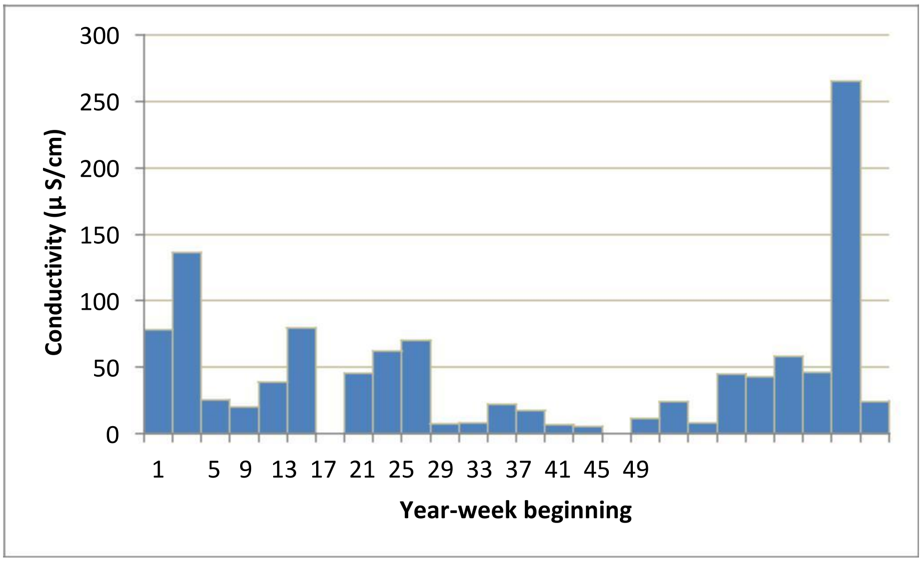

Figure 2. Conductivity of rainfall at Forsinard weather station in 2017.

The effect of this single high value on the average value can be considered by examining the amount of rainfall accumulated over each of the 2-weekly periods. Figure 3 shows the amount of rainfall corresponding to the conductivity values shown in Figure 2.

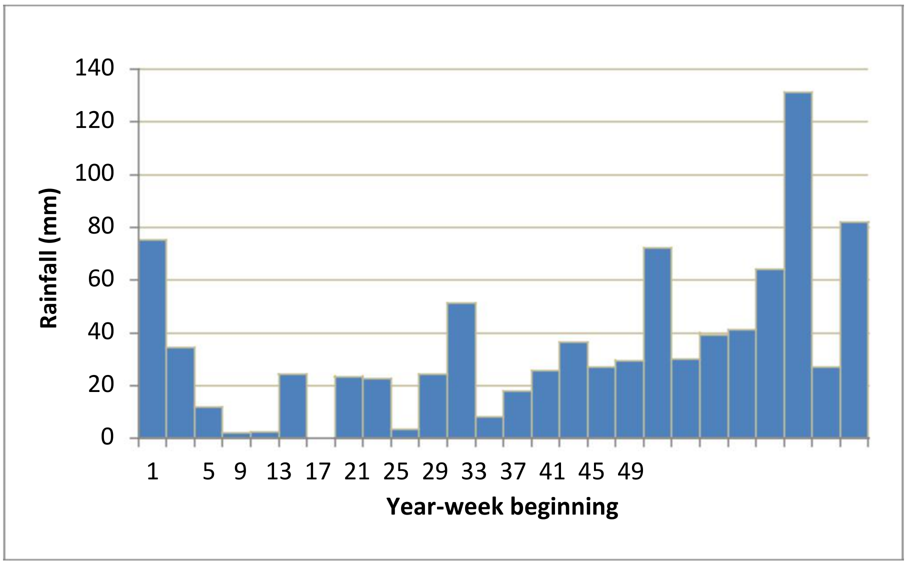

Figure 3. Rainfall amount at Forsinard weather station in 2017.

The rainfall amounts can be used to calculate a weighted average value for the year that combines the conductivity value with the matching quantity of rainfall. The weighted average was only slightly lower than the unweighted value at 45.7µS/cm but, in any case, the weighted average is the more appropriate value for use in the present context.

The conductivity of local rainfall sets the baseline value that is subsequently increased by passage of rain water through the catchments to streams. Comparing observed conductivity values relative to the baseline value shows more clearly the true extent of the differences between locations.

Figure 4 therefore shows the most informative summary of the survey data – the difference between the observed conductivity values and an assumed uniform value of 46 µS/cm for the average base-line conductivity of rainfall across the survey area.

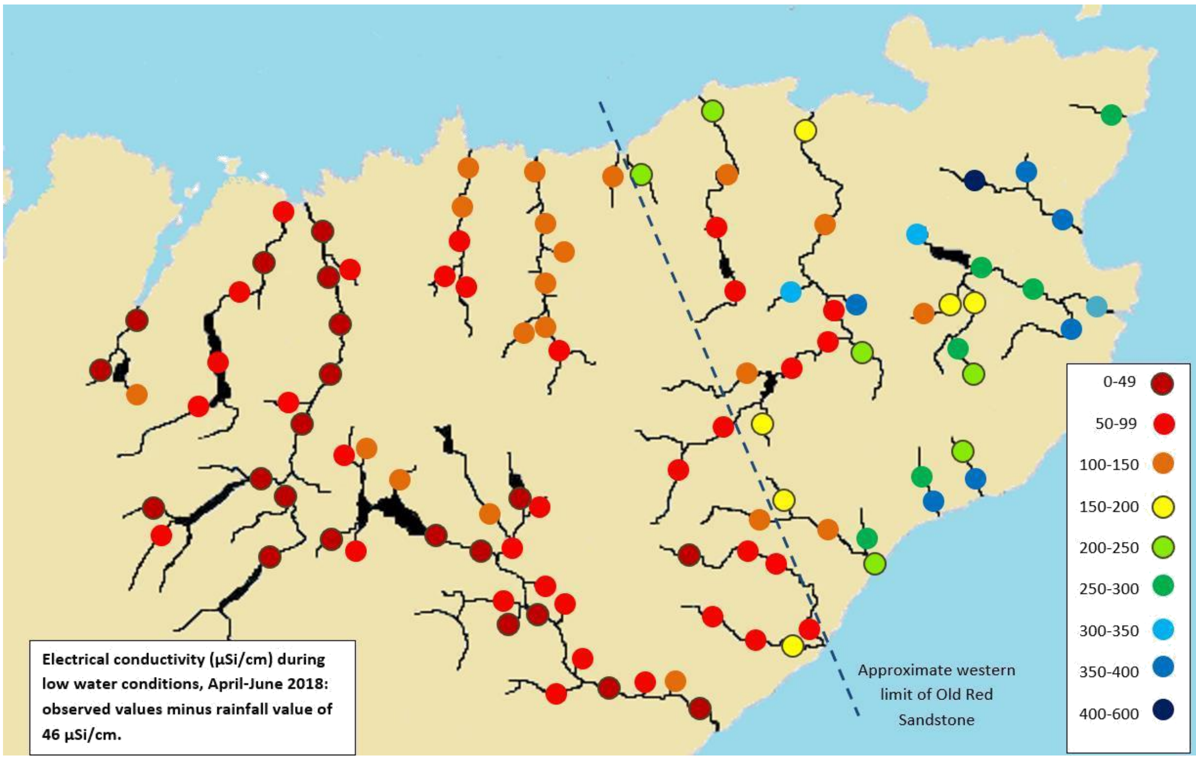

Figure 4. Conductivity values (µS/cm) for mainstem sites and major tributaries in the Northern rivers relative to an assumed rainfall base-line value of 46 µS/cm. The values are colour-coded by conductivity categories as per the inset key. The values for Berriedale/ Langwell and Dunbeath Rivers are adjusted upwards to compensate for their early survey date. The broken line indicates the approximate western limit of the Caithness sandstones.

Several notable features are evident from the figure. Under the stable low flow conditions in which the measurements were obtained -

1. For the Kinloch, Borgie, Naver and Helmsdale, conductivity values in the mainstem rivers were consistently low partly because the rivers were being driven by stored loch water issuing from high-capacity lochs in the upper catchments. Stored water is likely to be of low conductivity (see below).
2. Mainstem values tended to increase progressively in a downstream direction due to inputs of higher conductivity water issuing from tributaries. More generally, the conductivity of most rivers and streams tends to increase near the coast due to the residual effects of sea-spray driven inland in times of storm. Deposited salt is later delivered to rivers via inputs of correspondingly raised conductivity, particularly from sub-catchments close to the coast. Additionally, human populations and farming/ crofting tend to be concentrated along the coastal fringe in many of the northern river catchments. Both activities contribute to chemical enrichment of the lower parts of the some of the river catchments.
3. Figure 4 shows the approximate western limit of the continuous sedimentary bedrock (Old Red Sandstone) that covers Caithness

(http://mapapps.bgs.ac.uk/geologyofbritain/home.html). Conductivity values were generally higher to the east of the boundary, over the sandstones. To the west or south of the boundary, where the bedrocks are mostly of igneous or metamorphic origin, none of the conductivity values was greater than 200 µS/cm over the rainfall baseline and most were much lower. However, bedrock geology may not not be the only factor in play because the bedrock boundary is approximately coincident with the western boundary of the so-called "shelly tills" The shelly tills (they contain sea-shells) were scraped off the seabed of the Moray Firth during the last glaciation and deposited across the surface of the north-eastern part of the survey area by glaciers moving on-shore[1]. Presumably, because of their relatively recent marine origin, the shelly tills are still a potent source of soluble material for rainwater percolating through them.

The effect of large headwater lochs.

Table 1. Storage characteristics of river catchments with large headwater lochs.

River	River catchment area (km^2)	Mean annual discharge (m^3/s)	Headwater loch	Loch catchment area (km^2)	Loch volume ($m^3 \times 10^6$)	Days storage
Helmsdale	550	13	Badanloch complex	135	23	83
Naver	477	16	Lochs Naver	210	70	116
			Loch Choire	63	53	291
Borgie	139	4	Lochs Loyal/ Craggie	91	143	639
Kinloch	n/a	n/a	Loch an Dithreimh	26	39	~ 450

The presence of high-capacity headwater lochs weakens the link between rainfall and stream conductivity because of the lochs' capacity to store water over time. This can be examined more closely, as per Table 1, using data from the National River Flow Archive

[1] A.M. Hall and J.B. Riding (2016). The last glaciation in Caithness, Scotland: revised till stratigraphy and ice-flow paths indicate multiple ice flow phases. Scottish Journal of Geology 52/2, 77-89.

(http://nrfa.ceh.ac.uk/) and the Bathymetrical Surveys of Scottish Lochs, 1898-1909 (https://scotlandsplaces.gov.uk/digital-volumes/hydrographic-surveys/bathymetrical-surveys-scottish-lochs-1898-1909).

The Helmsdale catchment can be considered as an example. The current capacity of the Badanloch complex west of Kinbrace is around 23 million cubic meters (pers. comm. M. Wigan). SEPA estimates the catchment area of the Helmsdale to be 550 km^2 and the average annual discharge rate at the Helmsdale gauging station to be 13 m^3/s. According to the Bathymetrical Survey the catchment area of the Badanloch complex is about 135 km^2, or about 25% of the total area of the Helmsdale catchment. On this basis, the annual average discharge from Badanloch is likely to be around $3m^3/s$ and, when full, its storage capacity is therefore equivalent to around 83 days of discharge.

Using the same approach, it can be estimated that the combined capacity of the conjoined Lochs Loyal and Craggie at the head of the Borgie catchment is equivalent to about 640 days of storage. In the case of the Naver catchment, Loch Naver and Loch Choire have separate capacities of about 116 days and 291 days, respectively.

The Kinloch River is not gauged by SEPA and it is more difficult to estimate the equivalent values for Loch an Dithreimh. However, if the Kinloch's average annual discharge is assumed to be 50% of the Borgie value and if the loch's catchment area is taken to be 50% of total catchment area of Kinloch, then Loch an Dithreibh contains, very roughly, 450 days of storage.

Evidently, turnover of water in all these lochs is rather slow. This means that the water discharging from each of the lochs at the time of the survey (bearing in mind the lack of rainfall between April and June, 2018) had been stored over a period of months extending back into (and in some cases far beyond) the winter period of 2017-18. The conductivity of water leaving these lochs must be roughly equal to the average conductivity of all the water entering them. However, stored winter water will dominate the lochs' output due to high levels of winter precipitation and high inputs of low conductivity water from streams swollen by winter rain. As a result, even in early summer the conductivity of water leaving the lochs was very low – as indeed it probably always is.

Conclusions.

Kinloch, Borgie, Naver, Helmsdale and Berriedale/ Langwell form a set of relatively low conductivity rivers draining the land area in the west and southwest of the survey area. All these rivers lie over mostly igneous and metamorphic bedrocks and all, excepting Berriedale/ Langwell, are driven by headwater lochs discharging mostly winter water.

Moving eastwards along the north coast into Caithness, conductivity values in the Strathy and Halladale, and in the Sandside Burn at Reay, are still relatively low but apparently more benign than those measured further west. These rivers still drain areas of igneous and metamorphic bedrock but none of the group is fed by winter loch water.

The north-eastern part of the survey area lies over the sedimentary bedrocks and the shelly tills of Caithness. Conductivity values are consistently higher in all the north-eastern rivers. The highest values of all were observed in the Wick and Wester catchments probably, in part, because the effects of local farming and agriculture. However, the small Gill Burn catchment which adjoins the Wester catchment is not affected by farming. Although the conductivity of the Gill Burn was lower than in Wester, it was still very high (293 µS/cm over the rainfall baseline). Likewise, the Reisgill and Latheronwheel Burns south of Wick are not much impacted by farming but even in their upper reaches they show high conductivity values (207 and 282 µS/cm over the rainfall baseline, respectively).

This survey has identified variations in the hydrochemistry of the survey area's rivers and identified potential causes for what was observed. River conditions at the time of survey were extreme – indeed, the value of this particular survey depended on flows being low. In many cases, however, the conductivity values observed are not likely to be those that are experienced by fish and other organisms most of the time. When rainfall restores the rivers to their normal conditions, conductivity values are likely to fall although the extent of the changes will vary among locations. For example, ephemeral streams will become rapidly diluted by new rainfall but rivers below headwater lochs will probably remain much the same due to the high buffering capacity of the lochs.

The present survey covered extreme conditions that do not commonly occur. It will be a relatively simple matter to repeat this survey when the water table has been restored and normal flow conditions have been re-established. A repeat survey will document conductivity values more typical of those that fish routinely experience; the present survey will enable the results to be evaluated.

Acknowledgements

Thanks are due to John Mackay of the Trust for his help and support in the field, to all those who helped arrange access to the survey sites and to Wick Angling Association for the use of its vehicle.

Appendix.

*Dates and locations of survey and electrical conductivity values (*µSi/cm)

Date	River	Location	Place	Conductivity
21/04/2018	Langwell	ND 09691 22361	Turnal Burn	104
21/04/2018	Langwell	ND 08471 23216	Badnachie Burn	114
21/04/2018	Langwell	ND 07051 23141	Strathy Burn	79
21/04/2018	Langwell	ND 05996 23031	unnamed tributary	131
21/04/2018	Langwell	ND 04741 23506	Aultibea main	99
21/04/2018	Langwell	ND 04621 23801	Allt na Beithe	123
21/04/2018	Langwell	ND 03891 24121	Allt Staoine	149
21/04/2018	Langwell	ND 03846 24551	Allt na Luig	62
21/04/2018	Langwell	ND 01765 26006	Allt na Conlaich	110
21/04/2018	Langwell	ND 01580 26071	Allt Press Bhealaich	127
21/04/2018	Langwell	ND 00660 26286	Morven Burn	88
21/04/2018	Langwell	ND 00525 26051	Wagmore Main	88
21/04/2018	Langwell	ND 01990 25161	Main	94
21/04/2018	Langwell	ND 02015 24991	Allt na Laoighe	78
21/04/2018	Langwell	ND 01985 24496	Big Garvery Burn	101
21/04/2018	Langwell	ND 02020 24466	Little Garvery Burn	130
21/04/2018	Langwell	ND 02725 25071	unnamed tributary	71
21/04/2018	Langwell	ND 03896 24126	Fall Burn	150
21/04/2018	Langwell	ND 11517 22541	Langwell Main	121
24/06/2018	Langwell	ND 11590 22560	Langwell Main	168
22/04/2018	Berriedale	ND 11822 22906	Berriedale Main	98
22/04/2018	Berriedale	ND 10247 24546	Dun Burn	92
22/04/2018	Berriedale	ND 10937 25551	unnamed tributary	112
22/04/2018	Berriedale	ND 11022 25481	Millery Main	85
22/04/2018	Berriedale	ND 08016 30281	Allt an Dealain	208
22/04/2018	Berriedale	ND 07411 30356	Braemore Main	85
22/04/2018	Berriedale	ND 07296 30141	Allt Aoil	70
22/04/2018	Berriedale	ND 03721 29806	Allt Cam-sguaibe	104
22/04/2018	Berriedale	ND 03646 29986	Allt na Greighe	82
22/04/2018	Berriedale	ND 03401 29746	Chorrichoich Main	81
22/04/2018	Berriedale	ND 02480 29491	Allt Coire Rhiabhaich	108
22/04/2018	Berriedale	ND 02030 29906	Allt Bad a Chaoruinne	147
22/04/2018	Berriedale	NC 98417 31340	Feith Gainemh Mhor	69
22/04/2018	Berriedale	NC 98437 31296	Feith Chaorunn Mhor	81
22/04/2018	Berriedale	NC 98690 31106	Gobernuisgach Main	74
22/04/2018	Berriedale	NC 99690 30736	Feith Fhuaran	74
24/06/2018	Berriedale	ND 07280 30400	Braemore Main	114
24/06/2018	Berriedale	ND 07980 30260	Allt an Dealain	329
24/06/2018	Berriedale	ND 11800 22780	Berriedale Main	120

03/05/2018	Dunbeath	ND 15935 29935	Hatchery main	238
03/05/2018	Dunbeath	ND 15630 30405	Houstry Burn	218
03/05/2018	Dunbeath	ND 15935 29935	Houstry main	167
12/05/2018	Dunbeath	ND 15935 29935	Hatchery main	220
12/05/2018	Dunbeath	ND 15630 30405	Houstry Burn	258
12/05/2018	Dunbeath	ND 15590 30405	Main	174
12/05/2018	Dunbeath	ND 14319 30785	Achorn Burn	140
12/05/2018	Dunbeath	ND 14339 30785	Main	152
12/05/2018	Dunbeath	ND 12884 32055	Garbh Leathad	102
12/05/2018	Dunbeath	ND 12809 32100	Main	138
12/05/2018	Dunbeath	ND 12498 32425	Culvid	218
12/05/2018	Dunbeath	ND 12503 32450	Main	132
12/05/2018	Dunbeath	ND 12243 32650	Allt Ruad	103
12/05/2018	Dunbeath	ND 12268 32690	Main	137
12/05/2018	Dunbeath	ND 11523 32885	unnamed tributary	141
12/05/2018	Dunbeath	ND 11543 33011	Main	138
12/05/2018	Dunbeath	ND 11373 33096	Wag Burn	123
12/05/2018	Dunbeath	ND 11373 33121	Main	137
12/05/2018	Dunbeath	ND 11203 33156	Settlement Burn	164
12/05/2018	Dunbeath	ND 11198 33191	Main	137
12/05/2018	Dunbeath	ND 10958 33551	Allt Fuaran	196
12/05/2018	Dunbeath	ND 10923 33536	Main	137
12/05/2018	Dunbeath	ND 10713 33656	Leathad Breac	129
12/05/2018	Dunbeath	ND 10688 33611	Main	138
12/05/2018	Dunbeath	ND 10478 33676	10478 33676	116
12/05/2018	Dunbeath	ND 10482 33686	Main	139
12/05/2018	Dunbeath	ND 10052 36671	Achnaclyth Farm	140
12/05/2018	Dunbeath	ND 09552 33646	Polroy Burn	134
12/05/2018	Dunbeath	ND 09542 33696	Raffin Burn	179
24/06/2018	Dunbeath	ND 15930 29940	Hatchery main	277
24/06/2018	Dunbeath	ND 15630 30410	Houstry Burn	311
24/06/2018	Dunbeath	ND 15460 30420	Houstry main	227
28/05/2018	Thurso	ND 07781 42707	Backlass Burn	209
28/05/2018	Thurso	ND 08476 44767	Achscoriclate Burn	190
01/06/2018	Thurso	NC 98692 40727	Upper Rumsdale Burn	107
01/06/2018	Thurso	NC 99047 40872	Allt a Chaol-dhall	135
01/06/2018	Thurso	NC 99957 40847	Allt Loch na Nighinn	173
01/06/2018	Thurso	ND 00523 39937	Lower Rumsdale Burn	112
01/06/2018	Thurso	ND 00563 39187	Dalganachan main	101
01/06/2018	Thurso	ND 00045 37771	Allt Coille	101
01/06/2018	Thurso	NC 99932 37396	Saovie Burn	94
01/06/2018	Thurso	ND 00122 36961	Glutt main	97
01/06/2018	Thurso	ND 07336 46276	Sleeoch	154
01/06/2018	Thurso	ND 11597 48076	Old Woman's Pool main	106

02/06/2018	Thurso	ND 13457 52761	Achlachan Burn	411
02/06/2018	Thurso	ND 14357 49026	Dalemore	107
02/06/2018	Thurso	ND 14672 48926	Little River	267
02/06/2018	Thurso	ND 10127 53231	Braehour Burn	370
02/06/2018	Thurso	ND 13037 51891	Westerdale main	132
02/06/2018	Thurso	ND 12952 59541	Halkirk main	158
03/06/2018	Thurso	ND 11197 67211	Thurso town	197
05/05/2018	Wick	ND 20982 50984	Black Burn	319
05/05/2018	Wick	ND 20577 50944	Loch Burn	271
05/05/2018	Wick	ND 20582 50843	Acharole	158
05/05/2018	Wick	ND 24014 53499	Achingale	236
05/05/2018	Wick	ND 24159 53584	Strath	210
01/06/2018	Wick	ND 20278 59576	Stemster Burn	370
01/06/2018	Wick	ND 24759 55006	Watten Loch outlet	340
01/06/2018	Wick	ND 34449 51896	Fairies Hillock main	393
02/06/2018	Wick	ND 32249 48886	Haster Burn	404
02/06/2018	Wick	ND 28249 53606	Bilbster main	346
02/06/2018	Wick	ND 24011 47093	Camster lower	340
02/06/2018	Wick	ND 26294 42571	Camster upper	256
06/05/2018	Forss	ND 05370 52429	Torran	125
02/06/2018	Forss	ND 03501 60116	Broubster	140
02/06/2018	Forss	ND 04701 66256	Lythmore	218
03/06/2018	Forss	ND 03031 69816	Forss Bay	248
10/06/2018	Halladale	NC 89413 63271	Melvich Bridge	186
10/06/2018	Halladale	NC 90257 59650	main river	155
10/06/2018	Halladale	NC 89553 57651	Smigel Burn	177
10/06/2018	Halladale	NC 89153 55591	Millburn	157
10/06/2018	Halladale	NC 89533 52111	Dyke	159
10/06/2018	Halladale	NC 89633 52031	Dyke main	159
10/06/2018	Halladale	NC 90053 49551	Forsinain Bridge	157
10/06/2018	Halladale	NC 90693 48541	Forsinain Burn	178
10/06/2018	Halladale	NC 90623 48396	Forsinain main	149
10/06/2018	Halladale	NC 89398 45056	Ewe Burn	193
10/06/2018	Halladale	NC 89537 45008	Forsinard main	130
10/06/2018	Helmsdale	NC 87338 34536	Bannock Burn	121
10/06/2018	Helmsdale	NC 85127 31056	Strathbeg bridge	131
10/06/2018	Helmsdale	NC 83405 31716	main	72
10/06/2018	Helmsdale	NC 74005 39961	Rimsdale	129
17/06/2018	Helmsdale	ND 02185 16891	main	87
17/06/2018	Helmsdale	ND 01515 17676	Caen Burn	129
17/06/2018	Helmsdale	ND 01485 17536	Caen main	90
17/06/2018	Helmsdale	NC 98965 18711	Kilpheder Burn	166

17/06/2018	Helmsdale	NC 98380 18406	Eldrable Burn	93
17/06/2018	Helmsdale	NC 98355 18436	Eldrable main	86
17/06/2018	Helmsdale	NC 96924 18851	Torrish Burn	115
17/06/2018	Helmsdale	NC 95864 18681	Allt Breac	116
17/06/2018	Helmsdale	NC 94884 18756	Balvalaich main	85
17/06/2018	Helmsdale	NC 92058 18766	Kilearnan Burn	84
17/06/2018	Helmsdale	NC 91273 19291	Craggie Water	103
17/06/2018	Helmsdale	NC 91123 21046	Kildonan Burn	109
17/06/2018	Helmsdale	NC 90023 23791	Suisgill main	82
17/06/2018	Helmsdale	NC 89803 25146	Suisgill Burn	115
17/06/2018	Helmsdale	NC 87138 26941	Borrobol main	80
17/06/2018	Helmsdale	NC 86997 26671	Ascaig Burn	94
17/06/2018	Helmsdale	NC 86987 26771	Abhainn na Frithe	120
17/06/2018	Helmsdale	NC 87418 28481	Kinbrace Burn	117
17/06/2018	Helmsdale	NC 86727 30221	Burnfoot Burn	129
17/06/2018	Helmsdale	NC 85127 31041	Strathbeg Bridge	131
17/06/2018	Helmsdale	NC 83405 31716	main	72
17/06/2018	Helmsdale	NC 78746 37721	Feith a Chreagain	200
17/06/2018	Helmsdale	NC 77886 38531	Garbh Allt	177
17/06/2018	Helmsdale	NC 76800 39126	unnamed tributary	143
17/06/2018	Helmsdale	NC 86117 32396	Claggan Burn	104
17/06/2018	Helmsdale	NC 86227 32386	Bannock Burn main	124
17/06/2018	Helmsdale	NC 87338 34536	Bannock Burn	118
19/06/2018	Helmsdale	NC 79046 33301	Badanloch outflow	69
19/06/2018	Helmsdale	NC 78858 32766	Allt nam Meann	152
19/06/2018	Helmsdale	NC 75086 32896	Allt Fearne	153
19/06/2018	Helmsdale	NC 73156 32106	Gearnsary	103
19/06/2018	Helmsdale	NC 71824 31141	An Gorm Alt	122
19/06/2018	Helmsdale	NC 71574 30981	unnamed tributary	107
19/06/2018	Helmsdale	NC 70914 30961	unnamed tributary	83
19/06/2018	Helmsdale	NC 69634 30836	Malmadarie Burn	64
26/06/2018	Helmsdale	NC 72607 39931	Allt Lon a Chuil	142
26/06/2018	Helmsdale	NC 73985 39960	Rimsdale Burn	146
26/06/2018	Helmsdale	NC 76295 39400	Allt Chreimh	156
26/06/2018	Helmsdale	NC 87099 35532	Loch an Ruathair	82
10/06/2018	Naver	NC 69534 43911	Syre main	68
10/06/2018	Naver	NC 67918 38891	lower Mallart	59
10/06/2018	Naver	NC 66983 37836	main at Mallart	58
10/06/2018	Naver	NC 56880 35675	Mudale	78
10/06/2018	Naver	NC 56780 35055	Allt na Aire	111
10/06/2018	Naver	NC 72204 53916	Achargary main	80
10/06/2018	Naver	NC 72229 50911	Carnachy main	77
10/06/2018	Naver	NC 71894 48011	Rough Haugh main	73
10/06/2018	Naver	NC 71389 59315	Leckfurin main	91
10/06/2018	Naver	NC 71614 57435	Skelpick Burn	139

19/06/2018	Naver	NC 68843 30961	unnamed tributary	60
19/06/2018	Naver	NC 68303 31021	unnamed tributary	67
19/06/2018	Naver	NC 66873 31926	upper Mallart	57
19/06/2018	Naver	NC 66793 31501	unnamed tributary	72
19/06/2018	Naver	NC 66583 31491	Allt na Sroine	53
26/06/2018	Naver	NC 71820 54992	Achcheargary Burn	126
26/06/2018	Naver	NC 72153 51443	Carnachy Burn	150
26/06/2018	Naver	NC 71657 47874	Skail Burn	167
26/06/2018	Naver	NC 69506 44781	Langdale Burn	128
19/06/2018	Strathy	NC 89448 63126	Strathy Bridge	159
19/06/2018	Strathy	NC 83259 62501	Strathy main	151
19/06/2018	Strathy	NC 82632 61031	Bowside Lodge	141
19/06/2018	Strathy	NC 82567 59631	Dallangwell main	136
19/06/2018	Strathy	NC 82652 56481	Strathy main	144
19/06/2018	Strathy	NC 82519 56339	Strathy main	143
19/06/2018	Strathy	NC 82737 56326	Uair	141
19/06/2018	Reay	NC 97705 64976	Achvarasdale Burn	279
19/06/2018	Reay	NC 95714 64641	Sandside Burn	182
23/06/2018	East Caithness	ND 36885 67782	Gill Burn	339
24/06/2018	East Caithness	ND 24150 35720	Reisgill Burn lower	411
24/06/2018	East Caithness	ND 21560 39410	Reisgill Burn upper	253
24/06/2018	East Caithness	ND 18970 32210	Latheronwheel lower	413
24/06/2018	East Caithness	ND 17950 35940	Latheronwheel upper	328
02/06/2018	East Caithness	ND 27214 61596	Hastigrow	582
02/06/2018	East Caithness	ND 33204 58576	Wester Bridge	438
03/06/2018	East Caithness	ND 29564 62676	Barrock Mill	399
26/06/2018	Kinloch	NC 55703 52310	Lodge main	82
26/06/2018	Kinloch	NC 53597 50035	Allt Luib Moire	71
26/06/2018	Kinloch	NC 53843 50083	Main at footbridge	73
26/06/2018	Kinloch	NC 53165 49537	unnamed tributary	77
26/06/2018	Kinloch	NC 53189 49484	Allt a Luib Moire	66
26/06/2018	Kinloch	NC 53164 46822	Allt an Achaidh Mhoir	111
26/06/2018	Kinloch	NC 53984 46858	Allt a Dithreibh	166
26/06/2018	Kinloch	n/a	Loch an Dithriebh	70
10/06/2018	Borgie	NC 59756 44235	Inchkinloch	111
10/06/2018	Borgie	NC 61476 50875	Loyal/ Craggie junction	85
10/06/2018	Borgie	NC 65347 54615	Dalness	89
10/06/2018	Borgie	NC 66918 58815	Borgie Bridge	104
10/06/2018	Borgie	NC 68128 61045	Crossburn	104