UCL ENVIRONMENTAL CHANGE RESEARCH CENTRE

Surface-water Acidity in the River Dart Area

Report for the West Country Rivers Trust

ECRC Research Report Number 154

R. W. Battarbee, E. M. Shilland, G. L. Simpson, J. Salgado, B. Goldsmith, W. Gray & S. D. Turner

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2013

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Introduction

This report on the acidification of headwater streams of the River Dart follows the structure of the staged contract agreed with the West Country Rivers Trust (WCRT). Here we provide our responses to Stage 1 and Stage 2 of the contract. All tasks under Stage 1 and 2 have been completed. This report also refers to the ACCESS chemistry database already submitted to WCRT.

Stage 1:

"Is the situation on pH Dartmoor Natural? If yes then we need go no further because we would not want to seek to remediate a natural situation or is it anthropogenic? I.e. the pH is low due to a history of exceedance of critical loads for many years (if yes then we can proceed to stage 2)"

1. Collate, organise and inspect all existing historic water chemistry data for Dartmoor including critical load assessments

The chemical data we have assembled so far for Dartmoor and the Dartmoor region are presented in the ACCESS database provided to WCRT by Ewan Shilland. The database includes the following data-sets:

- UCL data from the original UK critical loads survey carried out by ENSIS-UCL under contract to the DETR (now Defra) in 1987 and 1988. The water samples were analysed by the Freshwater Fisheries Laboratory in Pitlochry and the results are identified in the database under the Chem Lab heading "MS" and coded CZSX or SSX in the database and Table 1 below.
- UCL data from the 2012 survey of Dartmoor streams carried out by ENSIS-UCL under this contract with chemistry analysed at UCL and identified in Table 1 and the database as "UCL" with DLP codes.
- CEH data from a survey of surface waters in the Dart catchment in 1998-1999 carried out by Chris Evans (Evans *et. al.*, 2001; Evans, Cooper, and Gannon, 2001) under contract to National Power, PowerGen, the Western Power Generation Programme and DETR, and identified in the database and Table 1 as "CEH" with CE codes.
- Environment Agency pH time-series data from several streams in the Dart catchment that have been continuously monitored for many years, although with differing start dates, and shown in the Database as a separate table headed "EApHdata". These sites are coded EA in Table 1. The data were supplied by the Environment Agency via Dylan Bright (WCRT).
- Acid Waters Monitoring Network (AWMN) data for the Narrator Brook for 2012. Narrator Brook has been an AWMN monitoring site since 1988. The full time-series data can be found in Shilland *et. al* (2012) and on the AWMN website (http://awmn.defra.gov.uk/resources/datasheets/site14_chem.pdf).

We have carefully checked the historical chemical data produced by third parties that are listed in the database and have found no obvious analytical errors. All site locations are shown in Google maps: http://goo.gl/maps/Ayx6e.

2. Collect, filter, and freeze water samples from 20 agreed locations including former CLAG sites and former sites in the Dart headwaters

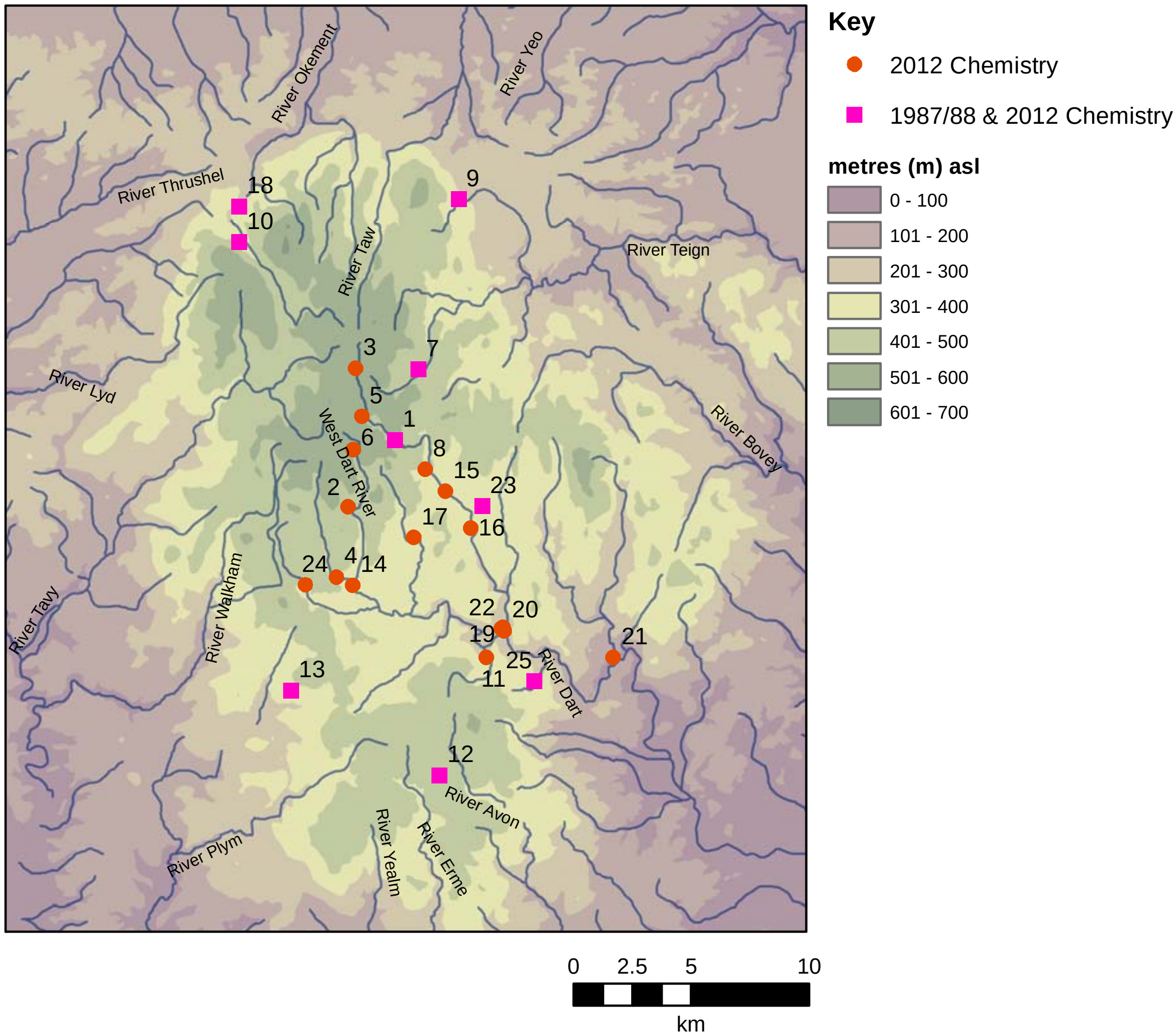
Using all available data we selected 25 sites for full water chemistry (Table 1, Figure 1 and Appendix 1) including nine sites used in the original critical loads campaign of 1987-88, five sites used by CEH in their 1998-1999 project, three EA pH monitoring sites, two sites sampled by Wilson in 2002-2003 (Wilson, 2004) and six new sites sampled by ENSIS-UCL in 2012. The old ENSIS-UCL 1987-1988 sites were included to enable a comparison between past and present chemistry, and the new sites were selected to represent a downstream gradient in alkalinity from the most acidic streams in the headwaters to the less acidic ones below the moorland boundary. Five additional previously sampled sites, easily accessible during the water sampling programme in 2012, were sampled for field chemistry only (Table 1 and Appendix 1).

Sampling was carried out in April 2012 by Ben Goldsmith and James Shilland. pH, water temperature and conductivity were measured in the field and samples of stone biofilm were taken for diatom analysis (to be analysed under a separate in-house UCL project on diatom biodiversity). Details of the field survey and results from field measurements are shown in the ACCESS database table headed "Field Survey" and Appendix 1. Water samples for laboratory analysis were filtered using a 0.45µm GFC filter, divided into two sub-samples and stored in a freezer at -18^{o} C at UCL.

Table 1 Water chemistry sampling sites 2012

Site Name	Site_Code	Sampling date	OS_GRIDREF	REMARKS
1_East Dart	SSX68	19/04/2012	SX 62600 81100	
2_West Dart	DLP5	19/04/2012	SX 60617 78286	
3_East Dart	DLP3	19/04/2012	SX 60937 84159	
4_Beardown Farm	EA6	20/04/2012	SX 60114 75311	
5_East Dart	DLP2	19/04/2012	SX 61203 82113	
6_West Dart	DLP4	19/04/2012	SX 60822 80714	
7_N. Teign River	CZSX68	19/04/2012	SX 63600 84100	
8_East Dart	DLP1	19/04/2012	SX 63875 79870	
9_Shilley Pool	CZSX69	23/04/2012	SX 65300 91300	
10_West Okement Weir Pool	CZSX58	23/04/2012	SX 56000 89500	
11_O'Brook	CE16	19/04/2012	SX 66468 71916	
12_Red Lake	CZSX66	20/04/2012	SX 64500 66900	
13_Crazywell Pool	CZSX57	20/04/2012	SX 58200 70500	
14_West Dart	EA5	20/04/2012	SX 60811 74973	
15_East Dart	CE8	19/04/2012	SX 64751 78935	
16_Bellever	CE9	19/04/2012	SX 65823 77390	
17_Cherry Brook	CE10	20/04/2012	SX 63405 76990	
18_Meldon Reservior	CZSX59	23/04/2012	SX 56000 91000	
19_Clapper Bridge	EA10	19/04/2012	SX 67193 73190	
20_Dartmeet	DLP6	19/04/2012	SX 67230 73041	
21_Above Mistresses Piece	WW4	19/04/2012	SX 71880 71902	
22_Dartmeet	WW2	19/04/2012	SX 67121 73119	
23_Pizwell brook	SSX67	19/04/2012	SX 66300 78300	
24_Black Brook	CE13	20/04/2012	SX 58806 74981	
25_Venford Reservoir	CZSX67	19/04/2012	SX 68500 70900	
Swincombe	CE14	19/04/2012	SX 64688 73150	Field chemistry only
Lower Cherrybrook bridge	WW11	19/04/2012	SX 63121 74832	Field chemistry only
Babeney	CE15	19/04/2012	SX 67342 75085	Field chemistry only
Moorlands Farm	EA7	19/04/2012	SX 62591 73862	Field chemistry only
Walla Brook	CE7	19/04/2012	SX 66848 78906	Field chemistry only

Sites ordered by ascending Ca, as measured in April 2012 survey.



Relief data from OS OpenData Landform PANORAMA
Contains Ordnance Survey data © Crown copyright and database right 2010

Rivers data from ShareGeo Open (http://hdl.handle.net/10672/85)

Figure 1. Map of 2012 water chemistry sampling points. Numbers refer to Table 1.

3. Analyse samples for all determinands needed to calculate SSWC critical loads

Calculation of critical loads for acidity using the Steady State Water Chemistry (SSWC) method is based on the difference between base cations (Ca, Mg, Na, K) and acid anions (SO_4, Cl, NO_3). Base cations were measured by ICP_AES and acid anions were measured by ion chromatography (IC). The results are shown in the ACCESS database table headed “Chemistry_Master” and designated as “UCL” in the ChemLab column. In Figure 2 to Figure 8 cation and anion data for the samples analysed are shown.. All sites are arranged in ascending order of Ca, as measured in the 2012 survey. Sea-salt corrected sulphate data (used in the critical loads calculations) are shown in Figure 9. Field pH measurements are provided in Figure 10. Key features of the data are the low Ca concentrations for many of the sites, indicating their sensitivity to acidification, and the relatively low but nevertheless significant concentrations of non-marine sulphate indicating the continuing influence of acid deposition and its legacy in this area. Nitrate levels at many sites are also above background suggesting that N leaching is also taking place and contributing to the acidity of the streams. The very low pH at some sites is probably related not only to sulphate and nitrate concentrations associated with acid deposition and its legacy but also to the presence of organic acidity (as dissolved organic carbon (DOC) (not measured)), typical of waters draining upland peaty soils.

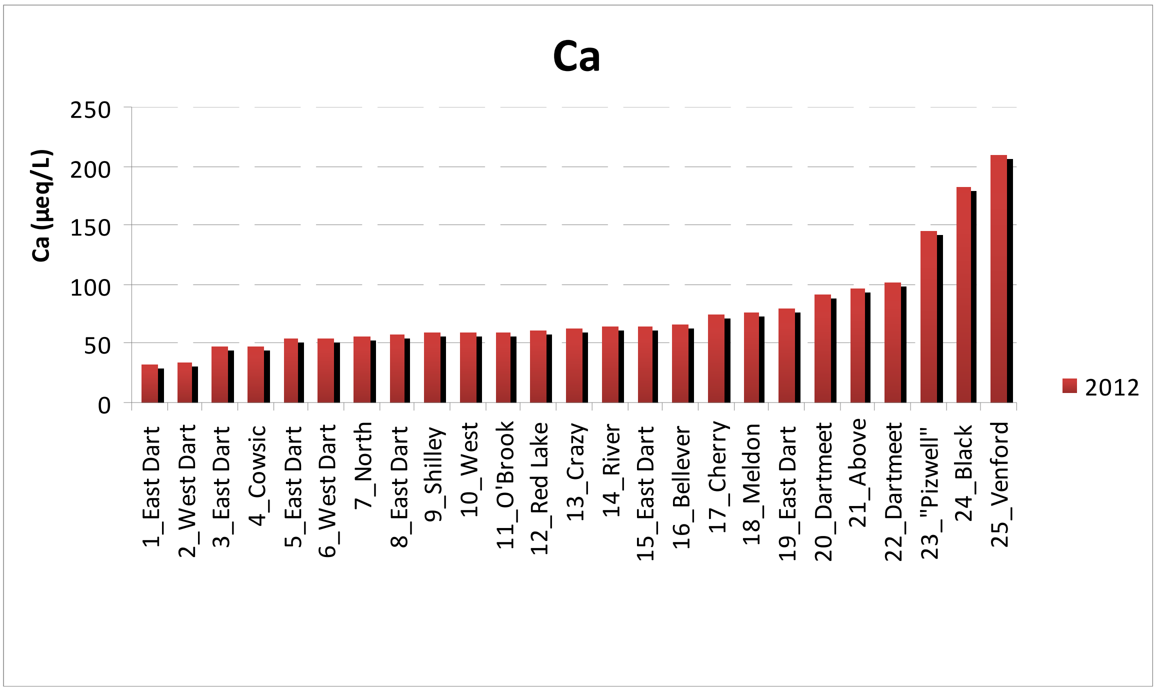


Figure 2. Calcium concentrations for water samples collected in April 2012 from Dartmoor streams

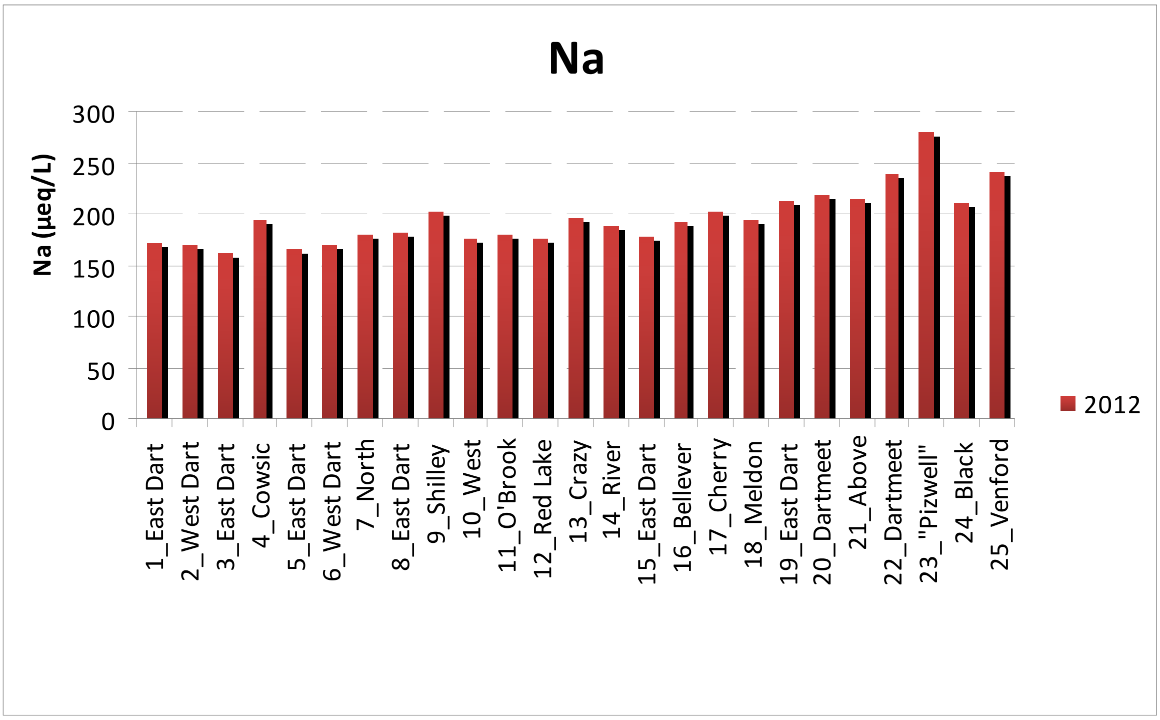


Figure 3. ***Sodium concentrations for water samples collected in April 2012 from Dartmoor streams***

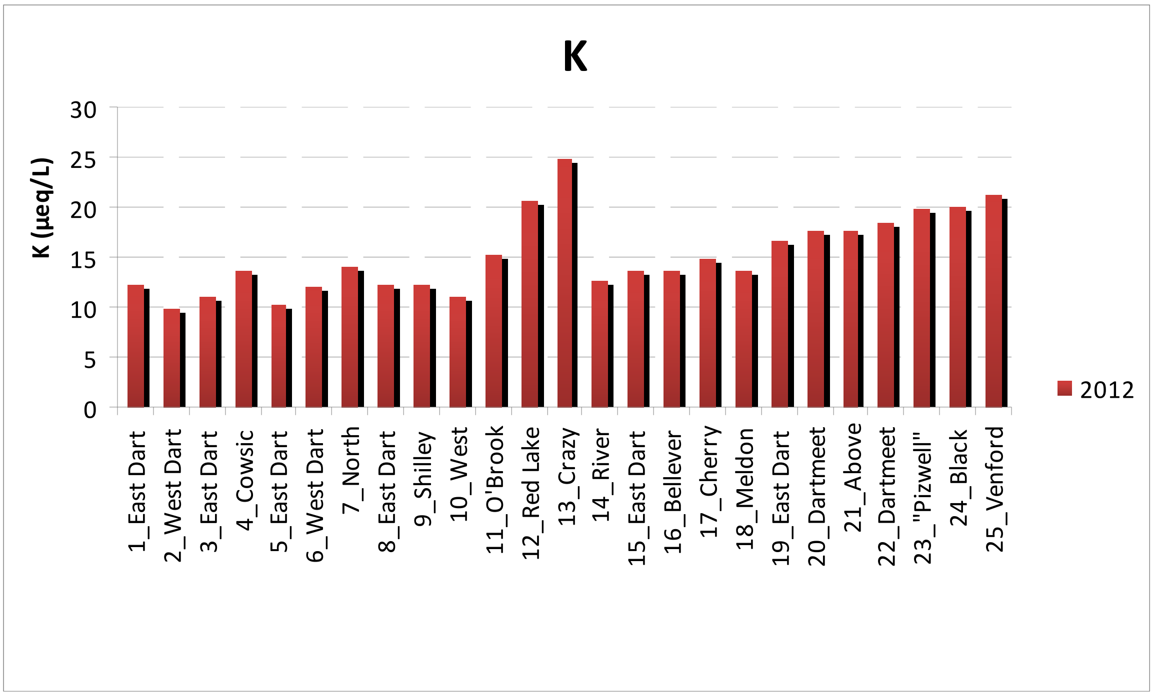


Figure 4. ***Potassium concentrations for water samples collected in April 2012 from Dartmoor streams***

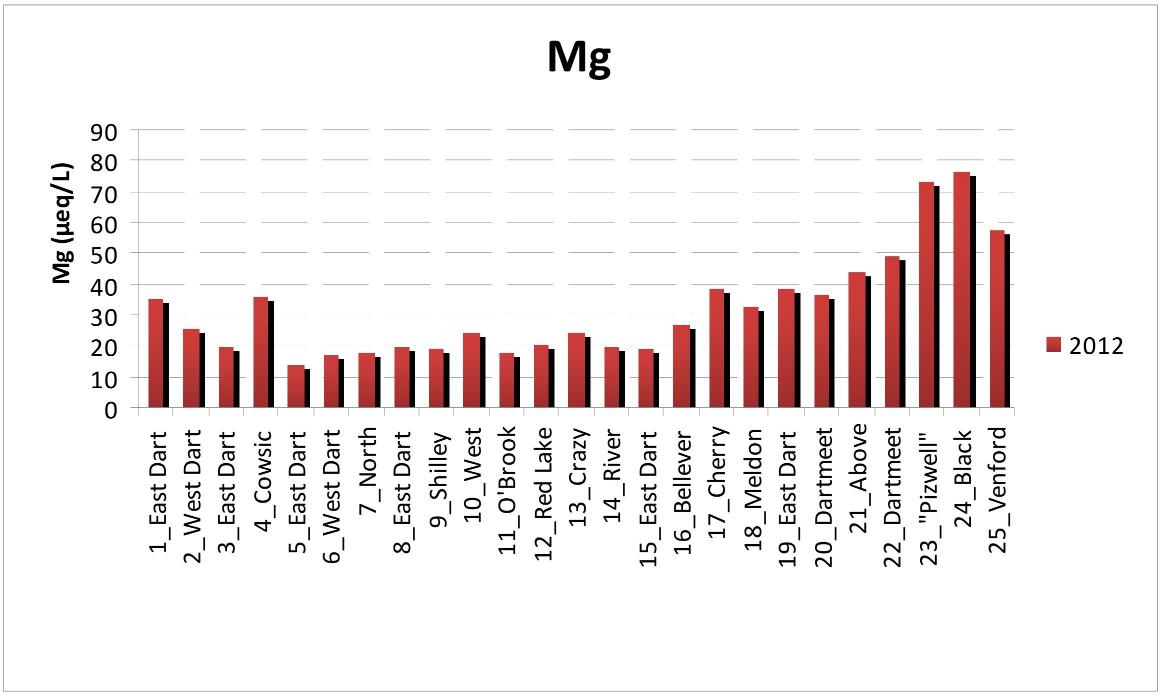


Figure 5. ***Magnesium concentrations for water samples collected in April 2012 from Dartmoor streams***

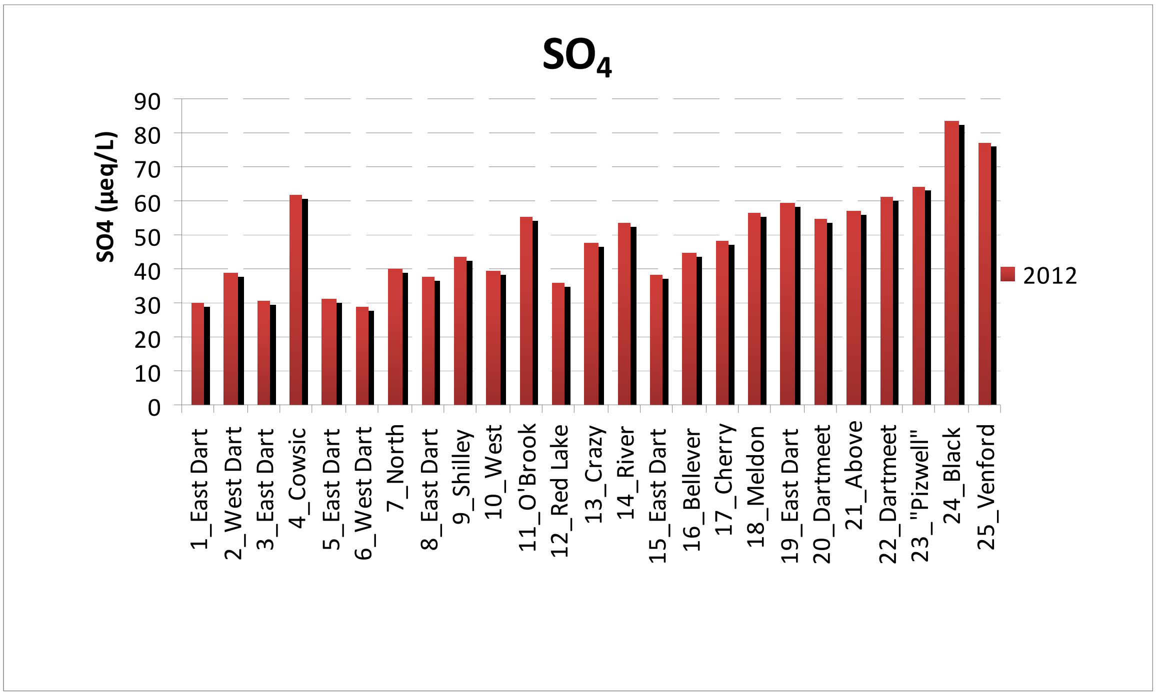


Figure 6. ***Sulphate concentrations for water samples collected in April 2012 from Dartmoor streams***

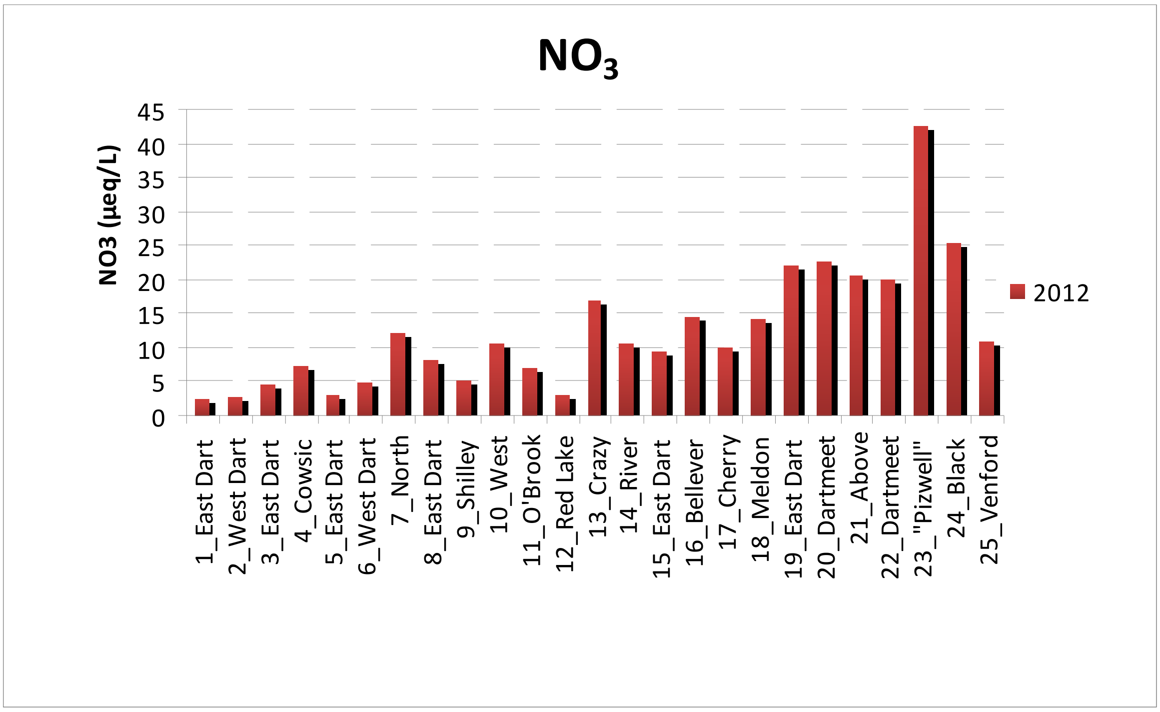


Figure 7. ***Nitrate concentrations for water samples collected in April 2012 from Dartmoor streams***

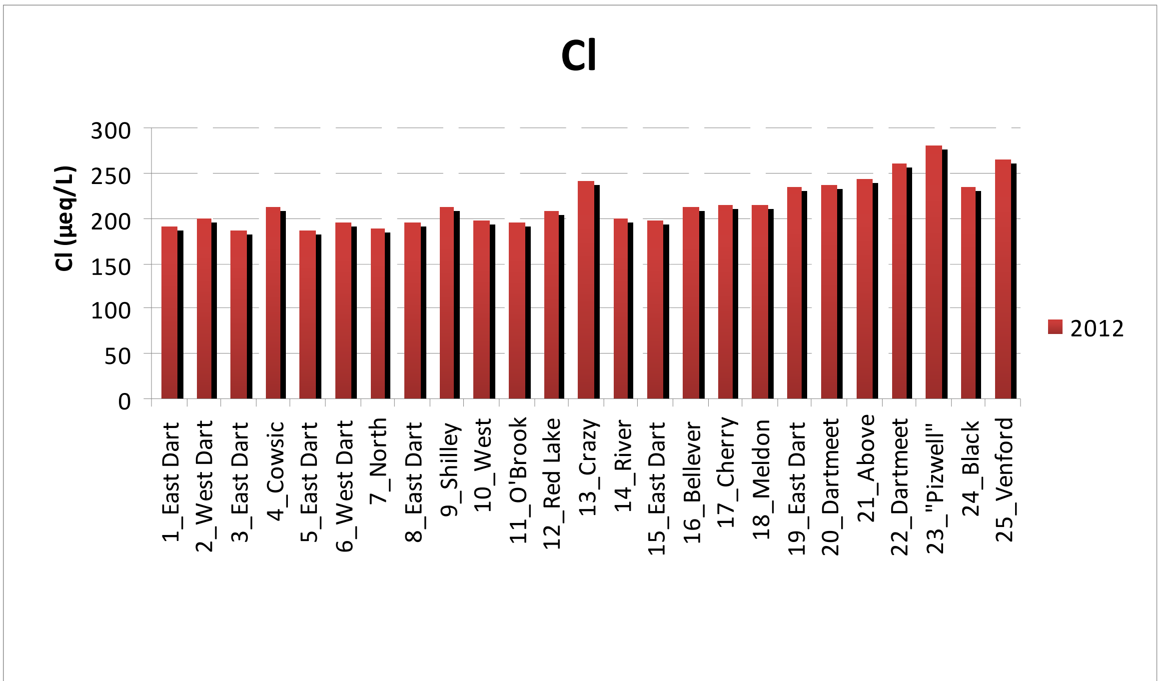


Figure 8. ***Chloride concentrations for water samples collected in April 2012 from Dartmoor streams***

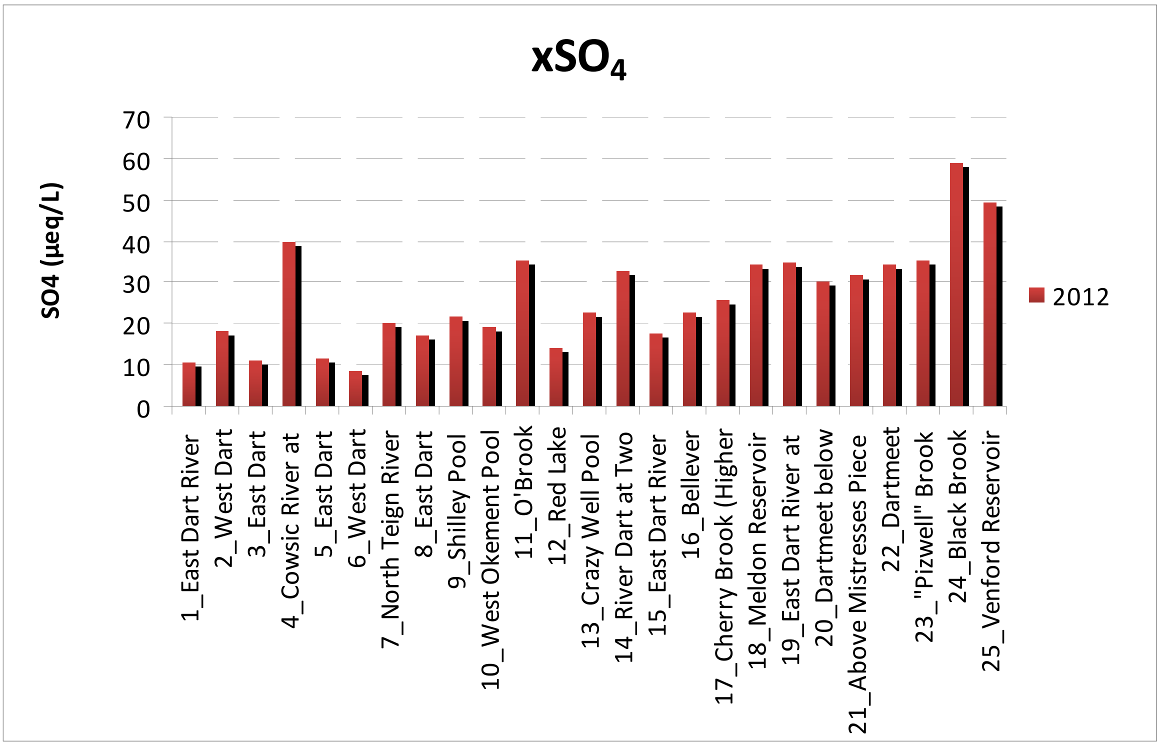


Figure 9. Non-marine sulphate concentrations for water samples collected in April 2012 from Dartmoor streams*.*

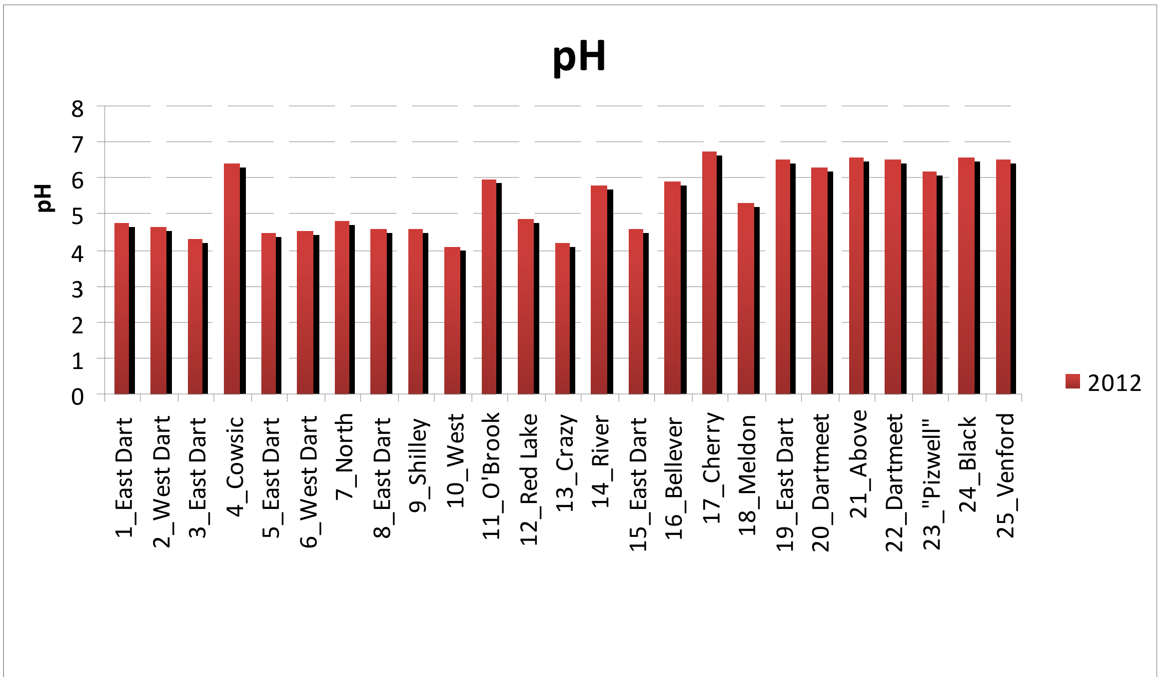


Figure 10. ***pH for water samples collected in April 2012 from Dartmoor streams***

4. Calculate reference and present day ANC for the new 2012 samples and calculate critical load exceedance for them for the present day and 2020.

Acid Neutralising Capacity (ANC) for the 2012 data was calculated using the ion balance approach by subtracting the sum of acid anions from the sum of base cations. The reference ANC was calculated assuming that nitrate concentrations prior to acidification were zero and non-marine sulphate concentrations were at a low background level (allowing a natural non-marine component e.g. due to volcanism). Figure 11 compares these ANC values. The data indicate that the reference ANC for all Dart headwaters except site 2 is greater than 30 µeq/l, whereas current values for many sites remain significantly below this value indicating those waters that remain acidified (according to the assumptions made).

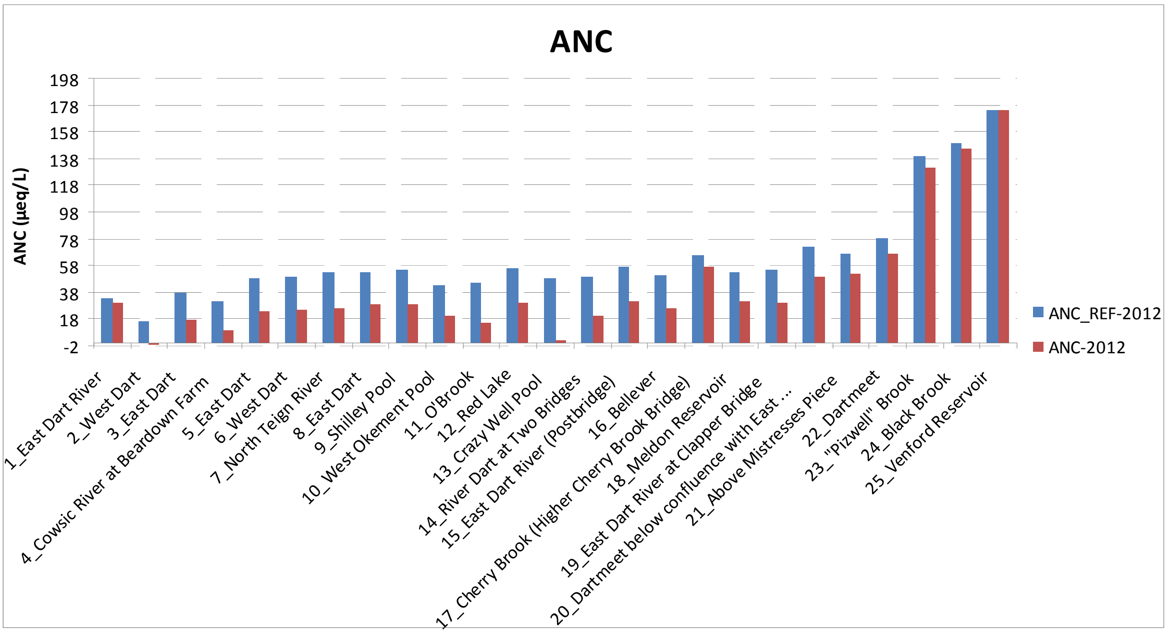


Figure 11. ***Histograms of ANC ref and ANC 2012 for the 25 sites analysed in 2012***

Critical load calculations were carried out on the data using ANC 20 as the critical value (ANC_{crit}) according to the national UK protocol (cf RoTAP 2012). Exceedance values are based on current (CBED 09-11) and future (FRAME 2020) S and N deposition data (provided courtesy of Jane Hall, CEH). The calculations presented here assume that deposition at all sites is to a moorland ecosystem. Adjustments for the proportion of stream catchments that are afforested need to be made when data on land-cover become available. The effect of such adjustments would be to increase the exceedance values as deposition over wooded surfaces are higher than over grassland ones. The results for the two dates are mapped in Figure 12 and the values are compared on a site by site basis in Figure 13. The map uses the colour coding system of the UNECE in which black represents the highest exceedance and blue represents sites that are not exceeded. Units are in keq H^+ ha^{-1} yr^{-1}.

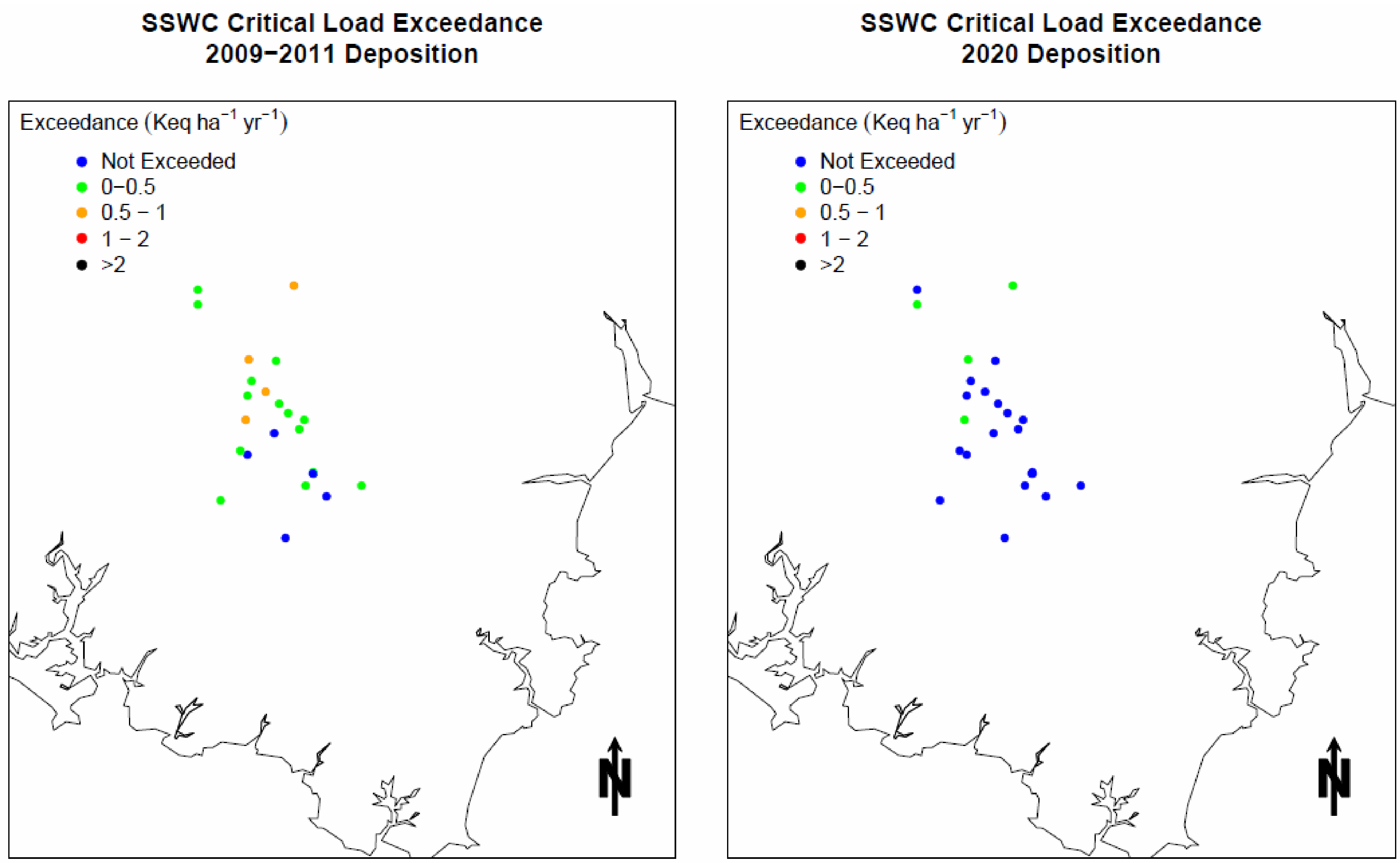


Figure 12. ***Critical load exceedance for the 25 sites sampled in 2012 for 2009-2011 and 2020 deposition respectively based on 2012 chemistry.***

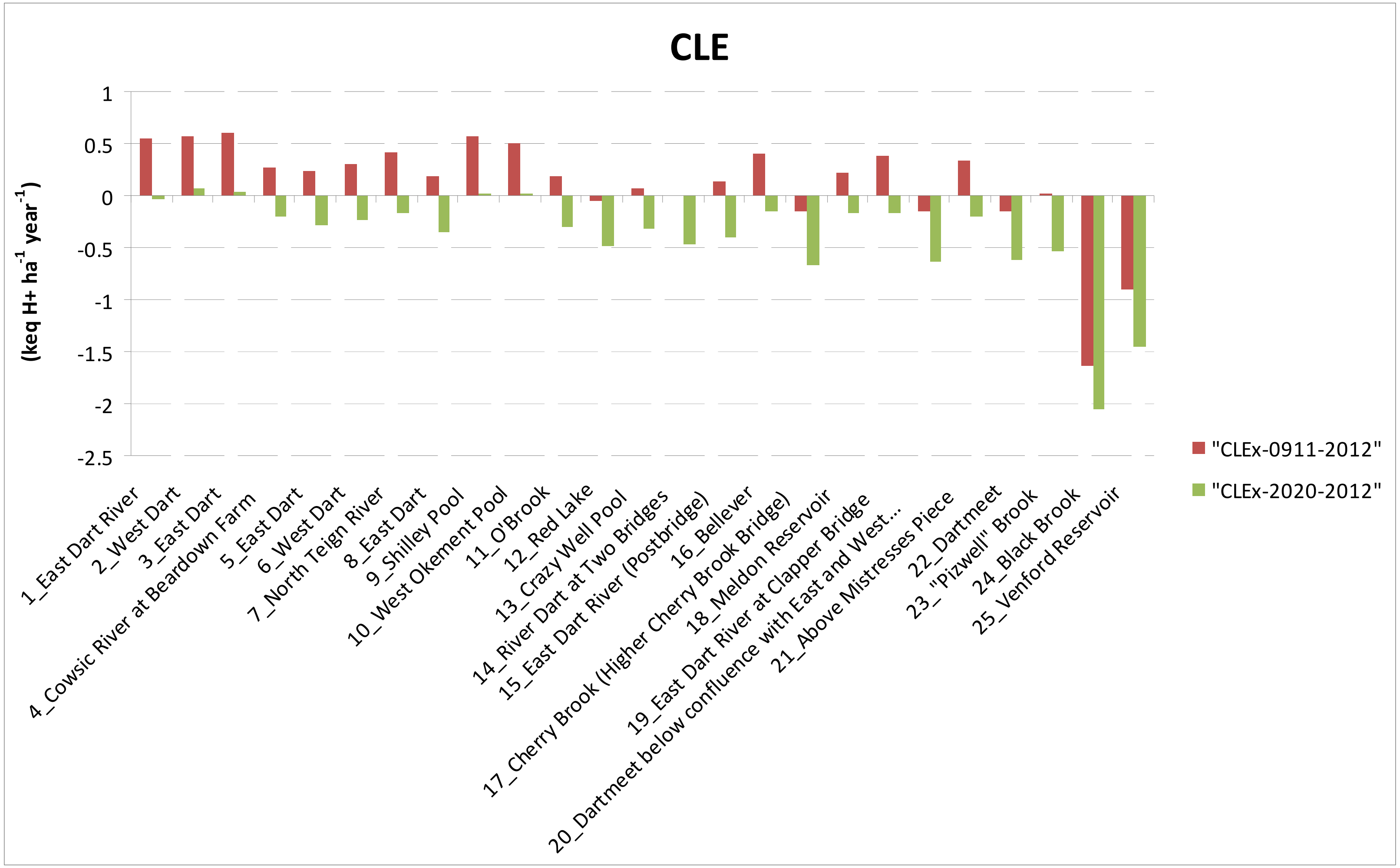


Figure 13. Comparison between critical load exceedance for the 25 sites sampled in 2012 for 2009-2011 and 2020 deposition respectively based on 2012 chemistry (as for Figure 12).

The SSWC model data indicate that the critical load is currently exceeded at many sites, although none is in the highest exceedance category. The projections for 2020 show no or only slight exceedances remaining indicating that all sites should have recovered or almost recovered sufficiently to attain the critical value of ANC 20 (in µeq/l) and thereby support a relatively healthy fish population by that date.

It should be noted, however, that the SSWC model tends to provide “best case scenario” values (see below) and that there is underlying uncertainty in any model output where values are computed from single water samples from streams. The major ion chemistry of stream water is strongly influenced by discharge variability. More robust critical load evaluations therefore require data from samples collected under a range of flow conditions. Moreover attainment of an ANC value of 20 does not represent a full recovery. The target for a full recovery is the ANC reference value, although this is also an uncertain value as it is based on the same flow dependent chemistry.

Stage 2*:*

“If this situation is anthropogenic then we want to look at recovery, will it recover in the next 10 years? (if yes then we are better to wait and need progress no further) or the next 50 years (if yes then we can progress to stage 3).”

1. Comparison of major ion chemistry between sites sampled in 1987-1988 and 2012

An estimate of the extent of recovery can be derived from a comparison between the chemistries of the 9 sites sampled in 1987-1988 with those of the same sites sampled in 2012. However, allowances need to be made for the problems associated with potential differences in streamflow between the sampling periods and the different analytical methods and laboratories used. Unfortunately it was not possible to include the AWMN site Narrator Brook in the comparisons due to a change in sampling location at the site, moving position upstream of a coniferous plantation in 1991. Differences in ion chemistry between the two time periods for the nine sites are shown in Figure 14 to Figure 18. The data show: (i) concentrations of Na and Cl are consistently higher in the 1987-88 samples suggesting that stream chemistry was more influenced by sea-salts and that flow may have been higher at that time; (ii) non-marine sulphate concentrations are significantly lower in the 2012 samples, very probably reflecting the effect of major reductions in S deposition that has taken place in the regions and across the UK over the last 25 years; (iii) there is little obvious difference in nitrate concentrations between the two surveys and, although low (<10 µeq/l), they remain higher than expected background levels; and (iv) despite the strong reduction in non-marine sulphate concentrations, pH values remain very low possibly due to the sulphate decrease being balanced by a reduction in labile Al (not measured) rather than H^+ and possibly also due to the presence of relatively high DOC levels (not measured) in the streams as noted above.

The differences between the two surveys are in accordance with expectation based on the evidence of data from the AWMN that indicates strong reductions in non-marine sulphate, little change in nitrate and significant reductions in labile Al at the most acidified sites (Kernan *et. al*. 2010). pH increase is muted at such sites. Overall there is therefore no reason to doubt that the headwaters of the Dart catchment have been acidified as a result of acid deposition and are now recovering.

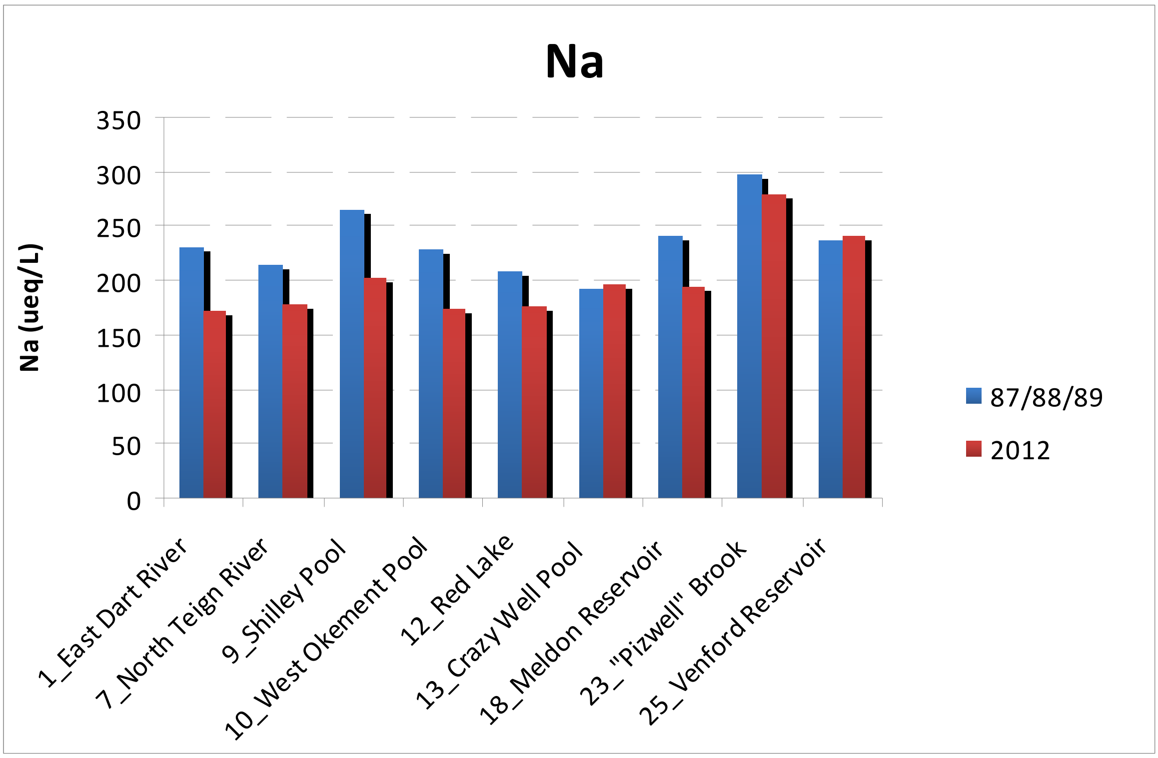


Figure 14. ***Comparison of sodium for 9 sites sampled in 1987-88 and 2012.***

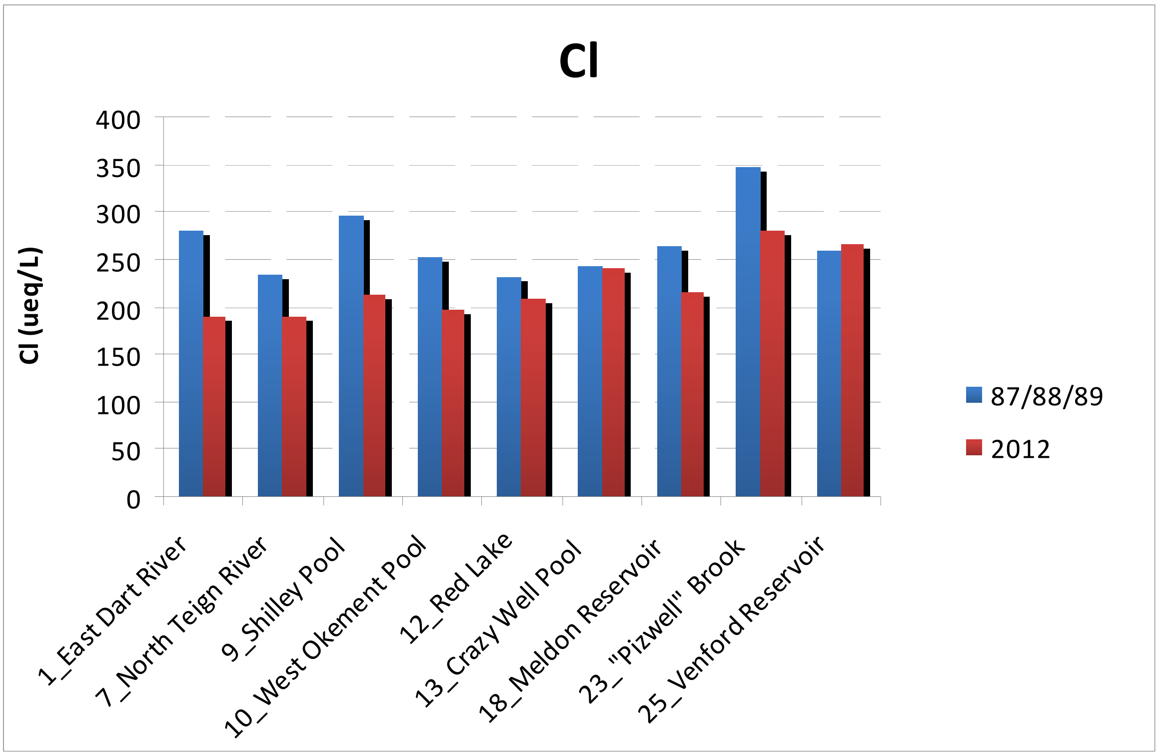


Figure 15. ***Comparison of chloride for 9 sites sampled in 1987-88 and 2012.***

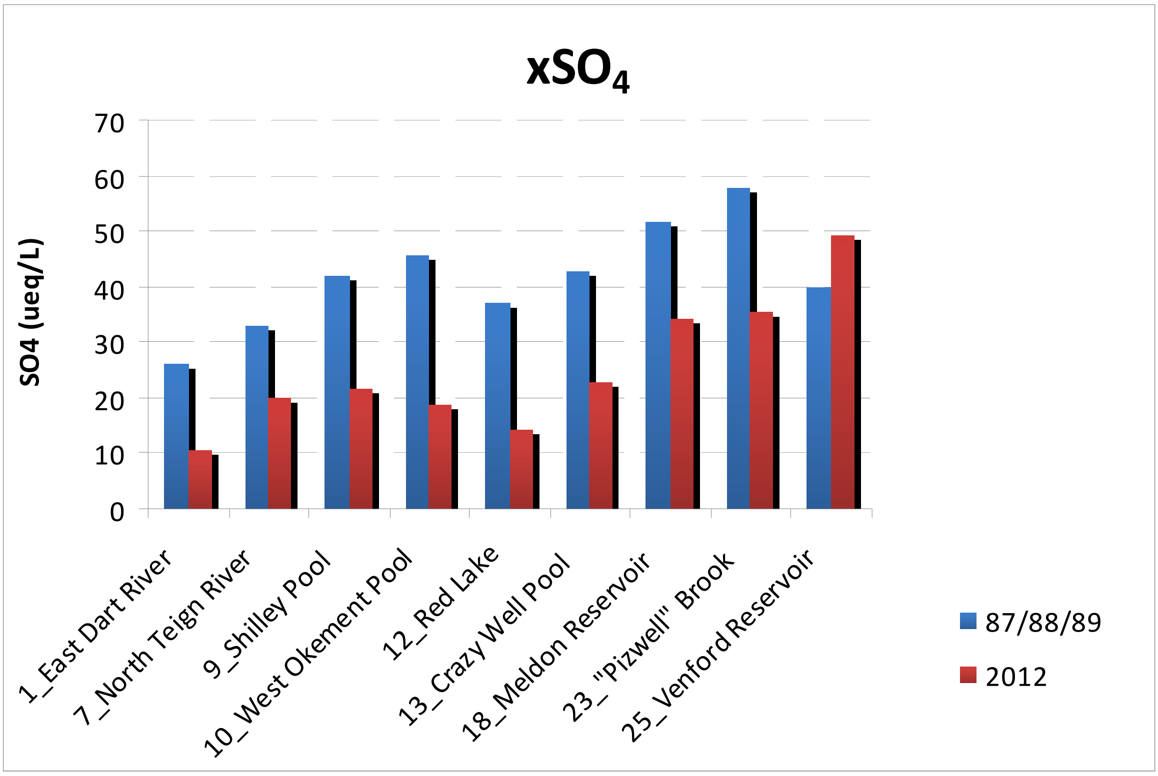


Figure 16. ***Comparison of non-marine sulphate for 9 sites sampled in 1987-88 and 2012.***

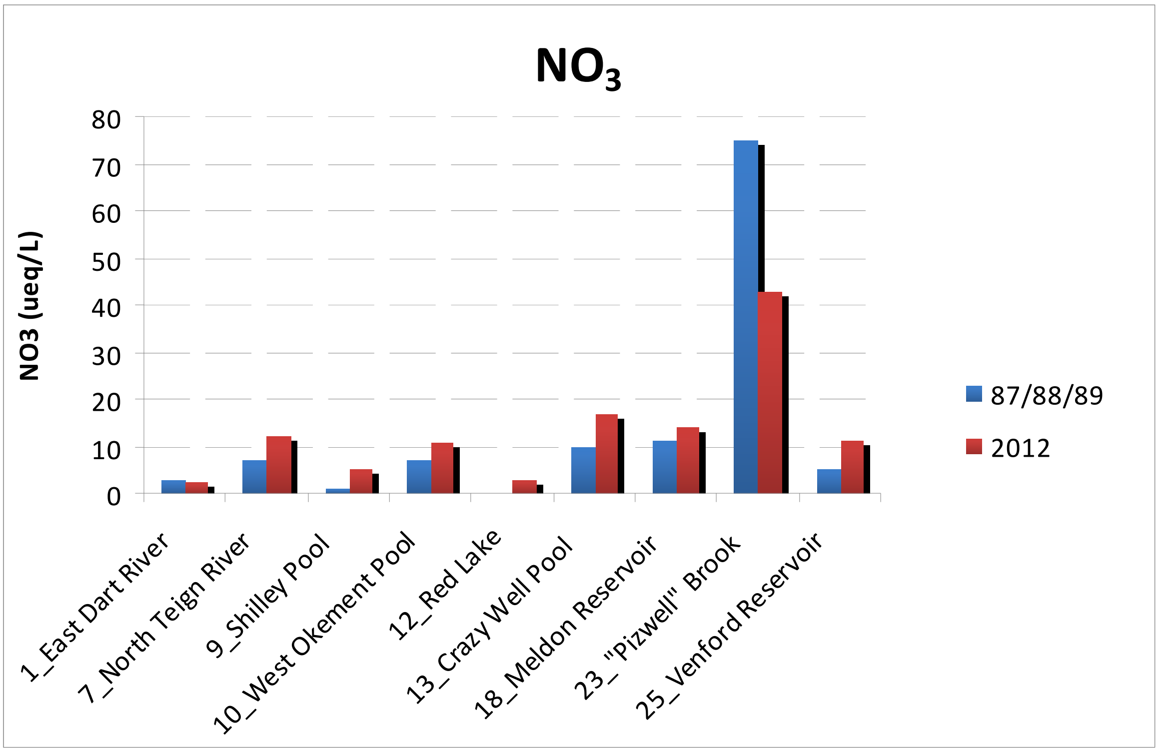


Figure 17. ***Comparison of nitrate for 9 sites sampled in 1987-88 and 2012.***

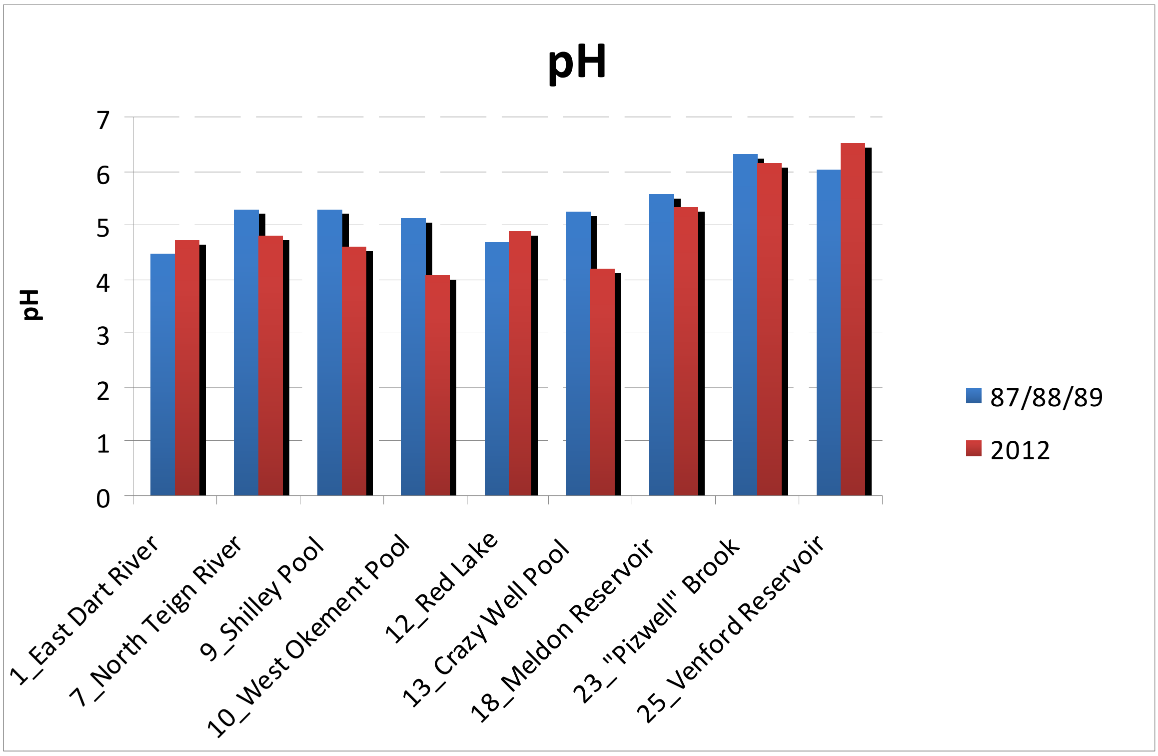


Figure 18. ***Comparison of pH for 9 sites sampled in 1987-88 and 2012.***

2. Comparison between critical load exceedances for 1987-88, 2012 and 2020

The rate of improvement (and extent of recovery) at the Dart sites can be further assessed from a comparison between the SSWC critical load exceedance values for 1988, 2012 and 2020 (Figure 19 and Figure 20). The 1988 values use the 1987-88 chemistry data from samples collected by ENSIS-UCL and analysed by the Freshwater Fisheries Laboratory (Pitlochry) at the time of the original national critical loads survey and modelled S and N deposition data for 1986-1988 (courtesy of Ron Smith, CEH). The 2012 values use the 2012 chemistry data from samples collected and analysed by ENSIS-UCL and CBED (Concentration Based Estimated Deposition) modelled deposition data for 2009-2011 (courtesy of Jane Hall, CEH), and the 2020 values use the 2012 samples for chemistry and deposition values modelled using FRAME (also courtesy of Jane Hall, CEH).

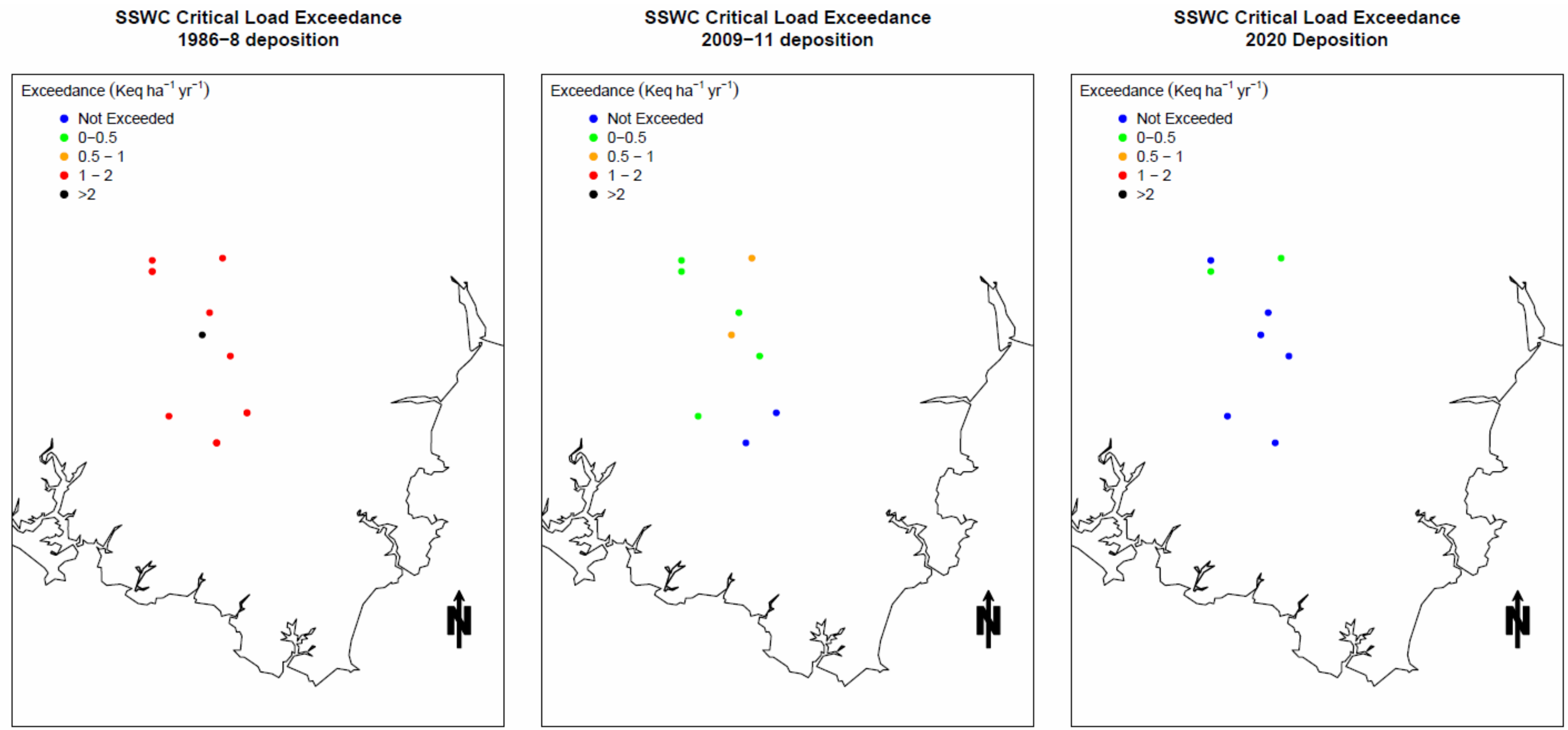


Figure 19. ***SSWC-based critical load exceedances for 1988 (based on 1987-88 chemistry and 1986-1988 modelled deposition), 2012 (based on 2012 chemistry and 2009-2011 CBED modelled deposition) and 2020 (based on 2012 chemistry and 2020 FRAME modelled deposition)***

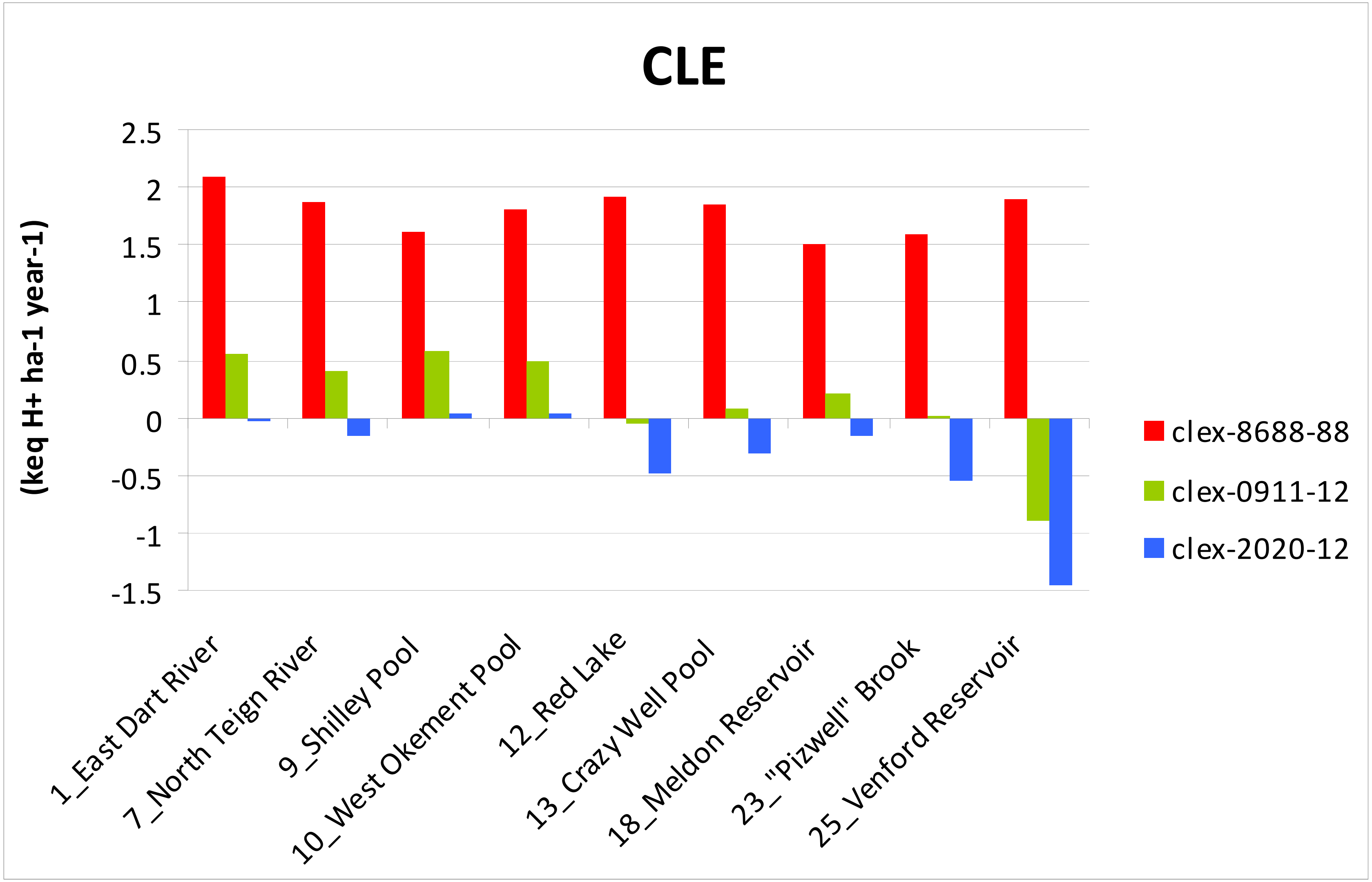


Figure 20. ***Comparison of SSWC-based critical load exceedances for 1988, 2012 and 2020 as for Figure 19.***

The data (Figure 19 and Figure 20) show that critical load exceedances have reduced from 1987-88 to the present day and that a further reduction is expected by 2020 to the extent, as pointed out above, that all of the sites sampled are projected not to, or only slightly to, exceed the ANC 20-based critical load by that date. The trend in exceedance reduction suggests that conditions for fish recruitment and survival should gradually improve and, all things being equal, the streams should be capable of supporting a healthy brown trout population within 10 years.

However, there are a number of caveats:

- As already indicated, the comparison between the critical load exceedance values for 1988 with those for 2012 and projected for 2020 needs to take into account seasonality and the uncertainty caused by differences in flow conditions between the two sampling periods (Curtis and Simpson, 2011). The lower non-marine base cation concentrations of the 1987-88 samples and the higher Cl levels compared with the 2012 samples suggests that flows were higher and more influenced by sea-salts during the earlier sampling period, a difference that would potentially cause the extent of recovery to date to be over-estimated.
- The critical load exceedance values presented here are based on the SSWC model. The model assumes there is a steady state between acid anion deposition and anion leaching. This assumption is not upheld, however, in cases where N deposition and nitrate leaching are not in balance. The First Order Mass Balance Model (FAB) then becomes the preferred critical load model as this model accounts for nitrogen dynamics in catchment soils and it can be used to predict the extent of nitrate leaching to surface waters as the soil's capacity to store or use N is exhausted. Although N deposition on Dartmoor and nitrate concentration in the Dart headwaters is not high, both are significantly above background values. Consequently, despite the reduction in N emissions that is taking place in the UK, nitrate concentrations in streams, including the Dart streams, may not necessarily decrease and may even increase should soils in the catchment become saturated by N. It is possible therefore that, in contrast to the SSWC model, the FAB model could indicate continuing critical load exceedance in 2020. As these two models represent the best and worst-case scenarios respectively the true exceedance values are likely to lie between them. One of our recommendations is to acquire the additional information needed on catchment soils to run FAB on the 2012 samples with both 2009-2011 and 2020 deposition fields.
- The critical load exceedance calculations do not take into account the potentially harmful effects of acid episodes associated with high runoff following storm events. We note that Wilson (2004) used continuous monitoring of two Dart headwater tributaries in 2003-2004 to demonstrate sustained pH depression from pH 6 to almost pH 4 after severe rainfall events. The severity of such events should decrease as sulphate levels fall, but acid episodes may continue to cause problems for fish and invertebrate populations even when critical loads are theoretically not exceeded (i.e. when ANC concentrations reach 20 µeq/l and over).
- Although the probability of brown trout occurrence at a site can be predicted from ANC concentration, a better predictor is labile monomeric aluminium (Malcolm *et. al.*, in

press) the concentration of which depends principally on catchment lithology, pH and DOC. There are no measurements of Labile-Al yet available for the Dart headwaters, although measurements at the nearby AWMN Narrator Brook site show concentrations that vary between approximately 0 and 50 µg/l with a mean of about 25 µg/l. It is likely therefore that concentrations in the more acidic headwaters of the Dart are higher than this, and that Labile-Al is indeed at concentrations likely to cause damage to fish. As recovery continues and pH and probably also DOC continue to increase Labile-Al concentrations should fall and become less toxic. Analysis of Dart samples to measure current labile-Al concentration is recommended to assess conditions for fish survival more accurately.

Summary and conclusions

- Headwater streams of the River Dart have been severely acidified by the effects of acid deposition.
- Following the major reduction in sulphur dioxide emissions that has taken place in the UK over the last 25 years sulphate concentrations in the streams have decreased strongly and ANC has increased.
- Nitrate concentrations are relatively low but well above the expected background at some sites.
- The lack of a decrease in pH between 1987-88 and 2012, despite the decrease in sulphate, may be due to changes in labile aluminium and DOC concentrations (not measured in this survey).
- Calculations of reference values for ANC indicate that all sites sampled in the Dart system had ANC values above 20 µeq/l prior to acidification and were therefore capable of supporting healthy populations of brown trout at that time.
- Fish populations at the present day are likely to be limited by high labile aluminium concentrations (not measured) that probably prevail in the headwater streams.
- SSWC model projections suggest that critical load exceedances will be eliminated or almost eliminated at all sites by 2020 and conditions for brown trout recruitment and survival should improve accordingly.
- Allowance needs to be made, however, for the potential impact of acid episodes that are likely to continue occurring following high rainfall events although the severity of these should decrease as conditions improve.
- The SSWC model gives results that can be regarded as representing the best-case scenario as the model does not take into account the possibility of any increase in nitrate leaching.
- There is uncertainty over the behaviour of N in catchment soils. It is possible that nitrate leaching could increase, and, as a strong acidifying anion, offset some of the gains that are being made from reductions in sulphate.

- We believe the data are well founded and accurate, but we should stress the limitations of drawing conclusions and making predictions for the future on the basis of single water samples.

Recommendations

Although there are many uncertainties, as described above, the data suggest that recovery is underway and that the rate of improvement is sufficiently rapid for liming of the upper moor not to be necessary. Before making any decision on liming we recommend that:

- the FAB model is used to calculate worst case exceedance values for 2020. The model uses the same water chemistry as the SSWC model but needs data on catchment soils;
- analysis of labile-Al and DOC concentrations are carried out to assess better the probability of brown trout occurrence using the new WFD fish tool;
- samples for one or more of the most acidic sites are collected and analysed on a fortnightly or monthly basis to assess variability in chemistry over an annual cycle.

If a decision is made to lime on a trial basis we recommend as previously advised that:

- the minimum amount of lime is added to minimise damage to algal and plant communities in the streams;
- biological surveys of the sites to be limed are carried out for at least one year before liming and two years after;
- one of the headwaters of the Dart remains un-limed to act as a control;
- waters below the limed sites are monitored to assess the effect of liming on downstream communities.

In the context of both the local region and the UK as a whole, we also recommend that the West Country Rivers Trust consider setting up one of the Dart headwater sites as a long-term monitoring site to become part of the new Upland Waters Monitoring Network (UWMN) that will supersede the AWMN, and as such, complement the Narrator Brook. In this way the chemistry and biology (including fish populations) of representative sensitive upland streams in the region can be tracked in response to future changes in acidity, nitrogen leaching and climate change and compared to changes at sites elsewhere in the UK.

Next steps

The two remaining Stages are:

Stage 3: could the addition of lime mitigate the effect? yes (go to stage 4)/no (stop work)

Stage4: what is the best method based on case studies? What are the implications for the riverine ecosystem down stream? How reversible is the effect?

A review of literature on liming as a remedial measure for acidification is currently being prepared along with estimates for carrying out the work recommended above.

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Appendix 1 Field Sampling Details

Photograph	
Field_Site_Code	CE10
Site Name	Cherry Brook
Sampling date	20/04/2012
Time	11:30:00
FIELD GPS Site Easting	263415
FIELD GPS Site Northing	77000
Sampled By	JDS
Photo Number	1001998
Weather	4/8 cloud windy
Flow	Medium
Stream Width (m)	3.5
Clarity/Colour	Clear
Diatom Scrape	Y
Catchment/Land Use	Fenced grazing.
Fish Seen	N
Aquatic Plants	Y
%bed cover	100
Species	moss
Remarks	Park in small car park 100m from bridge
Field Meter	YSI Prof
pH	6.74
H+ (Calculated)	0.18
Temp	7.70
Field O2	11.03
Cond (uS/cm)	27.70

Photograph	
Field_Site_Code	CE13
Site Name	Black Brook
Sampling date	20/04/2012
Time	13:01:00
FIELD GPS Site Easting	258806
FIELD GPS Site Northing	74981
Sampled By	JDS
Photo Number	1002001
Weather	4/8 cloud windy
Flow	Medium
Stream Width (m)	5.5
Clarity/Colour	Clear
Diatom Scrape	Y
Catchment/Land Use	Fenced grazing.
Fish Seen	N
Aquatic Plants	Y
%bed cover	70
Species	moss
Remarks	Park in layby by bridge.
Field Meter	YSI Prof
pH	6.55
H+ (Calculated)	0.28
Temp	9.70
Field O2	10.50
Cond (uS/cm)	41.10

Photograph	
Field_Site_Code	CE14
Site Name	Swincombe
Sampling date	19/04/2012
Time	15:37:00
FIELD GPS Site Easting	264687
FIELD GPS Site Northing	73131
Sampled By	JDS
Photo Number	1001991
Weather	8/8 cloud, windy
Flow	Medium
Stream Width (m)	4.0
Clarity/Colour	Clear
Diatom Scrape	Y
Catchment/Land Use	Common grazing. Poached.
Fish Seen	N
Aquatic Plants	Y
%bed cover	20
Species	moss
Remarks	Park at old large wood pile near bridge.
Field Meter	YSI Prof
pH	5.94
H+ (Calculated)	1.14
Temp	9.50
Field O2	10.77
Cond (uS/cm)	27.70

Photograph	No Photo
Field_Site_Code	CE15
Site Name	Babeney
Sampling date	19/04/2012
Time	12:55:00
FIELD GPS Site Easting	267375
FIELD GPS Site Northing	75055
Sampled By	JDS
Photo Number	no photo
Weather	5/8 cloud, dry, windy
Flow	Medium
Stream Width (m)	10.0
Clarity/Colour	Clear
Diatom Scrape	Y
Catchment/Land Use	Common grazing.
Fish Seen	N
Aquatic Plants	Y
%bed cover	10
Species	
Remarks	Park at turning spot before stables that says no parking
Field Meter	YSI Prof
pH	6.38
H+ (Calculated)	0.41
Temp	9.40
Field O2	10.64
Cond (uS/cm)	46.00

Photograph	
Field_Site_Code	CE16
Site Name	O'Brook
Sampling date	19/04/2012
Time	15:06:00
FIELD GPS Site Easting	266468
FIELD GPS Site Northing	71916
Sampled By	JDS
Photo Number	1001989
Weather	8/8 cloud, windy
Flow	Medium
Stream Width (m)	2.5
Clarity/Colour	Clear
Diatom Scrape	Y
Catchment/Land Use	Common grazing.
Fish Seen	N
Aquatic Plants	Y
%bed cover	70
Species	moss
Remarks	Park next to bridge.
Field Meter	YSI Prof
pH	5.95
H+ (Calculated)	1.12
Temp	9.00
Field O2	10.74
Cond (uS/cm)	24.10

Photograph	
Field_Site_Code	CE7
Site Name	Walla Brook
Sampling date	19/04/2012
Time	10:46:00
FIELD GPS Site Easting	266848
FIELD GPS Site Northing	78906
Sampled By	JDS
Photo Number	1001985
Weather	Dry,windy
Flow	Medium
Stream Width (m)	2.5
Clarity/Colour	Clear
Diatom Scrape	Y
Catchment/Land Use	Common grazing, poached at edge.
Fish Seen	N
Aquatic Plants	Y
%bed cover	50
Species	
Remarks	Park next to the bridge. 10m from sampling point.
Field Meter	YSI Prof
pH	5.78
H+ (Calculated)	1.65
Temp	7.00
Field O2	11.27
Cond (uS/cm)	40.70

Photograph	
Field_Site_Code	CE8
Site Name	East Dart
Sampling date	19/04/2012
Time	10:50:00
FIELD GPS Site Easting	264507
FIELD GPS Site Northing	79043
Sampled By	BG
Photo Number	135 & 136
Weather	5/8 cloud, breezy, dry
Flow	Medium
Stream Width (m)	5.0
Clarity/Colour	Clear, slightly brown
Diatom Scrape	Y
Catchment/Land Use	Rough enclosed grazing / Juncus marsh
Fish Seen	N
Aquatic Plants	Y
%bed cover	25
Species	P.poly, C.ham, G.flu, bryophytes
Remarks	Park at visitors centre.
Field Meter	YSI pH
pH	4.59
H+ (Calculated)	25.70
Temp	6.40
Field O2	
Cond (uS/cm)	

Photograph	
Field_Site_Code	CE9
Site Name	Bellever
Sampling date	19/04/2012
Time	12:26:00
FIELD GPS Site Easting	265815
FIELD GPS Site Northing	77392
Sampled By	JDS
Photo Number	1001987
Weather	Dry,windy
Flow	Medium
Stream Width (m)	6.0
Clarity/Colour	Clear
Diatom Scrape	Y
Catchment/Land Use	Common grazing, poached at edge.
Fish Seen	N
Aquatic Plants	N
%bed cover	
Species	
Remarks	Park at Forestry car park 100 m from site. Walk along road to the bridge.
Field Meter	YSI Prof
pH	5.90
H+ (Calculated)	1.25
Temp	7.50
Field O2	11.26
Cond (uS/cm)	25.10

Photograph	
Field_Site_Code	CZSX57
Site Name	Crazywell Pool
Sampling date	20/04/2012
Time	15:00:00
FIELD GPS Site Easting	258219
FIELD GPS Site Northing	70441
Sampled By	BG
Photo Number	170-173
Weather	8/8 cloud, breezy, showers
Flow	Medium
Stream Width (m)	N/A
Clarity/Colour	Clear, slightly brown
Diatom Scrape	Y
Catchment/Land Use	Rough grazing with extensive Nardus & Molinia + Calluna
Fish Seen	N
Aquatic Plants	N
%bed cover	
Species	
Remarks	Walk in from Burrator. Old mine header reservoir - no outflow under normal conditions. No littoral stones - diatoms taken from 2 boulders and suubmerged bed rock
Field Meter	YSI pH
pH	4.20
H+ (Calculated)	63.09
Temp	9.30
Field O2	
Cond (uS/cm)	

Photograph	
Field_Site_Code	CZSX58
Site Name	West Okement Weir Pool
Sampling date	23/04/2012
Time	14:30:00
FIELD GPS Site Easting	256017
FIELD GPS Site Northing	89899
Sampled By	BG
Photo Number	179-182
Weather	8/8 cloud, breezy, rain
Flow	Spate
Stream Width (m)	7.0
Clarity/Colour	Clear, slightly brown
Diatom Scrape	Y
Catchment/Land Use	Rough grazing with Nardus, Molinia, bracken
Fish Seen	N
Aquatic Plants	Y
%bed cover	<10
Species	difficult to see
Remarks	Walk in from Meldon Reservoir car park. Diatom sample dubious due to high water levels - unknown if stones used were submerged at normal flow - could not reach normal river bed. Sampled just below the weir
Field Meter	YSI pH
pH	4.09
H+ (Calculated)	81.28
Temp	6.80
Field O2	
Cond (uS/cm)	

Photograph	
Field_Site_Code	CZSX59
Site Name	Meldon Reservior
Sampling date	23/04/2012
Time	15:30:00
FIELD GPS Site Easting	256365
FIELD GPS Site Northing	91676
Sampled By	BG
Photo Number	186-88
Weather	8/8 cloud, breezy, rain
Flow	High
Stream Width (m)	10.0
Clarity/Colour	Clear, slightly brown
Diatom Scrape	Y
Catchment/Land Use	Rough grazing with Nardus, Molinia & bracken
Fish Seen	N
Aquatic Plants	?
%bed cover	
Species	difficult to see
Remarks	Walk in from Meldon Reservoir car park. Diatom sample dubious due to high water levels - unknown if stones used were submerged at normal flow - could not reach normal river bed. Sampled just below the dam - dam over-topping, but stream flow not spate.
Field Meter	YSI pH
pH	5.32
H+ (Calculated)	4.78
Temp	8.20
Field O2	
Cond (uS/cm)	

Photograph	
Field_Site_Code	CZSX66
Site Name	Red Lake
Sampling date	20/04/2012
Time	12:30:00
FIELD GPS Site Easting	264499
FIELD GPS Site Northing	66809
Sampled By	BG
Photo Number	165-169
Weather	3/8 cloud, breezy, showers
Flow	Medium
Stream Width (m)	N/A
Clarity/Colour	Slightly turbid, slightly brown
Diatom Scrape	Y
Catchment/Land Use	Rough grazing with extensive Molinia tussocks
Fish Seen	N
Aquatic Plants	Y
%bed cover	<1%
Species	P.polygonifolius, G.fluitans & Bryophytes seen
Remarks	Walk in from the east - very remote. Old reservoir site - no outflow observed. Newt (palmate?) seen. Water slightly turbid with fine organics - cloggs filter
Field Meter	YSI pH
pH	4.87
H+ (Calculated)	13.48
Temp	8.20
Field O2	
Cond (uS/cm)	

Photograph	
Field_Site_Code	CZSX67
Site Name	Venford Reservoir
Sampling date	19/04/2012
Time	14:40:00
FIELD GPS Site Easting	268721
FIELD GPS Site Northing	71430
Sampled By	JDS
Photo Number	1001989
Weather	8/8 cloud, windy
Flow	Medium
Stream Width (m)	1.5
Clarity/Colour	Clear
Diatom Scrape	Y
Catchment/Land Use	Common grazing.
Fish Seen	N
Aquatic Plants	Y
%bed cover	10
Species	
Remarks	Park at dam car park and follow fence line of dam works down to site. (east side of dam)
Field Meter	YSI Prof
pH	6.51
H+ (Calculated)	0.30
Temp	9.40
Field O2	10.67
Cond (uS/cm)	43.30

Photograph	
Field_Site_Code	CZSX68
Site Name	N. Teign River
Sampling date	19/04/2012
Time	12:52:00
FIELD GPS Site Easting	263654
FIELD GPS Site Northing	84059
Sampled By	BG
Photo Number	152 & 153
Weather	5/8 cloud, breezy, dry
Flow	Medium
Stream Width (m)	3.0
Clarity/Colour	Clear, slightly brown
Diatom Scrape	Y
Catchment/Land Use	Rough grazing with Molinia tussocks and c. 5% gorse / Calluna
Fish Seen	N
Aquatic Plants	Y
%bed cover	40
Species	Bryophytes only
Remarks	Walk in from the south
Field Meter	YSI pH
pH	4.80
H+ (Calculated)	15.84
Temp	8.20
Field O2	
Cond (uS/cm)	

Photograph	
Field_Site_Code	CZSX69
Site Name	Shilley Pool
Sampling date	23/04/2012
Time	11:00:00
FIELD GPS Site Easting	265293
FIELD GPS Site Northing	91211
Sampled By	BG
Photo Number	174-178
Weather	8/8 cloud, breezy, rain
Flow	Spate
Stream Width (m)	3.0
Clarity/Colour	Clear, slightly brown
Diatom Scrape	Y
Catchment/Land Use	Rough grazing with Nardus, Molinia, Calluna & Ulex
Fish Seen	N
Aquatic Plants	N
%bed cover	
Species	
Remarks	Walk in from east - the name \"Pool\" is slightly misleading - this site is riverine with a small (10m wide) impounded pool - water very much flowing throughout. Water clear - but with some suspended load
Field Meter	YSI pH
pH	4.59
H+ (Calculated)	25.70
Temp	6.60
Field O2	
Cond (uS/cm)	

Photograph	
Field_Site_Code	DLP1
Site Name	East Dart
Sampling date	19/04/2012
Time	11:20:00
FIELD GPS Site Easting	263875
FIELD GPS Site Northing	79870
Sampled By	BG
Photo Number	137 & 138
Weather	6/8 cloud, breezy, dry
Flow	Medium
Stream Width (m)	4.0
Clarity/Colour	Clear, slightly brown
Diatom Scrape	Y
Catchment/Land Use	Rough grazing with c. 50% gorse
Fish Seen	N
Aquatic Plants	Y
%bed cover	75
Species	bryophytes only
Remarks	Walk in from the south
Field Meter	YSI pH
pH	4.57
H+ (Calculated)	26.91
Temp	7.40
Field O2	
Cond (uS/cm)	

Photograph	
Field_Site_Code	DLP2
Site Name	East Dart
Sampling date	19/04/2012
Time	14:45:00
FIELD GPS Site Easting	261203
FIELD GPS Site Northing	82113
Sampled By	BG
Photo Number	156 & 157
Weather	8/8 cloud, windy, showers
Flow	Medium
Stream Width (m)	2.0
Clarity/Colour	Clear, slightly brown
Diatom Scrape	Y
Catchment/Land Use	Rough grazing with extensive Molinia tussocks
Fish Seen	N
Aquatic Plants	Y
%bed cover	75
Species	bryophytes only
Remarks	Walk in from the south or possibly east
Field Meter	YSI pH
pH	4.47
H+ (Calculated)	33.88
Temp	7.80
Field O2	
Cond (uS/cm)	

Photograph	
Field_Site_Code	DLP3
Site Name	East Dart
Sampling date	19/04/2012
Time	13:55:00
FIELD GPS Site Easting	260937
FIELD GPS Site Northing	84159
Sampled By	BG
Photo Number	154 &155
Weather	8/8 cloud, breezy, showers
Flow	Medium
Stream Width (m)	1.5
Clarity/Colour	Clear, slightly brown
Diatom Scrape	Y
Catchment/Land Use	Rough grazing with extensive Molinia tussocks
Fish Seen	N
Aquatic Plants	Y
%bed cover	75
Species	bryophytes only
Remarks	Walk in from the south or possibly east
Field Meter	YSI pH
pH	4.31
H+ (Calculated)	48.97
Temp	7.00
Field O2	
Cond (uS/cm)	

Photograph	
Field_Site_Code	DLP4
Site Name	West Dart
Sampling date	19/04/2012
Time	16:40:00
FIELD GPS Site Easting	260822
FIELD GPS Site Northing	80714
Sampled By	BG
Photo Number	161 & 162
Weather	8/8 cloud, windy, showers
Flow	Medium
Stream Width (m)	1.0
Clarity/Colour	Clear, brown
Diatom Scrape	Y
Catchment/Land Use	Rough grazing with extensive Molinia tussocks & Juncus in valley
Fish Seen	N
Aquatic Plants	Y
%bed cover	25
Species	bryophytes only
Remarks	Walk in from the south. Rocks with a heavy coating of orange/brown (iron?) peaty deposit - May impact on diatom sample.
Field Meter	YSI pH
pH	4.50
H+ (Calculated)	31.62
Temp	6.40
Field O2	
Cond (uS/cm)	

Photograph	
Field_Site_Code	DLP5
Site Name	West Dart
Sampling date	19/04/2012
Time	17:00:00
FIELD GPS Site Easting	260617
FIELD GPS Site Northing	78286
Sampled By	BG
Photo Number	163 & 164
Weather	8/8 cloud, windy, showers
Flow	Medium
Stream Width (m)	4.5
Clarity/Colour	Clear, slightly brown
Diatom Scrape	Y
Catchment/Land Use	Rough grazing with extensive Molinia tussocks
Fish Seen	N
Aquatic Plants	Y
%bed cover	<10
Species	Bryophytes only
Remarks	Walk in from the south
Field Meter	YSI pH
pH	4.63
H+ (Calculated)	23.44
Temp	8.30
Field O2	
Cond (uS/cm)	

Photograph	
Field_Site_Code	DLP6
Site Name	Dartmeet
Sampling date	19/04/2012
Time	16:15:00
FIELD GPS Site Easting	267230
FIELD GPS Site Northing	73041
Sampled By	JDS
Photo Number	1001992
Weather	8/8 cloud, windy
Flow	Medium
Stream Width (m)	15?
Clarity/Colour	Peaty
Diatom Scrape	Y
Catchment/Land Use	Common grazing.
Fish Seen	N
Aquatic Plants	N
%bed cover	too wide and peaty to see
Species	
Remarks	Park at public car park and walk down public footpath past left side of a large chicken run then turn right to get to the river.
Field Meter	YSI Prof
pH	6.27
H+ (Calculated)	0.53
Temp	8.80
Field O2	10.94
Cond (uS/cm)	26.70

Photograph	
Field_Site_Code	EA10
Site Name	Clapper Bridge
Sampling date	19/04/2012
Time	16:34:00
FIELD GPS Site Easting	267200
FIELD GPS Site Northing	73271
Sampled By	JDS
Photo Number	1001993
Weather	8/8 cloud, windy
Flow	Medium
Stream Width (m)	15?
Clarity/Colour	Peaty
Diatom Scrape	Y
Catchment/Land Use	Common grazing.
Fish Seen	N
Aquatic Plants	Y
%bed cover	v wide 10 of river in view
Species	moss
Remarks	Park at public car park.
Field Meter	YSI Prof
pH	6.52
H+ (Calculated)	0.30
Temp	8.90
Field O2	10.83
Cond (uS/cm)	30.70

Photograph	
Field_Site_Code	EA5
Site Name	West Dart
Sampling date	20/04/2012
Time	12:29:00
FIELD GPS Site Easting	260794
FIELD GPS Site Northing	75035
Sampled By	JDS
Photo Number	1002000
Weather	3/8 cloud, windy
Flow	Medium
Stream Width (m)	5.5
Clarity/Colour	Clear
Diatom Scrape	Y
Catchment/Land Use	Fenced grazing.
Fish Seen	N
Aquatic Plants	Y
%bed cover	5
Species	moss
Remarks	Park in large bus stop by hotel. Walk down old concrete steps just before the bridge
Field Meter	YSI Prof
pH	5.77
H+ (Calculated)	1.69
Temp	9.50
Field O2	10.93
Cond (uS/cm)	25.20

Photograph	
Field_Site_Code	EA6
Site Name	Beardown Farm
Sampling date	20/04/2012
Time	12:12:00
FIELD GPS Site Easting	260313
FIELD GPS Site Northing	75321
Sampled By	JDS
Photo Number	1001999
Weather	3/8 cloud, windy
Flow	Medium
Stream Width (m)	3.5
Clarity/Colour	Clear
Diatom Scrape	Y
Catchment/Land Use	Fenced grazing.
Fish Seen	N
Aquatic Plants	Y
%bed cover	60
Species	moss
Remarks	Park in large bus stop by hotel. Cross the bridge and turn right following footpath up the side of the Cowsick river valley until you come to the Beardown farm bridge.
Field Meter	YSI Prof
pH	6.40
H+ (Calculated)	0.39
Temp	8.40
Field O2	10.77
Cond (uS/cm)	26.30

Photograph	
Field_Site_Code	EA7
Site Name	Moorlands Farm
Sampling date	19/04/2012
Time	17:53:00
FIELD GPS Site Easting	262603
FIELD GPS Site Northing	73876
Sampled By	JDS
Photo Number	1001997
Weather	8/8 cloud, windy
Flow	Medium
Stream Width (m)	4.0
Clarity/Colour	Clear
Diatom Scrape	Y
Catchment/Land Use	Fenced grazing.
Fish Seen	N
Aquatic Plants	Y
%bed cover	70
Species	moss
Remarks	Take turning to hotel and drive down to the left past farm and park next to bridge opposite outward bound lodge.
Field Meter	YSI Prof
pH	6.64
H+ (Calculated)	0.22
Temp	9.00
Field O2	10.43
Cond (uS/cm)	33.60

Photograph	
Field_Site_Code	SSX67
Site Name	Pizwell brook
Sampling date	19/04/2012
Time	11:10:00
FIELD GPS Site Easting	266345
FIELD GPS Site Northing	78262
Sampled By	JDS
Photo Number	1001986
Weather	Dry,windy
Flow	Medium
Stream Width (m)	1.5
Clarity/Colour	Clear
Diatom Scrape	Y
Catchment/Land Use	Common grazing, poached at edge.
Fish Seen	N
Aquatic Plants	N
%bed cover	
Species	
Remarks	Park at Farm road end. Walk up track and in between farm buildings and follow farm track till site.
Field Meter	YSI Prof
pH	6.16
H+ (Calculated)	0.69
Temp	7.60
Field O2	11.04
Cond (uS/cm)	42.70

Photograph	
Field_Site_Code	SSX68
Site Name	East Dart
Sampling date	19/04/2012
Time	15:30:00
FIELD GPS Site Easting	262721
FIELD GPS Site Northing	81086
Sampled By	BG
Photo Number	159 & 160
Weather	8/8 cloud, windy, showers
Flow	Medium
Stream Width (m)	4.0
Clarity/Colour	Clear, slightly brown
Diatom Scrape	Y
Catchment/Land Use	Rough grazing with extensive Molinia tussocks
Fish Seen	N
Aquatic Plants	Y
%bed cover	50
Species	Bryophytes only
Remarks	Walk in from the south or possibly east
Field Meter	YSI pH
pH	4.72
H+ (Calculated)	19.05
Temp	8.00
Field O2	
Cond (uS/cm)	

Photograph	
Field_Site_Code	WW11
Site Name	Lower Cherrybrook bridge
Sampling date	19/04/2012
Time	17:21:00
FIELD GPS Site Easting	263121
FIELD GPS Site Northing	74832
Sampled By	JDS
Photo Number	1001996
Weather	8/8 cloud, windy
Flow	Medium
Stream Width (m)	4.0
Clarity/Colour	Clear
Diatom Scrape	Y
Catchment/Land Use	Fenced grazing.
Fish Seen	N
Aquatic Plants	Y
%bed cover	70
Species	moss
Remarks	Park next to bridge
Field Meter	YSI Prof
pH	6.57
H+ (Calculated)	0.26
Temp	9.00
Field O2	11.00
Cond (uS/cm)	30.60

Photograph	
Field_Site_Code	WW2
Site Name	Dartmeet
Sampling date	19/04/2012
Time	16:50:00
FIELD GPS Site Easting	267121
FIELD GPS Site Northing	73119
Sampled By	JDS
Photo Number	1001994
Weather	8/8 cloud, windy
Flow	Medium
Stream Width (m)	15?
Clarity/Colour	Peaty
Diatom Scrape	Y
Catchment/Land Use	Common grazing.
Fish Seen	N
Aquatic Plants	N
%bed cover	but v wide
Species	
Remarks	Park at public car park. Cross bridge and take footpath on the left past some houses down to ancient stepping stones.
Field Meter	YSI Prof
pH	6.52
H+ (Calculated)	0.30
Temp	8.80
Field O2	10.89
Cond (uS/cm)	35.80

Photograph	
Field_Site_Code	WW4
Site Name	Above Mistresses Piece
Sampling date	19/04/2012
Time	14:02:00
FIELD GPS Site Easting	271882
FIELD GPS Site Northing	71901
Sampled By	JDS
Photo Number	1001988
Weather	6/8 cloud, windy
Flow	Medium
Stream Width (m)	8.0
Clarity/Colour	Peaty
Diatom Scrape	Y
Catchment/Land Use	Common grazing.Small amount of poaching.
Fish Seen	N
Aquatic Plants	N
%bed cover	
Species	
Remarks	Park next to cattle grid. A bit tight. 20 m to site
Field Meter	YSI Prof
pH	6.57
H+ (Calculated)	0.26
Temp	8.30
Field O2	11.33
Cond (uS/cm)	31.40