A summary of strontium and oxygen isotope variation in human tooth enamel excavated from Britain over the last 6000 years.

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Abstract

This paper presents a compilation of strontium and oxygen isotope data from human tooth enamel that has been produced at NERC Isotope Geosciences Laboratory over the last *c.*15 years. These many and often small studies are here combined to provide an overview of data from Britain. The strontium isotope composition ranges between 0.7078 and 0.7165 (excluding individuals deemed to be of non-British origin). The median Sr concentration is 84 ppm but there is a vector of increasing Sr concentrations related to seawater strontium isotope composition that is seen in individuals predominantly from the west coast of Scotland attributed to the used of kelp as a fertilizer. The oxygen isotope data is normally distributed with a mean value of 17.7‰ ± 1.4‰ (2SD n=615). Two sub-populations of local individuals have been identified that provide control groups for human enamel values from the eastern side of Britain where there are lower rainfall levels: 17.2‰ ± 1.26‰, (2SD, n=83) and western area of Britain where rainfall levels are higher = 18.2‰ ± 0.98‰, (2SD, n=41). These data make it possible to make direct comparisons of population means between burial populations and the control dataset to assess commonality of origin.

Introduction

Since the 1990's the isotope compositions of strontium and oxygen have been used by archaeologists to determine residential origins of our human ancestors. The basic premise is "you are what you eat and drink" and that the isotope values for strontium and oxygen in body tissues, such as bone and enamel bioapatite, can be linked through the biosphere to the geologic (strontium) and climatic (oxygen) environment in which an individual lived.
Over the past *c.*15 years the NERC Isotope Geosciences Laboratory (NIGL) has analysed *c.* 1000 archaeological tooth enamel samples. The aim of this paper is to use this data to: 1)

assess the overall structure and range of human isotope data from Britain over the past 6000 years; 2) compare these data with independent assessments of such ranges; 3) define limiting values and datasets in order to provide a set of references and methods that can be used for comparative studies in archaeological, forensic and modern migratory studies.

The basic principles of using strontium and oxygen isotope analysis of tooth enamel to comment on the childhood origins of humans is well documented[1]. In essence, strontium isotope composition provides links to the land where food was grown or grazed, and oxygen isotope composition is linked to the source of drinking water[2-4].

Materials and Methods

The data for this study come from a large number of published sources[4-25] and from a number of unpublished and grey literature studies. The tooth enamel analysed is from individuals excavated at 74 British archaeological sites dating from the Neolithic to the 19th century A.D. and from across much of Britain. These samples were not collected systematically and this has inevitably introduced certain geographic biases, such that East Anglia, SW England and Wales are poorly represented (Figure 1). The reported dataset has not been filtered and includes individuals that are unlikely to be of British origin.

To preserve internal consistency and avoid inter-laboratory method bias, only data produced at NIGL is used for this study. With the exception of oxygen isotope data for West Heslerton and Monkton, all $^{87}Sr/^{86}Sr$ and $\delta^{18}O$ values were obtained using the methods given in Evans et al. (2006). Oxygen isotope analysis for West Heslerton and Monkton samples was carried out by laser fluorination[26]. The data are presented in Appendix 1, location and references to published sources in Appendix 2. The Levinson[2] drinking water equation modified by Chenery et al. 2010[4] and equation 4 from Daux et al. 2008[3] are the phosphate oxygen to drinking water conversions used in this paper when discussing the relationship between oxygen isotope composition measured in tooth enamel and ‘drinking water’.

Strontium concentration range and isotope composition found in individuals excavated from Britain.

Knowing the range of biosphere isotope values that can be found within Great Britain gives us an important tool for identifying individuals who fall outside those limits and hence can be defined as non-British. To do this we need to characterise British variation, but this is not straightforward. It is helpful to consider Scotland separately from England and Wales because it has a different geological history and thus different geological and strontium isotope characteristics. Britain is divided, geologically, along a line referred to as the “Iapetus Suture”. This geological junction runs from what is now the Solway Firth north east across England, roughly parallel with the England/Scotland border. This marks the contact between two different geological terrains: Scotland, derived from an ancient continent with parts still present in NW Scotland over 2000 million year old, known as Laurentia; and England and Wales, which were part of a micro-continent called Avalonia which has a maximum age of only *c.* 700 million years[27]. Scotland also contains the youngest rocks in Britain, the Tertiary Basalts, and hence has the potential for a much wider range of strontium isotope biosphere compositions compared with England and Wales.

The strontium concentrations and isotope compositions of the human tooth enamel available from Britain (Scotland, England and Wales combined) are presented in Figure 2. The mean and standard deviation of the concentrations and isotope ratios are 105 ±138 ppm (2SD, n=614) and 0.7099 ±0.0026 (2SD, n=614), respectively. The isotope compositions range between a minimum value of 0.7064 and a maximum of 0.7205. However, there is independent evidence to suggest that neither of these individuals is of British origin[8, 10,28] and consequently they have been excluded, reducing the range for Britain to 0.7078–0.7165.

Maximum $^{87}Sr/^{86}Sr$ values. Because the geology of Scotland is much older than that of most of England and Wales, and biosphere values up to 0.72 have been obtained from Scottish vegetation[29], it is to be expected that individuals with the highest values will be found in Scotland. However, bone preservation is poor in upland acidic soils, which means that skeletal survival is low in the Scottish Highlands and there is limited data available to provide a reliable estimate. The highest human value from Scotland is ^{87}Sr/^{86}Sr = 0.7165 (PH SK 71).

The best estimate for a maximum human value for England and Wales comes from the average provided by the analysis of a historically defined group of 16 local individuals recovered from the medieval cemetery at Hereford Cathedral. With a highest measured value of 0.7140, the group provides a mean ^{87}Sr/^{86}Sr of 0.7124 ± 0.0022(2SD, n=16). A high value of 0.7142 was also obtained in England from a single individual from the Blackfriars cemetery in Gloucester, less than 30 miles away from Hereford[5], but as a single individual there is more uncertainty about its likely geographic origin.

We have, therefore, a local maximum of 0.7140 from Hereford as the current highest human value from England and Wales and a possible highest value from Scotland of 0.7165.

Minimum values

Unlike the maximum human isotope values, which show a high degree of dispersal, there is a relatively clear minimum baseline for England and Wales of $^{87}Sr/^{86}Sr = 0.7078$, which originates within the Cretaceous Chalk terrain. In Scotland, the Tertiary volcanic rocks are the primary source of low $^{87}Sr/^{86}Sr$ values and the lowest recorded human individual comes from Cnip in the Outer Hebrides with a $^{87}Sr/^{86}Sr$ value of 0.7078 (Cnip-D, Montgomery et al., 2003); this individual is not of Outer Hebridean origin but has a value that could be derived from the basalt terrains of the inner Hebridean islands such as Skye.

The range of strontium isotope ratios in human enamel is compared with the range of values measured in the British biosphere[30] (Figure 3). These box plots highlight two features: 1) that the medians 0.7096 (, n=614) and 0.7097 (n=313) are similar for enamel and biosphere respectively with both having a tail of values towards the higher ranges of values; 2) that the human data is less diverse (inter-quartile rang 0.0014) than the biosphere data (inter-quartile range = 0.0024) which is largely based on plant samples. This can be explained as a result of humans ingesting food from a variety of origins and hence creating an average composition of their intake, thereby reducing the range of values in comparison to populations lower down the food chain[31].

The effect of environmental factors on the strontium concentrations

The majority of samples have strontium concentrations below 150 ppm (median value of data is 84 ppm), but a significant number have values up to 417 ppm (Cnip G). A notable feature of the strontium system is the large proportion of individuals displaying high enamel strontium concentrations that are accompanied by a $^{87}Sr/^{86}Sr$ value resembling that of modern seawater. The majority of individuals, with elevated strontium concentration and seawater strontium isotope compositions, were excavated from island or coastal areas of Scotland that are associated with machair soils. These are calcium carbonate-rich soils, developed in marine shell debris, and often constitute the most fertile areas of these islands. There is no evidence that high enamel strontium concentrations are related fundamentally either to diagenesis within a carbonate-rich burial environment, or to the exploitation of a carbonate-rich soil resource during life; that is, elevated concentrations are not seen in other high carbonate terrains such those of chalk and limestone[32]. Accordingly, the characteristic strontium compositions seen in some Scottish island communities have been linked to the use of kelp as food, fodder and fertilizer [32]. Seaweed, such as kelp, has high strontium content[33-36] and thus abundant strontium with a seawater signature is released into the terrestrial biosphere and food chain when it is used to fertilize soils and as a food source[35, 36].

Oxygen isotope data from Britain

The best estimate of enamel phosphate oxygen isotope composition of individuals of British origin describes a near normal distribution (kurtosis =0.3, skewness = -0.13) with a mean of 17.7‰ ± 0.7 (1SD, n=615) (Figure 4). This is in good agreement with the value of 17.7‰ ± 0.9 (2SD, n=55 from 9 sites) proposed in Chenery et al. (2010). The distribution of the complete dataset is more asymmetric (kurtosis = 1.6 and skewness = -0.61), with a mean of 17.6‰ ± 0.8 (1SD, n=666). However, this includes data from exotic individuals from sites where there is evidence for non-British origin, comprising: 1) intrusive burials at the Lankhills cemetery in Winchester (Hampshire) classified as non-British on the basis of burial practice and burial goods [8]; 2) decapitated individuals from a Viking-Period execution pit near Weymouth (Dorset) interpreted as the executed crew of a long ship[28] and 3) Roman Period burials of decapitated individuals from York [13, 17, 38]; 4) a Bronze Age individual with a rich burial assemblage including artefacts of continental origin[39]; 5) a Roman Period burial with eastern European artefacts[40] . We accept that there is a degree of circularity in this rejection procedure, but the exclusion of 51 samples represents a 7.1 % rejection rate, and we feel that the resulting data are a more realistic representation of the British population.

The range of oxygen isotope values for local individuals within Britain is not unique[41]. As similar values can be found in France, northern Mediterranean countries[42] and south eastern Norway, it is not possible to discriminate exotic (non-British) individuals from these locations using oxygen isotope values alone.

Information for the range of British $\delta^{18}O_{(VSMOW)}$ in drinking water comes from two sources: 1) the contour map of Darling et al.[46] representing geographic variation in recent spring and groundwater (dataset not available) and UK tap water values; 2) the British Geological Survey's (BGS) archive of shallow borehole and surface water data. The oxygen isotope map presents the weighted mean of spatially distributed $\delta^{18}O_{(VSMOW)}$ values across Britain at 0.5‰ intervals ranging from >-5.0‰ to <8.5‰. We have calculated a mean for Britain of -7.2‰, using the area distribution of this map, based on 1‰ contour intervals. While Darling et al.[46] do not provide the whole dataset used to construct the map, they do provide data for tap water; these $\delta^{18}O_{(VSMOW)}$ values range from -4.6‰ (Lands End, extreme SW England) to -9.3‰ (Cairngorms, Scotland). Although the range of water $\delta^{18}O_{(VSMOW)}$ values for the

Darling map range between -4.0‰ and -9.0‰, values above -5.0‰ are spatially restricted and hence rare (see Table 1). The BGS data (Figure 5) provide a mean for Britain of -7.4‰ ±1.7 (n=975, 2SD) which is good agreement with our calculated. While the BGS dataset is not as comprehensive as the mapped data, they are sufficient for comparison with archaeological data in the discussion below. The equation 4 of Daux et al.[3] was applied to our enamel data (excluding known exotic individuals), from which a mean of -6.7‰ ± 1.2 (1SD, n=615) was derived.

The mean and standard deviation for the British drinking water and for the calculated drinking water values derived from the archaeological tooth enamel do overlap, but they are not the same (Figure 6). This is largely caused by the inequalities in sample distribution across Britain (Figure 1), and the particular lack of archaeological enamel data from Scotland.

However, there are a number of other factors that might contribute to the imperfect match between actual and calculated water values that need to be taken into account when assigning a place of origin to an individual. These are: 1) the teeth that have been used include some that mineralized in early childhood when the consumption of breast milk was high; 2) ingested fluids were fractionated during food processing; 3) the climate has varied through time; 4) the dataset includes more exotic individuals from warmer than those from colder climates. We can address some of these issues, and in so doing, comment generally on the processes that may affect oxygen isotope results from human dental enamel.

1) Choice of tooth

The choice of tooth for analysis is important. Teeth mineralize at different times in childhood[43] and in order to relate the tooth enamel value to that of drinking water it is necessary to analyse teeth that do not have a pre-weaning dietary component. Breast milk oxygen is fractionated during the metabolic processes which take place in the body of the mother, such that enamel formed during breast feeding can be up to 2‰ higher in oxygen isotope composition than enamel formed after weaning. Although deciduous teeth are not included in this dataset, breastfeeding may have continued during the development of the permanent dentition that commences mineralization in the first year of life, particularly the incisors, canines and first molars. The oxygen isotope composition of first, second and third molars from thirty Anglo-Saxon individuals from the Lincoln area of Britain [44] is presented in

Figure 7a. These data show that M2 and M3 agree well with each other and that the earlier forming M1 enamel has a higher mean oxygen isotope value.

The main dataset has been acquired over many years and includes a mixture of tooth types and their range is displayed in Fig 7b. The data do not show the same relationship between the M1 and the M2 & M3 as seen in the Lincolnshire dataset. This is probably because the relationship between the compositions of the teeth that form at different ages is masked by sources of greater variation such as that caused by the geographic distribution of archaeological sites. Hence, although the variation in tooth type may have contributed to the overall scatter of the data, it is not the primary cause of apparent offset between tooth enamel and British aquifer values.

2) The effect of modified water sources

Evaporation can shift the isotope compositions of potable water sources away from that of average regional rainwater, towards a higher range of oxygen isotope values. For example, lakes may show enrichment of 1–2‰ in temperate climates and much more in arid conditions[45]. This effect is recorded in the large lakes of northern Denmark where evaporation from the surface increases the $\delta^{18}O$ value of the lake by 1.5 to 2‰ above rainwater[46]. This water then flows out of the lakes in rivers that transport enriched ^{18}O water across northern Denmark. The evaporative effect is minimal in Britain where meteoric ground water computations fall within 0.5‰ of average rainfall values[47]. Accordingly, for British born individuals it is unlikely that there is a significant shift caused by drinking from water sources modified by naturally occurring evaporative processes. However, drinking processed water (such as beer or tea), or deriving a significant proportion of water intake from cooked foods with a high water content such as stews, soups and porridges (i.e. pottage) could result in a combined oxygen isotope value for water intake higher than that of the natural water composition of a local area. This effect is discussed in detail in Brettell et al.[48].

3) The effect of Climate change

The last 10,000 years are well documented with respect to climate variation, however, there is still considerable uncertainty in the data and such uncertainties increase with increasing antiquity. It is estimated that a 1°C shift in the mean temperature is required to move the rainwater $\delta^{18}O$ values by 0.57‰[49], which equates to *c.* ± 0.37‰ in tooth enamel[3]. Such a temperature shift exceeds current estimates for changes in the British climate during the Holocene [50]. There are differences in the range of enamel $\delta^{18}O$ values that we have documented through time (Figure 8). The data from the Neolithic Period is higher than other periods, which might be attributable to a warmer climate. However, most of the samples of Neolithic age are from sites on the west coast of Scotland, an area with the highest recorded groundwater oxygen isotope values in Britain. Climate effects can only be confirmed when isotope variations through time can be established from a restricted locality.

4) Disproportionate numbers of unidentified exotic individuals.

It is almost certain that the dataset includes individuals who did not spend their childhood in Britain. We have been very conservative in only rejecting 51 samples where there is evidence for non-British origin. However, there are likely to be other unidentified exotic individuals and if a greater proportion of these individuals originated within a climate zone with higher ambient drinking water values than lower (or *vice versa*) this will introduce a bias into the overall dataset.

The other factors that could influence the relationship between the water and enamel profiles are difficult to address on current evidence and remain as uncertainties in our interpretations. Well constrained studies are needed to assess these factors. In summary, the main causes of discrepancy between the water and enamel datasets is thought to arise from the different geographic sample distribution, the types of teeth used and the presence of unidentified immigrants.

Subdividing oxygen isotope composition of British human enamel into two end member groups.

Britain and Ireland have been contoured for variations in drinking water composition at the 0.5‰ and 1‰ interval, however, we do not yet have enough well provenanced archaeological data to test whether this level of contouring can be applied to direct measurements of human tooth enamel. It is, however, possible to identify within the existing British dataset into at least two biogeographic climate-groups that, to the best of our knowledge, record values from "local" individuals. This is, by nature, subjective but it should be possible to improve upon as more datasets become available.

The two chosen subsets of archaeological data represent bio-climatic areas of the British Isles which are also characterized by low rainfall, predominantly on the leeward (eastern) side of the country, and a higher rainfall zone that is largely restricted to the windward side of western and southern British Isles. The windward side records rainfall of >1000 mm/A [51]and drinking water values that range between -4 to -7 ‰[47]. Annual rainfall in the leeward side is < 1000 mm[51] and drinking water ranges between -7 and -9 ‰ [47](see appendix). These two zones represent the extremes of a broad national trend in drinking water composition that is driven by long term patterns of atmospheric and oceanic circulation, and by a range of regional geographic variables[47]. For simplicity, we have named the selected subsets "windward" (where ambient $\delta^{18}O_{(VSMOW)}$ values are likely to be higher) and "leeward" (where ambient $\delta^{18}O_{(VSMOW)}$ values are likely to be lower). However, it should be noted that this is a simplification of the expected pattern of variation, and the geographic areas that they represent.

The archaeological subsets identified with the leeward area is comprised of the following datasets: two "local" Anglo Saxon populations from Rutland[52-54]; Auldhame, a Medieval village in Lothian[16]; the 18-19th century AD populations for Chelsea where there is documentary evidence of the origin of most of the individuals[10]; three Bronze Age individuals from West Heslerton[5]. The windward subset corresponds to data from Scottish island populations defining "locals" by their high strontium concentrations and seawater isotope signature. These include individuals from Cnip, Galson[7] South Uist,[55] and Orkney[56]. England and Wales are represented by a Bronze Age individual from Great Orme [57], two Anglo Saxon individuals from Anglesey and 25 Medieval individuals from Hereford Parish.

The normal distribution curves and the 95% confidence intervals on the population means are given in Figure 9. The leeward area individuals have a mean of 17.2‰ ±1.3‰, (2SD,distribution skewness = 0.27, kurtosis= 0.74, n=83) this equates to a drinking water value of -7.5‰ ± 1.8‰, (2SD, n=83[3]) and the windward area individuals have a mean of 18.2‰± 1.0‰, (2SD, distribution skewness = -0.18, kurtosis= 0.22, n=41).which equates to a drinking water value of (-5.8‰ ± 1.8‰[3]). Both datasets conform to a normal distribution using the Anderson Darling normality test (p=0.08 and 0.35 respectively). An ANOVA analysis shows that the means of these two populations are significantly different from one another at 95% CI, supporting the hypothesis that these represent different populations.

These two datasets provide a statistical definition for the oxygen isotope composition of human tooth enamel within two isotopically contrasting geographic zones within the British Isles.. It can be assumed that these statistical ranges represent the degree of ambient variation that might be seen within populations exposed to the extremes of drinking water composition within the British Isles. In the following sections the oxygen isotope data from a number of populations, sub-populations and individuals obtained from isotopically intermediate geographic zones are analysed on the basis of their relationship to these two control datasets.

Distinguishing between burial populations

One of the primary aims of isotope studies is to identify individuals who are displaced relative to their childhood origin and, where possible, constrain their place of origin. Examples of this approach using oxygen isotope sub-populations are shown in Figure 10. The data from Catterick, a Romano-British garrison[58], plots between the two defining populations in a central zone consistent with the geographic position of Catterick, which is broadly central with respect to the east and west coasts, and with the interpretation that most of the individuals were of local origin.[58]

The second example is a group of four Anglo-Saxon period individuals, excavated from a site (Easington) on the east coast on England, near Hull[14]. They should plot within data from the leeward area, if they are from the broader Easington area, but they overlap with the data from the more westerly windward area. This indicates that they were not raised on the east coast of England and highlights a feature of humans dating from the Anglo-Saxon period that has been observed before, namely that these populations tend to have higher $\delta^{18}O_{(VSMOW)}$ values than would be expected from the region where they were buried[22, 59].

During the *adventus Saxonum*, migrants were documented as originating largely from the areas to the east and northeast of Britain, principally Denmark and Northern Germany, where rainfall $\delta^{18}O_{(VSMOW)}$ values are the same or lower than those of Britain. Thus, higher values, which suggest a more westerly origin, are at odds with historically documented patterns of migration [59]. It has been suggested that the higher $\delta^{18}O_{(VSMOW)}$ values may be a function of diet caused by a significant proportion of water coming from beer and potage, the production of which will enrich and hence elevate the oxygen isotope compositions relative to the source water supply[48]. However, the elevated $\delta^{18}O_{(VSMOW)}$ values seen is some Anglo-Saxon groups may be a true indication of a non-local origin and be caused by drinking lake water[60] enriched through evaporation as described above.

It is thus possible that the relatively high oxygen isotope ratios found in early Anglo-Saxon groups in the UK (such as those found at Easington) may be indicative of an origin in Jutland or other regions of Denmark, where lake water, and its run-off in rivers, is a major source of drinking water. Such a suggestion will need testing but it draws attention to the need to understand local conditions and behaviour when interpreting data.

Subdividing data from a single burial site.

Burials from cemeteries such as Lankhills, near Winchester[8, 61], display a wide range of oxygen isotope compositions. Some individuals have been proposed, on the basis of grave goods, to be of a continental origin[62], and some, because of high, or extremely low $^{87}Sr/^{86}Sr$ values have been interpreted as of non-local origin; the remaining data form a distinct cluster. Using the drinking water conversion equation of Levinson, the conventional cut-off argument[61] suggests that enamel phosphate oxygen isotope values above 18.6‰ lie outside the range for British drinking water and hence are of non-British origin. However, this interpretation depends upon the choice of drinking water equation used, and as shown by Pollard *at al.*[63], introduces large regression errors into the debate.

The oxygen isotope composition of tooth enamel from individuals from Lankhills cemetery is shown in a probability density curve (Figure 11). The main peak centres on a value of *c*. 18.1‰, which equates to a drinking water value of -5.9‰, using Daux et al 2010[3] equation 4 which is close to the predicted values of -6 ‰ to -7‰ for that part of Britain [47]. There are a number of individuals with lower values, these are predominantly those identified as being of continental origin on the basis of grave goods[8, 62], and a group of 13 individuals, at the highest end of the range. If these 13 individuals are treated as a sub-group, and compared with the high rainfall area dataset, the sub-group are a population with an oxygen isotope composition that has a significantly higher mean at 95% CI than the windward dataset.

Not only do the 13 individuals have a restricted and unusual range of oxygen isotope compositions, but they also show a restricted range of strontium isotope values: of 0.7089 ± 0.0005 (1SD, n=13). The strontium composition is typical of a limestone terrain and indistinguishable from the area in which they were found, namely on the Chalk. However, by combining the oxygen and strontium characteristics it is possible to assess the probability of their origin in Britain versus their origin from other likely places, in this case, elsewhere in the Roman Empire.

Niche modelling using both strontium and oxygen isotope data.

The combined probability of oxygen and strontium isotope values for Britain is given in Table 1. This table is based on numerically combining the surface area expression of both the strontium biosphere values, derived from calculating the relative areas of isotope subdivision on the British strontium biosphere map[30] and the area of drinking water isotope compositions derived from the 1‰ contoured map [47]. About 1% of the area of Britain can accommodate a combination of strontium isotope ratios below 0.7092 and drinking water values above -6 ‰.

The most likely place that could accommodate this combination is somewhere such as the Isle of Skye where oxygen isotope compositions are heaviest and strontium biosphere values might yield low enough $^{87}Sr/^{86}Sr$ values[64].

This probability can be compared with data from the Roman Empire. This map was produced by calculating the area drinking water values, using modern rainwater data[41], for the area of Europe occupied by the Roman Empire, excluding Britain. About 16% of the Roman Empire outside Britain accommodates drinking water values between -3‰ and -5‰ , mostly in the southern and eastern Mediterranean margins and eastern Spain (Figure 12). We do not have a map of the strontium biosphere values of the Empire but these can be estimated from the geology of the area. Mesozoic sediments, including limestone, are common in these areas[65] with mineral waters recording values between 0.707-0.708[66]. Plant and human data from Syria[67], Greece[68, 69], Italy[70] and Egypt[71] also provide similar strontium isotope values. There are large areas of habitable land around the Mediterranean that can accommodate both the strontium and oxygen isotope values of the outlying individuals found in the Lankhills cemetery. Hence, the isotope combination can be quantified as 1% probability of a British origin (strontium and oxygen) against a 15% probability (controlled by the drinking water distribution as limestone, with appropriate $^{87}Sr/^{86}Sr$ values, is widespread in this region[65]) of an origin within another part of the Roman Empire. This approach provides a probability of origin that, hopefully, is more informative than simply trying to demonstrate whether or not a group is of British origin.

When these methods are applied to an individual, rather than being able to compare data from populations, there is far more uncertainty, and claims that someone is or is not of a certain origin have hung on a combination of the drinking water equations used, the inter-laboratory compositions and reference material[72-74]. In the last section we discuss the interpretation of the data from a single individual using the example of the Amesbury Archer[39].

Characterizing the origin of an individual.

The Amesbury Archer's grave is the richest Bronze Age burial in Britain[39]. He was excavated in 2002 along with an associated burial of a young man, referred to as the Archer's Companion. The two men had unusual non-metric traits in the bones of their feet suggesting they were biologically related[39]. The oxygen isotope composition of both teeth (P2 & M3) from the Archer was 16.2‰. In contrast, the companion shows a significant difference in $\delta^{18}O_{VSMOW}$ between two teeth with the earlier forming premolar having a value of 17.0‰

and a later forming 3rd molar a value of 16.4‰. There has been much discussion of the origin of these individuals centring on whether the tooth enamel of the Archer excludes him from a British origin. This debate has hinged on calculating a drinking water value which, as shown by Pollard et al[63], incurs large errors and depends upon the equation chosen.

The tooth enamel value of 16.2‰ is within the 3 sigma range of the British oxygen isotope values as defined above. In other words there is, at best, a 2.5% probability that he is of British origin based on oxygen. However, more than one tooth has been analysed. If the four tooth enamel analyses from the Archer and the Companion are treated as a population subset and compared with the leeward area dataset they are significantly different populations at 95% confidence intervals (Figure 13).

Roman Period and earlier populations from Germany, Austria, Hungary and Czech Republic are dominated by $^{87}Sr/^{86}Sr$ values similar to that of the Archer's teeth[75-77], and these parts of continental Europe also have drinking water/rainwater values which could supply the oxygen isotopes values recorded in his tooth enamel[41, 78].

So although isotope analysis cannot definitely provide an answer as to whether he spent his childhood in Britain it can provide evidence that the man in this unusually rich burial has an unusual oxygen isotope composition in his teeth that represents, at best, 5% of the British population and that there are areas in continental Europe where his combined strontium and oxygen isotope tooth composition would be far more typical of the parent population.

Conclusions.

The data compiled in this paper provide a reference dataset for British populations from the Neolithic to 18th century AD.

The typical range of strontium isotope values is from 0.7078 to 0.7142 (England and Wales) and to 0.7165 (Scotland).

Strontium concentrations in Britain range between 20 and 180 ppm but there is a trend towards high strontium concentrations associated with a $^{87}Sr/^{86}Sr$ ratio around 0.7092. This feature appears to be related to the cultural practice of using seaweed to fertilise poor marginal soils.

Oxygen isotopes from tooth enamel in Britain display a normal distribution of data with a mean 17.7‰ ± 0.7‰, (1SD) n=615. Drinking water oxygen isotope values have a range of -7.41‰ ± 1.68‰ (n=975, 2SD).

Datasets based on “local” individuals define two subdivisions of Britain, based on human enamel values: leeward area = 17.2‰ ±0.6‰, (1SD, n=83) and windward area = 18.2‰ ± 0.5‰ (1SD, n=41).

These two populations can be used as control groups against which to compare populations of unknown origin. As this comparison is based on direct measurements of tooth enamel oxygen composition it removes the problem of having to convert to drinking water values with the associated uncertainties, choices and error expansion.

These data should provide a useful reference set for archaeological, forensic and environmental studies.

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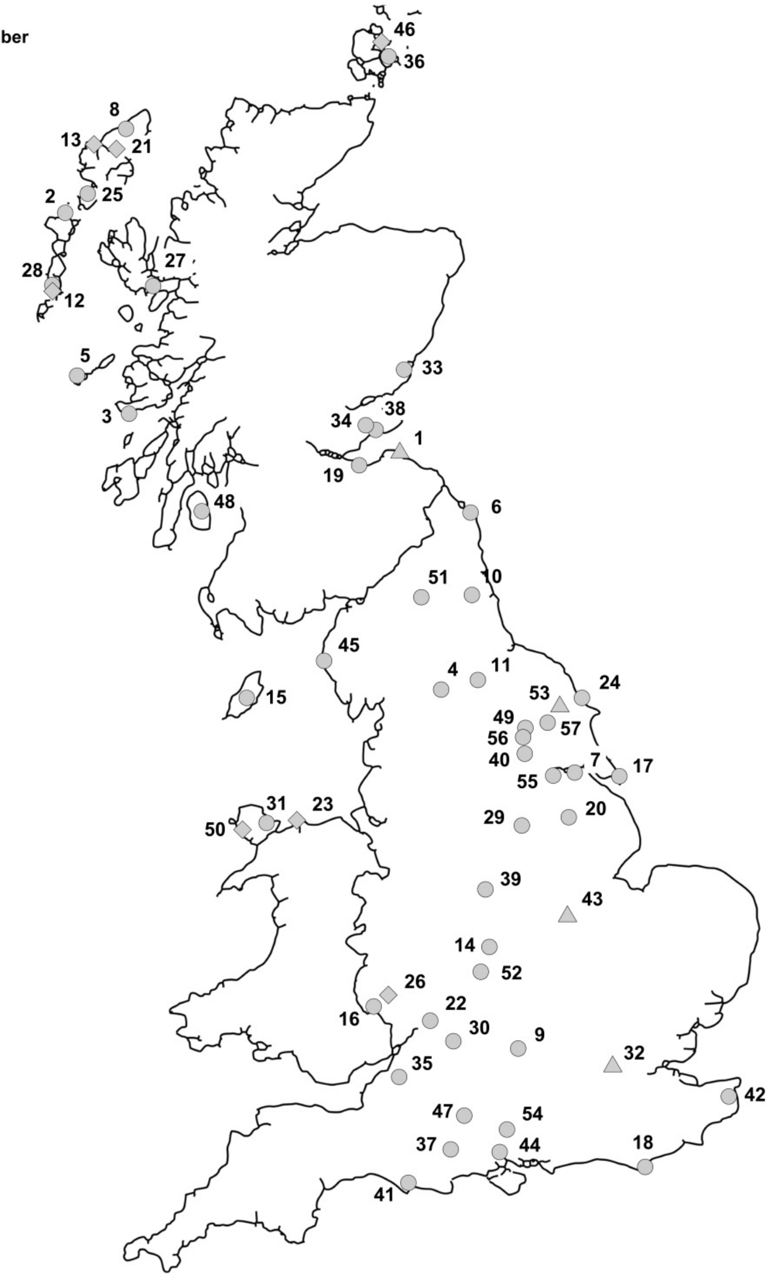
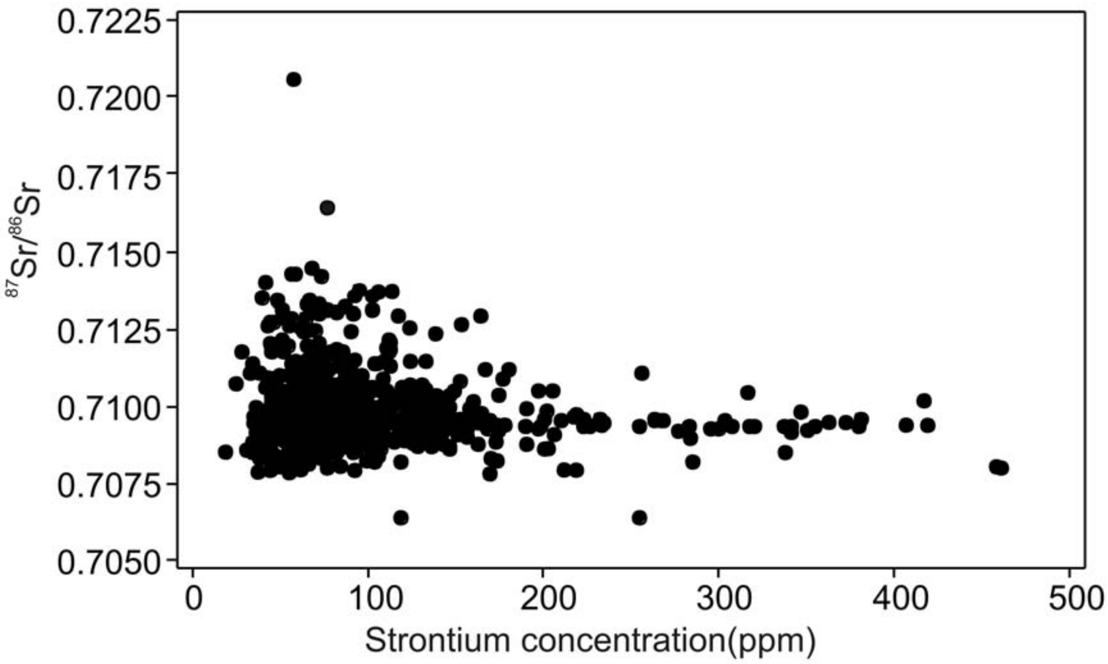
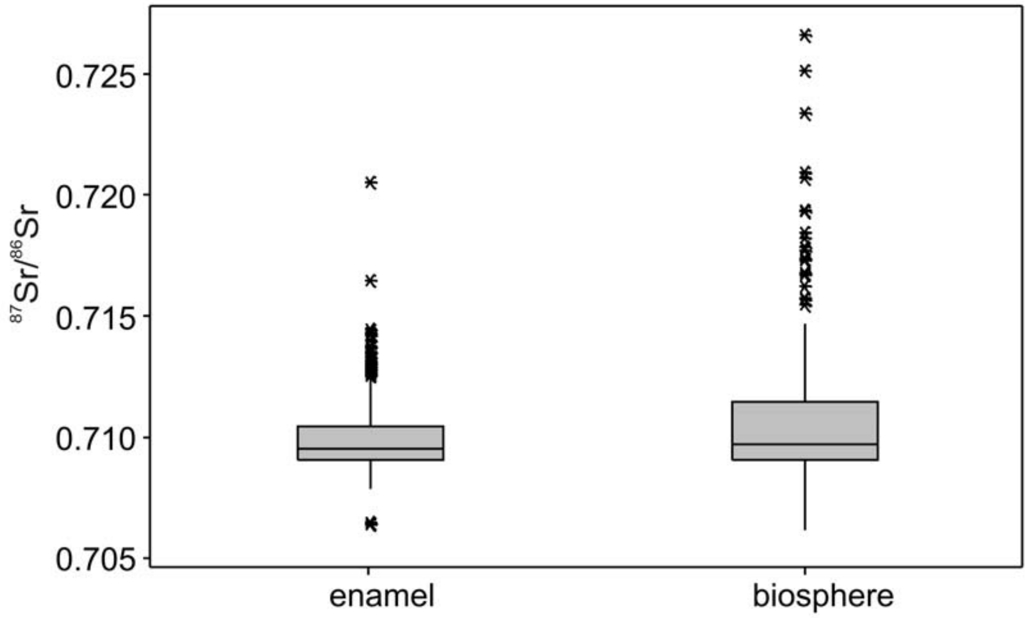
Site Name	**Site Number**
Aldhame	1
An Corran	2
Ardachy	3
Bainbridge Fort	4
Balevullin	5
Bamburgh	6
Barton-on-Humber	7
Barvas	8
Berinsfield	9
Black Gate	10
Catterick	11
Cladh Hallan	12
Cnip	13
Coventry	14
Cronk Keillane	15
Dore Abbey	16
Easington	17
Eastbourne	18
Edinburgh area	19
Fillingham	20
Galson	21
Gloucester area	22
Great Orme	23
Gristhorpe	24
Haugabost	25
Hereford	26
High Pastures Cave	27
Kilpheder	28
Kilton Hill	29
Kingshill	30
Llanbedrgoch	31
London	32
Lunan bay	33
Lundin Links	34
Mangotsfield	35
Mine Howe	36
Monkton	37
Rameldry	38
Repton	39
Riccall Landing	40
Ridgeway Hill	41
Ringlemere	42
Rutland	43
Southampton Friary	44
St Bees	45
St Thomas Kirk	46
Stonehenge	47
Tormor, Arran	48
Towthorpe	49
Tywyn y Capel	50
Vindolanda	51
Wasperton	52
West Heslerton	53
Winchester	54
Witton	55
York	56
Yorkshire Wolds	57

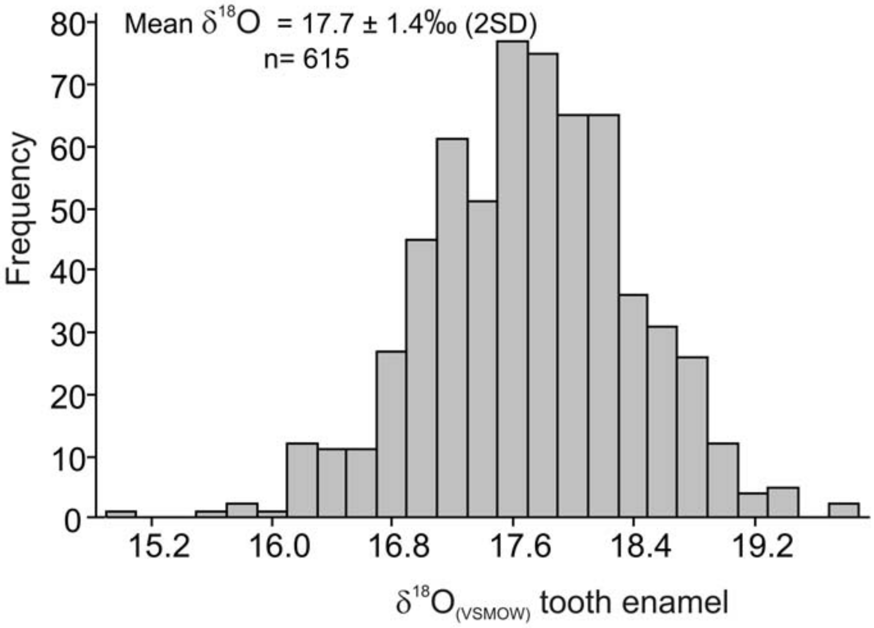


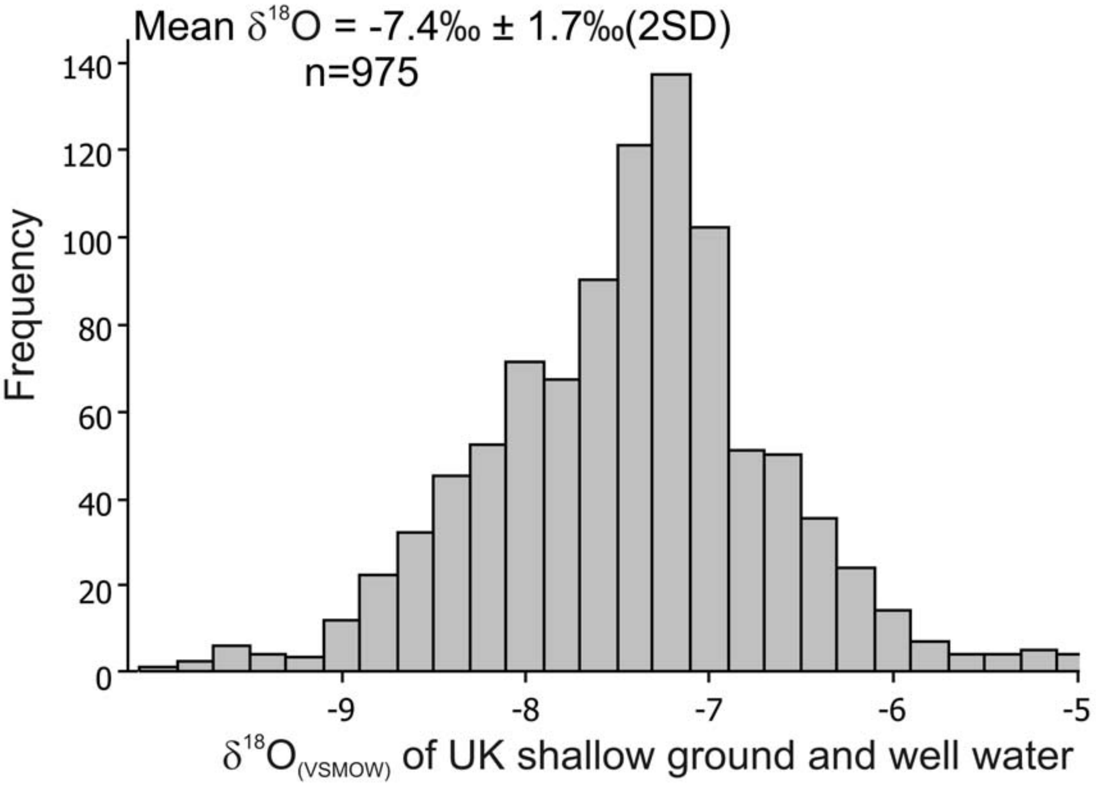


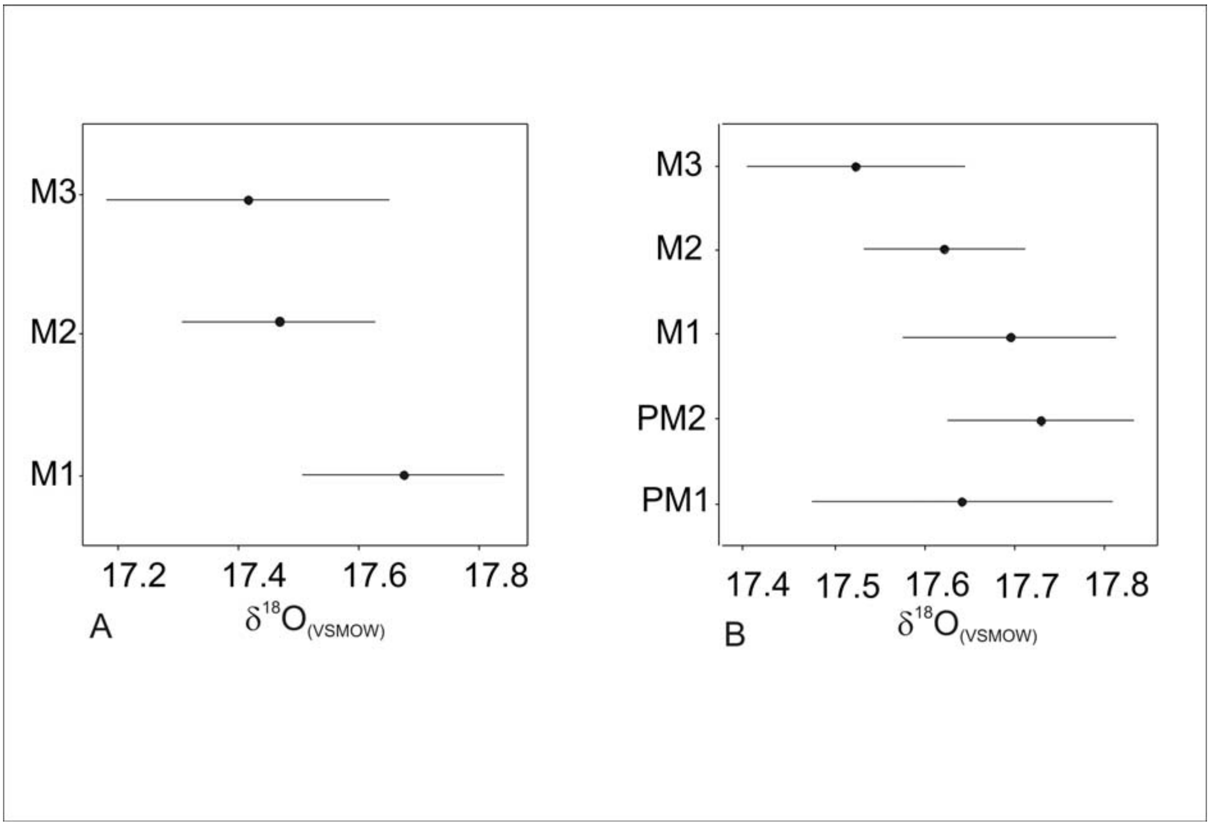
$^{87}Sr/^{86}Sr$
0.7225
0.7200
0.7175
0.7150
0.7125
0.7100
0.7075
0.7050
0
100
200
300
400
500
Strontium concentration(ppm)

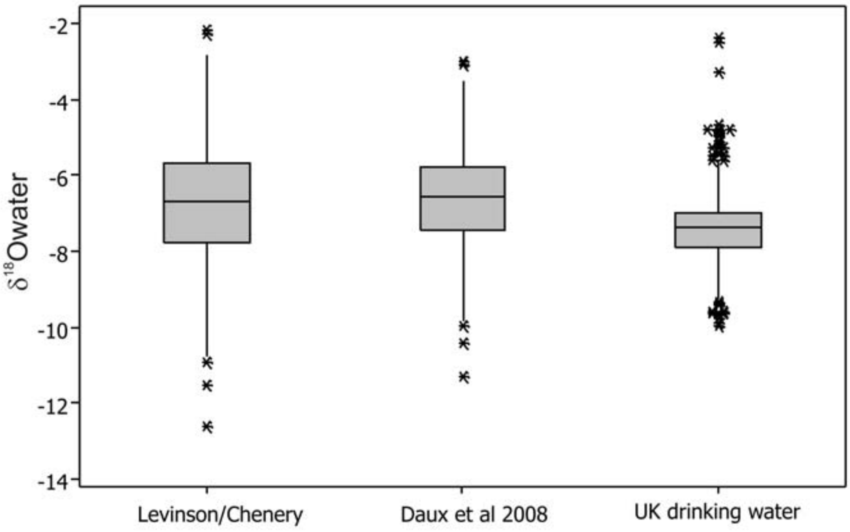


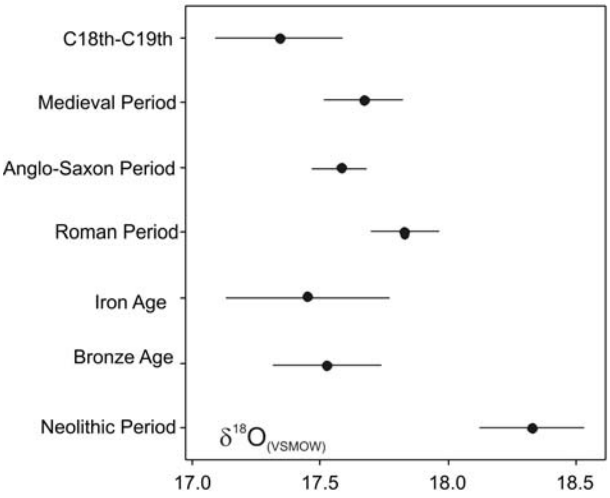
$^{87}Sr/^{86}Sr$
0.725
0.720
0.715
0.710
0.705
enamel
biosphere

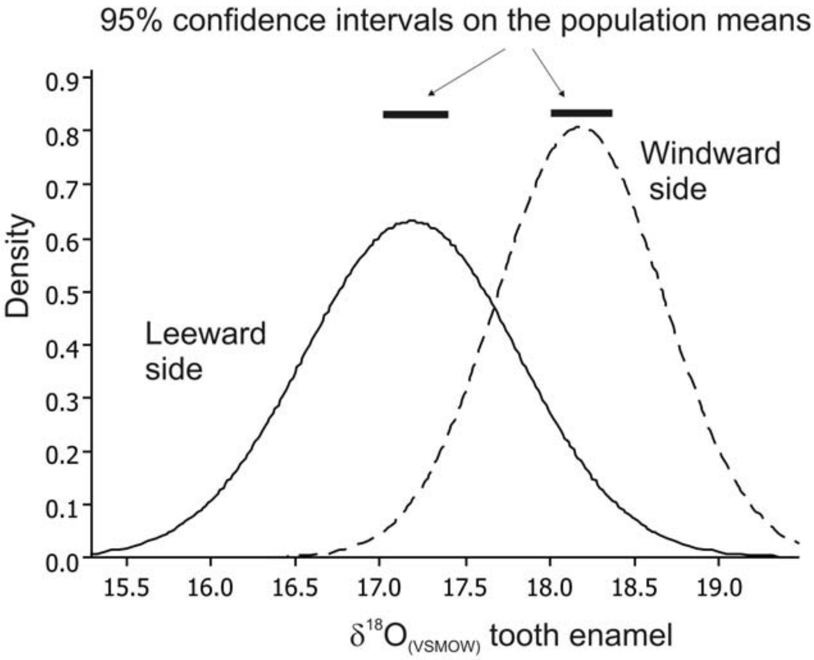

Mean $\delta^{18}O$ = 17.7 ± 1.4‰ (2SD)
n= 615
Frequency
0
10
20
30
40
50
60
70
80
15.2
16.0
16.8
17.6
18.4
19.2
$\delta^{18}O_{(VSMOW)}$ tooth enamel

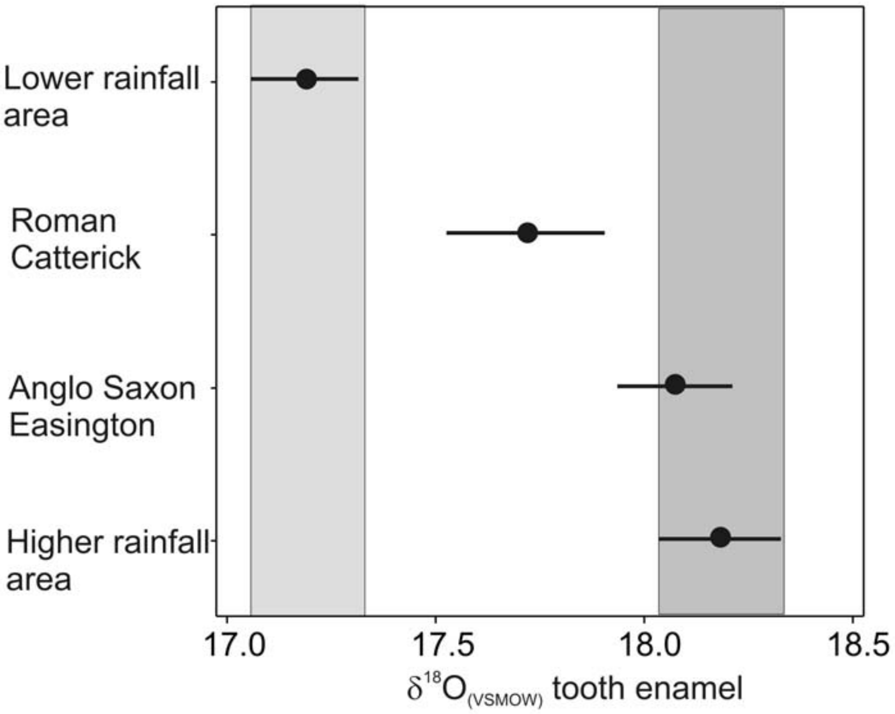

Mean δ18O = -7.4‰ ± 1.7‰(2SD)
n=975
Frequency
0
20
40
60
80
100
120
140
-9
-8
-7
-6
-5
δ18O(VSMOW) of UK shallow ground and well water

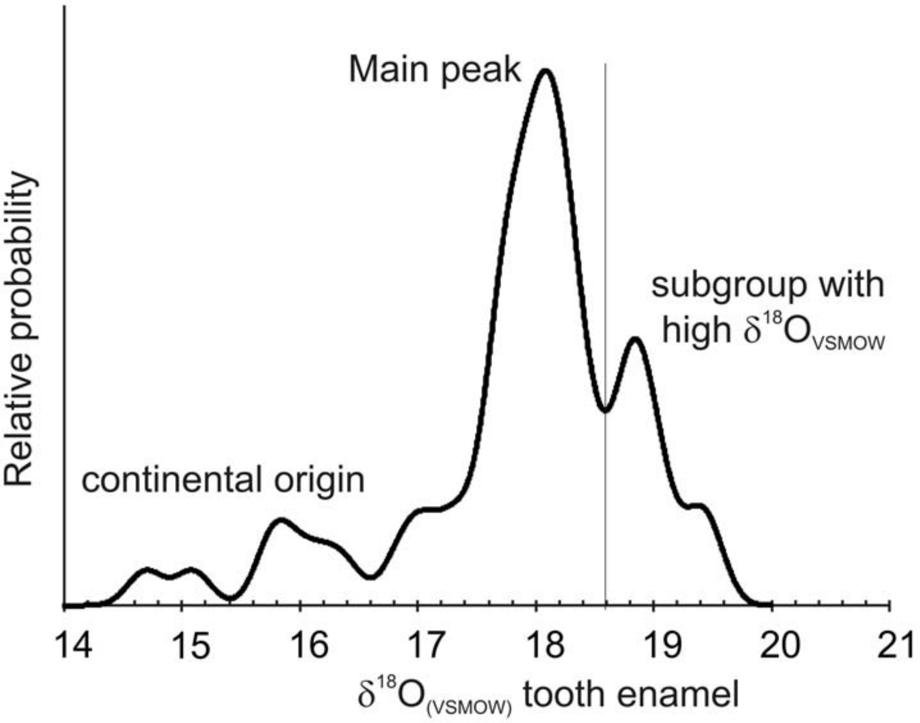

M3
M2
M1
17.2
17.4
17.6
17.8
A
$\delta^{18}O_{(VSMOW)}$
M3
M2
M1
PM2
PM1
17.4
17.5
17.6
17.7
17.8
B
$\delta^{18}O_{(VSMOW)}$

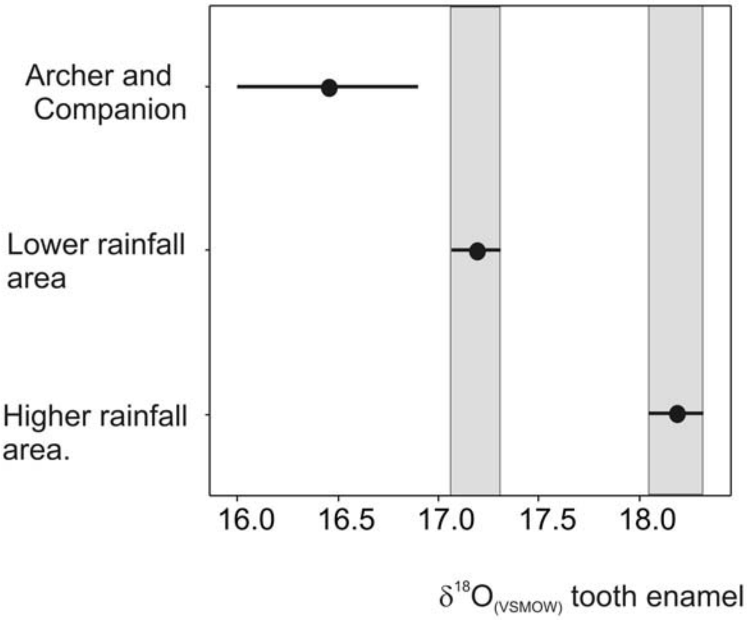

-2
-4
-6
-8
-10
-12
-14
δ^{18}Owater
Levinson/Chenery
Daux et al 2008
UK drinking water

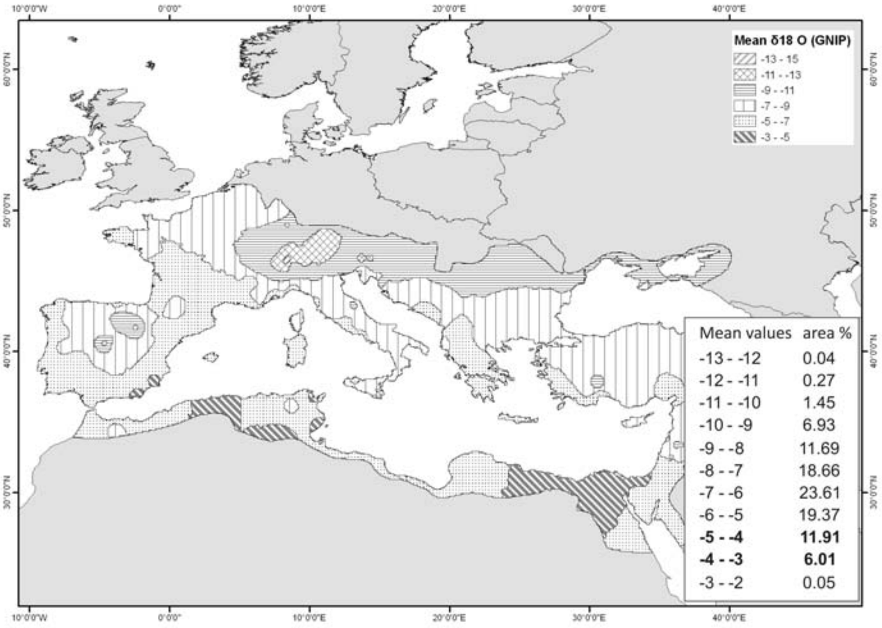

C18th-C19th
Medieval Period
Anglo-Saxon Period
Roman Period
Iron Age
Bronze Age
Neolithic Period
$\delta^{18}O_{(VSMOW)}$
17.0
17.5
18.0
18.5


95% confidence intervals on the population means
Density
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Windward side
Leeward side
15.5
16.0
16.5
17.0
17.5
18.0
18.5
19.0
$\delta^{18}O_{(VSMOW)}$ tooth enamel


Lower rainfall area
Roman Catterick
Anglo Saxon Easington
Higher rainfall area
17.0
17.5
18.0
18.5
$\delta^{18}O_{(VSMOW)}$ tooth enamel


Relative probability
Main peak
subgroup with high $\delta^{18}O_{VSMOW}$
continental origin
14
15
16
17
18
19
20
21
$\delta^{18}O_{(VSMOW)}$ tooth enamel





Mean values	area %
-13 - -12	0.04
-12 - -11	0.27
-11 - -10	1.45
-10 - -9	6.93
-9 - -8	11.69
-8 - -7	18.66
-7 - -6	23.61
-6 - -5	19.37
-5 - -4	**11.91**
-4 - -3	**6.01**
-3 - -2	0.05

Sample	Tooth	Sr (mg/kg)	^{87}Sr/^{86}Sr	δ^{18}0(VSMOW)	Age	Site	higher /lower rainfall
AL18	M2	69	0.710981		Bronze Age	Aldro	
AL19	C	39	0.708315	18.4	Bronze Age	Aldro	
AL20	pM2	66	0.709818	17.7	Bronze Age	Aldro	
Al21	pM1	35	0.708512		Bronze Age	Aldro	
Al22	M1	31	0.708588	18.3	Bronze Age	Aldro	
AL23	pM2	40	0.708361	18.6	Bronze Age	Aldro	
Bore-2	M2	149	0.709292		Iron Age	An Corren	
Bore-3	M2	107	0.709512		Iron Age	An Corren	
AULD-SK-071	M2			17.4	Medieval	Auldhame	
AULD-SK-074	M2	158	0.709926	18.1	Medieval	Auldhame	Lower rainfall
AULD-SK-122	M2	143	0.708751	17.1	Medieval	Auldhame	Lower rainfall
AULD-SK-158	M2	92	0.713542	17.3	Medieval	Auldhame	Lower rainfall
AULD-SK-216	M2	75	0.709339	18.2	Medieval	Auldhame	Lower rainfall
AULD-SK-219	M2	84	0.710213	17.2	Medieval	Auldhame	Lower rainfall
AULD-SK-318	M2	85	0.709637	16.5	Medieval	Auldhame	Lower rainfall
AULD-SK-327	M2	142	0.709484	19.0	Medieval	Auldhame	Lower rainfall
AULD-SK-352	M2	92	0.708903	16.5	Medieval	Auldhame	Lower rainfall
AULD-SK-394	M2	140	0.709329	17.3	Medieval	Auldhame	Lower rainfall
AULD-SK-467	M2	178	0.709390	16.9	Medieval	Auldhame	Lower rainfall
AULD-SK-520	M2	99	0.710593	16.9	Medieval	Auldhame	Lower rainfall
AULD-SK-626	M2	200	0.708647	18.0	Medieval	Auldhame	Lower rainfall
AULD-SK-663	M2	460	0.708012	17.4	Medieval	Auldhame	Lower rainfall
AULD-SK-669	M2	285	0.708189	17.6	Medieval	Auldhame	Lower rainfall
AULD-SK-714	M2	128	0.710306	18.3	Medieval	Auldhame	Lower rainfall
AULD-SK-733	M2	108	0.710841	16.8	Medieval	Auldhame	Lower rainfall
AULD-SK-742	M2	137	0.710037	17.7	Medieval	Auldhame	Lower rainfall
AULD-SK-752	M2	168	0.709236	17.5	Medieval	Auldhame	Lower rainfall
AULD-SK-868	M2	167	0.711162	17.5	Medieval	Auldhame	Lower rainfall
AULD-SK-883	M2	203	0.708647	18.2	Medieval	Auldhame	Lower rainfall
SF 614	M1	124	0.712550	18.6	Roman	Bainbridge Fort	
SF 615	M2	83	0.709940	17.9	Roman	Bainbridge Fort	
Tire-20	M2	355	0.709344		Neolithic	Balevullin	
B99 135	no record	33	0.711035	17.2	Medieval	Bamburgh	
BAM 99 -130	no record	78	0.711197	17.4	Medieval	Bamburgh	
BAM 99-129	no record	47	0.710937	18.0	Medieval	Bamburgh	
BH 99 124a	no record	28	0.711740	17.8	Medieval	Bamburgh	
BH 99 124b	no record	25	0.710747	18.6	Medieval	Bamburgh	
BH 99-134	no record	55	0.710478	16.0	Medieval	Bamburgh	
BH 99-135	no record			17.2	Medieval	Bamburgh	
BH98	no record	152	0.710772		Medieval	Bamburgh	
D48	pM2	65	0.711486	15.0	Medieval	Bamburgh	
D49	pM2	80	0.710649	17.1	Medieval	Bamburgh	
D50	pM2	38	0.711052	17.2	Medieval	Bamburgh	
D51	pM2	132	0.710052	17.7	Medieval	Bamburgh	
D52	M2	59	0.708925	17.6	Medieval	Bamburgh	
D53	M3	62	0.711084	16.8	Medieval	Bamburgh	
D54	pM2	68	0.710946	16.2	Medieval	Bamburgh	
D55	M2	116	0.709429	17.1	Medieval	Bamburgh	
D56	pM2	137	0.709830	16.8	Medieval	Bamburgh	
D57	M2	65	0.709816	17.6	Medieval	Bamburgh	
D58	pM2	78	0.710510	17.0	Medieval	Bamburgh	
D59	M3	115	0.709957	16.6	Medieval	Bamburgh	

D60	pM2	125	0.710162	17.2	Medieval	Bamburgh	
BH0580-M1	M1			18.8	Anglo-Saxon	Barton upon Humber	
BH1105-M1	M1			17.1	Anglo-Saxon	Barton upon Humber	
BH1105-M2	M2			17.0	Anglo-Saxon	Barton upon Humber	
BH1105-M3	M3			17.3	Anglo-Saxon	Barton upon Humber	
BH1136-M1	M1			17.1	Anglo-Saxon	Barton upon Humber	
BH1136-M2	M2			16.9	Anglo-Saxon	Barton upon Humber	
BH1136-M3	M3			17.5	Anglo-Saxon	Barton upon Humber	
BH1327-M2	M2			17.2	Anglo-Saxon	Barton upon Humber	
BARV-11	M2	156	0.709249	18.5	Iron Age	Barvas	Higher rainfall
Ber-001	pM2	86	0.709245	17.8	Anglo-Saxon	Berinsfield	
Ber-004	pM2	91	0.711151	17.5	Anglo-Saxon	Berinsfield	
Ber-005	M2	57	0.709493	18.3	Anglo-Saxon	Berinsfield	
Ber-006	pM2	55	0.709795	17.1	Anglo-Saxon	Berinsfield	
Ber-008	pM2	68	0.709128	18.1	Anglo-Saxon	Berinsfield	
Ber-010	pM2	47	0.709157	17.6	Anglo-Saxon	Berinsfield	
Ber-018	pM2	75	0.709258	17.7	Anglo-Saxon	Berinsfield	
Ber-020	pM2	57	0.708959	18.0	Anglo-Saxon	Berinsfield	
Ber-026	M2	79	0.709339	18.2	Anglo-Saxon	Berinsfield	
Ber-030	pM2	79	0.708820	17.6	Anglo-Saxon	Berinsfield	
Ber-042	pM2	76	0.708328	18.2	Anglo-Saxon	Berinsfield	
Ber-049	M3 L	93	0.709066	18.1	Anglo-Saxon	Berinsfield	
Ber-054	M2	49	0.709427	18.3	Anglo-Saxon	Berinsfield	
Ber-061	pM2	65	0.709302	17.6	Anglo-Saxon	Berinsfield	
Ber-073	pM2	37	0.709433	17.6	Anglo-Saxon	Berinsfield	
Ber-081	M2	60	0.708364	17.3	Anglo-Saxon	Berinsfield	
Ber-141	pM2	46	0.709321	17.5	Anglo-Saxon	Berinsfield	
Ber-150	pM2	65	0.709732	17.8	Anglo-Saxon	Berinsfield	
Ber-152	pM2	77	0.709463	18.1	Anglo-Saxon	Berinsfield	
BG030-M1	M1			17.8	Anglo-Saxon	Black Gate Newcastle	
BG030-M2	M2			17.7	Anglo-Saxon	Black Gate Newcastle	
BG030-M3	M3			17.9	Anglo-Saxon	Black Gate Newcastle	
BG040-M1	M1			17.9	Anglo-Saxon	Black Gate Newcastle	
BG040-M2	M2			17.8	Anglo-Saxon	Black Gate Newcastle	
BG040-M3	M3			18.0	Anglo-Saxon	Black Gate Newcastle	
BG048-M1	M1			17.7	Anglo-Saxon	Black Gate Newcastle	
BG248-M1	M1			17.7	Anglo-Saxon	Black Gate Newcastle	
BG248-M2	M2			17.4	Anglo-Saxon	Black Gate Newcastle	
BG252-M1	M1			18.3	Anglo-Saxon	Black Gate Newcastle	
BG252-M2	M2			17.4	Anglo-Saxon	Black Gate Newcastle	
BG252-M3	M3			17.5	Anglo-Saxon	Black Gate Newcastle	
BG314-M1	M1			17.9	Anglo-Saxon	Black Gate Newcastle	
BG314-M2	M2			17.8	Anglo-Saxon	Black Gate Newcastle	
BG314-M3	M3			17.3	Anglo-Saxon	Black Gate Newcastle	
BG365-M1	M1			17.9	Anglo-Saxon	Black Gate Newcastle	
BG386-M1	M1			17.6	Anglo-Saxon	Black Gate Newcastle	
BG386-M2	M2			17.4	Anglo-Saxon	Black Gate Newcastle	
BG386-M3	M3			17.5	Anglo-Saxon	Black Gate Newcastle	
BG422-M1	M1			17.2	Anglo-Saxon	Black Gate Newcastle	
BG433-M1	M1			17.1	Anglo-Saxon	Black Gate Newcastle	
BG433-M2	M2			17.5	Anglo-Saxon	Black Gate Newcastle	
BG433-M3	M3			17.5	Anglo-Saxon	Black Gate Newcastle	
BG498-M1	M1			18.0	Anglo-Saxon	Black Gate Newcastle	
BG498-M2	M2			17.5	Anglo-Saxon	Black Gate Newcastle	
BG498-M3	M3			17.3	Anglo-Saxon	Black Gate Newcastle	

BG499-M1	M1			17.4	Anglo-Saxon	Black Gate Newcastle	
BG499-M2	M2			17.5	Anglo-Saxon	Black Gate Newcastle	
BG499-M3	M3			18.0	Anglo-Saxon	Black Gate Newcastle	
BG534-M1	M1			16.9	Anglo-Saxon	Black Gate Newcastle	
BG534-M2	M2			17.1	Anglo-Saxon	Black Gate Newcastle	
BG534-M3	M3			16.9	Anglo-Saxon	Black Gate Newcastle	
BG567-M1	M1			17.1	Anglo-Saxon	Black Gate Newcastle	
BG567-M2	M2			17.2	Anglo-Saxon	Black Gate Newcastle	
BG567-M3	M3			16.4	Anglo-Saxon	Black Gate Newcastle	
BG576-M1	M1			18.2	Anglo-Saxon	Black Gate Newcastle	
BG576-M2	M2			17.7	Anglo-Saxon	Black Gate Newcastle	
BG576-M3	M3			17.8	Anglo-Saxon	Black Gate Newcastle	
BG581-M1	M1			17.4	Anglo-Saxon	Black Gate Newcastle	
BG581-M2	M2			16.8	Anglo-Saxon	Black Gate Newcastle	
BG581-M3	M3			17.1	Anglo-Saxon	Black Gate Newcastle	
BG591-M1	M1			18.0	Anglo-Saxon	Black Gate Newcastle	
BG591-M2	M2			17.7	Anglo-Saxon	Black Gate Newcastle	
BG591-M3	M3			18.1	Anglo-Saxon	Black Gate Newcastle	
BG595-M1	M1			18.0	Anglo-Saxon	Black Gate Newcastle	
BG626-M1	M1			17.3	Anglo-Saxon	Black Gate Newcastle	
BG626-M2	M2			17.1	Anglo-Saxon	Black Gate Newcastle	
BG626-M3	M3			16.8	Anglo-Saxon	Black Gate Newcastle	
BG637-M1	M1			18.5	Anglo-Saxon	Black Gate Newcastle	
BG637-M2	M2			18.4	Anglo-Saxon	Black Gate Newcastle	
BG637-M3	M3			18.0	Anglo-Saxon	Black Gate Newcastle	
BG659-M1	M1			17.1	Anglo-Saxon	Black Gate Newcastle	
BG659-M2	M2			17.1	Anglo-Saxon	Black Gate Newcastle	
BG659-M3	M3			16.8	Anglo-Saxon	Black Gate Newcastle	
209	pM1	62	0.710959		Medieval	Blackfriars, Gloucester	
341	pM1R	59	0.714232	17.9	Medieval	Blackfriars, Gloucester	
341	pM1L	56	0.714288	17.5	Medieval	Blackfriars, Gloucester	
357	pM2	56	0.711355		Medieval	Blackfriars, Gloucester	
77	pM1	66	0.711971	17.6	Medieval	Blackfriars, Gloucester	
89	pM1	70	0.708877	16.8	Medieval	Blackfriars, Gloucester	
1 (Boscombe)	pM2	63	0.707950	17.3	Bronze Age	Boscombe and Amesbury	
1 (Boscombe)	M3	77	0.707964	16.8	Bronze Age	Boscombe and Amesbury	
2 (Boscombe)	M3	189	0.709308	17.9	Bronze Age	Boscombe and Amesbury	
2 (Boscombe)	pM2	108	0.709270	17.5	Bronze Age	Boscombe and Amesbury	
25001	pM2	55	0.709825	17.6	Bronze Age	Boscombe and Amesbury	
25005?	pM2	55	0.709724	17.7	Bronze Age	Boscombe and Amesbury	
3 (Boscombe)	pM2	55	0.707851	18.0	Bronze Age	Boscombe and Amesbury	
3 (Boscombe)	M3	45	0.708003	17.6	Bronze Age	Boscombe and Amesbury	
4 (Boscombe)	pM2	38	0.707837	17.8	Bronze Age	Boscombe and Amesbury	
4 (Boscombe)	M3	50	0.708042	17.5	Bronze Age	Boscombe and Amesbury	
5 (Boscombe)	pM2	52	0.708226	17.6	Bronze Age	Boscombe and Amesbury	
5 (Boscombe)	M3	44	0.707910	17.5	Bronze Age	Boscombe and Amesbury	
6 (Boscombe)	pM2	49	0.713436	17.5	Bronze Age	Boscombe and Amesbury	
6 (Boscombe)	M3	59	0.711433	17.3	Bronze Age	Boscombe and Amesbury	
7 (Boscombe)	M3	86	0.711743	17.0	Bronze Age	Boscombe and Amesbury	
7 (Boscombe)	pM2	77	0.713093	16.9	Bronze Age	Boscombe and Amesbury	
BD 53535 25217	pM2	52	0.708222	18.8	Bronze Age	Boscombe and Amesbury	
BD 56240 6445	M2	66	0.708085	17.5	Bronze Age	Boscombe and Amesbury	
BDLC 53535 25010	pM2	40	0.713519	17.5	Bronze Age	Boscombe and Amesbury	
BDLC 53535 25010	M3	45	0.711871	17.4	Bronze Age	Boscombe and Amesbury	
Wx1238*	pM2		0.708550	17.0	Bronze Age	Boscombe and Amesbury	

Wx1238*	M3		0.709490	16.4	Bronze Age	Boscombe and Amesbury	
*Wx1291A Archer**	M3		0.709400	16.2	Bronze Age	Boscombe and Amesbury	
*Wx1291A Archer**	pM2		0.710340	16.2	Bronze Age	Boscombe and Amesbury	
CW 14	M3	50	0.708023	17.8	Bronze Age	Callis Wold	
CW12	pM1	92	0.707952	16.4	Bronze Age	Callis Wold	
CW13	pM1	44	0.712010	18.5	Bronze Age	Callis Wold	
CW 275	pM2	39	0.708896		Neolithic	Callis Wold	
CW10	C	46	0.708437		Neolithic	Callis Wold	
CW11	pM1	55	0.709325	18.2	Neolithic	Callis Wold	
CW9	M2	49	0.709865	17.9	Neolithic	Callis Wold	
CBB-255-M2	M2	46	0.710350	17.8	Roman	Catterick	
CBF-277-M3	M3	114	0.713680	17.3	Roman	Catterick	
CBF-324-M3	M3	131	0.709350	18.4	Roman	Catterick	
CBF-324-P2	pM2	118	0.709230	18.5	Roman	Catterick	
CBF-422-M3	M3	94	0.708990	17.1	Roman	Catterick	
CBF-475-M3	M3	75	0.710340	17.9	Roman	Catterick	
CBF-564-M2	M2	122	0.709250	17.1	Roman	Catterick	
CBF-632-M2	M2	57	0.710530	18.0	Roman	Catterick	
CBF-678-M3	M3	89	0.709110	16.9	Roman	Catterick	
CBF-679-M2	M2	106	0.713670	17.7	Roman	Catterick	
CBF-687-M1	M1	94	0.709460	19.0	Roman	Catterick	
CBF-709-M2	M2	85	0.709030	18.1	Roman	Catterick	
CBF-746-M2	M2	90	0.710950	17.1	Roman	Catterick	
CBF-746-M3	M3	104	0.710530	17.5	Roman	Catterick	
CBF-756-P2	pM2	74	0.710310	17.9	Roman	Catterick	
CBF-801-M3	M3	153	0.709550	18.5	Roman	Catterick	
CBF-812-M1	M1	64	0.709520	17.9	Roman	Catterick	
CBF-CX732-M3	M3	50	0.710160	16.8	Roman	Catterick	
CBRI-037-M2	M2	78	0.710160	17.8	Roman	Catterick	
CBRI-077-M3	M3	84	0.710260	18.0	Roman	Catterick	
CBRI-136-M2	M2	61	0.709970	17.3	Roman	Catterick	
CBRI-163-M2	M2	96	0.710050	17.6	Roman	Catterick	
CBRI-166-M3	M3	80	0.710470	17.4	Roman	Catterick	
CBRI-389-M1	M1	50	0.709600	17.8	Roman	Catterick	
CBRI-484-M1	M1	143	0.709470	17.7	Roman	Catterick	
CDS-PIV9-P2	pM2	138	0.710260	18.1	Roman	Catterick	
CHP-941-M3	M3	100	0.709790	17.0	Roman	Catterick	
CHP-942-M3	M3	80	0.709520	18.0	Roman	Catterick	
CHP-942-P2	pM2	87	0.709990	17.5	Roman	Catterick	
CHE 1051	M1	141	0.709268	17.5	C18th -19th	Chelsea	
CHE 792	pM2	118	0.706361	18.9	C18th -19th	Chelsea	
CHE 104	M2	117	0.709087	17.7	C18th -19th	Chelsea	Lower rainfall
CHE 147	pM1	83	0.708765	17.4	C18th -19th	Chelsea	Lower rainfall
CHE 161	pM2	198	0.709310	17.0	C18th -19th	Chelsea	Lower rainfall
CHE 18	pM2	277	0.709216	17.5	C18th -19th	Chelsea	Lower rainfall
CHE 19	pM2	73	0.710898	18.6	C18th -19th	Chelsea	Lower rainfall
CHE 285	M2	111	0.708974	18.8	C18th -19th	Chelsea	Lower rainfall
CHE 31	M1	128	0.708932	17.5	C18th -19th	Chelsea	Lower rainfall
CHE 35	pM2	137	0.709270	17.8	C18th -19th	Chelsea	Lower rainfall
CHE 39	pM2	104	0.709318	17.4	C18th -19th	Chelsea	Lower rainfall
CHE 392	pM2	154	0.709217	16.9	C18th -19th	Chelsea	Lower rainfall
CHE 552	M2	83	0.709880	17.3	C18th -19th	Chelsea	Lower rainfall
CHE 654	M2	125	0.709449	17.2	C18th -19th	Chelsea	Lower rainfall
CHE 697	pM2	76	0.709202	17.2	C18th -19th	Chelsea	Lower rainfall
CHE 713	M3	156	0.709468	17.3	C18th -19th	Chelsea	Lower rainfall

CHE 744	pM2	163	0.709449	17.4	C18th -19th	Chelsea	Lower rainfall
CHE 750	pM2	98	0.709163	17.6	C18th -19th	Chelsea	Lower rainfall
CHE 841	M2	175	0.710357	16.7	C18th -19th	Chelsea	Lower rainfall
CHE 856	pM2	175	0.709190	17.6	C18th -19th	Chelsea	Lower rainfall
CHE 918	M2	135	0.709298	17.9	C18th -19th	Chelsea	Lower rainfall
Che 980	pM2	90	0.708903	17.4	C18th -19th	Chelsea	Lower rainfall
CHE 990	M2	39	0.709380	16.2	C18th -19th	Chelsea	Lower rainfall
CHE 994	pM2	197	0.709295	17.9	C18th -19th	Chelsea	Lower rainfall
CHSU-5425-1	M1			17.7	Bronze Age	Clad Hallan	
CGSU-0105-1	no record	226	0.709395	17.8	Bronze Age	Clad Hallan	Higher rainfall
CHO1-2316	C	223	0.709354	19.1	Bronze Age	Clad Hallan	Higher rainfall
CHO1-2316	M2	295	0.709276	18.3	Bronze Age	Clad Hallan	Higher rainfall
CHO1-2638	M2	299	0.709264	17.8	Bronze Age	Clad Hallan	Higher rainfall
CHO1-2727	C	217	0.709619	18.5	Bronze Age	Clad Hallan	Higher rainfall
CHO1-2727	M2	201	0.709588	18.1	Bronze Age	Clad Hallan	Higher rainfall
CHSU-5087-1	pM1?	380	0.709359	18.6	Bronze Age	Clad Hallan	Higher rainfall
CHSU-5159-1	M2	267	0.709541	18.6	Bronze Age	Clad Hallan	Higher rainfall
CHSU-5424-1-1	M1	317	0.709355	18.7	Bronze Age	Clad Hallan	Higher rainfall
CHSU-5424-2-1	M2	342	0.709356	18.6	Bronze Age	Clad Hallan	Higher rainfall
CHSU-5424-3-1	M3	303	0.709528	18.4	Bronze Age	Clad Hallan	Higher rainfall
CNIP BA	C	158	0.709460		Bronze Age	Cnip	
CNIP A	pM1	101	0.710488	16.7	Norse	Cnip	
CNIP B	dI1	152	0.709595	17.8	Norse	Cnip	
CNIP C	pM1	210	0.709526		Norse	Cnip	
CNIP D	C	218	0.707932	17.2	Norse	Cnip	
CNIP D	pM1	169	0.707802	16.7	Norse	Cnip	
CNIP E	pM1	58	0.708575	17.3	Norse	Cnip	
CNIP F	dI1	165	0.709771		Norse	Cnip	
CNIP G	dI1	417	0.710190		Norse	Cnip	
CNIP-A-SK3-e	M2	232	0.709606	18.2	Norse	Cnip	Higher rainfall
CNIP-D-SK3-e	M2	320	0.709346	18.9	Norse	cnip	Higher rainfall
COV 1248	M2	63	0.709620	16.3	C18th -19th	Coventry	
Cov 417	pM1	94	0.710436	16.6	C18th -19th	Coventry	
COV 434	pM2	139	0.709778	16.1	C18th -19th	Coventry	
COV 50	pM1	95	0.709972	17.0	C18th -19th	Coventry	
COV 516	M2	351	0.709183	16.8	C18th -19th	Coventry	
COV 672	M2	113	0.709940	16.3	C18th -19th	Coventry	
COV 77	pM2	91	0.710417	16.2	C18th -19th	Coventry	
Cov 808	pM1	107	0.709974	16.6	C18th -19th	Coventry	
COV 978	pM1	142	0.709151	17.1	C18th -19th	Coventry	
COV 866	M2	109	0.710028	17.3	C18th -19th	Coventry	
CK 1225	M2	107	0.710456	17.9	Medieval	Cronk Keillane	
CK 1226	M2	113	0.712072	17.3	Medieval	Cronk Keillane	
CK 1234	M2	74	0.710990	17.7	Medieval	Cronk Keillane	
CK 1236	M2	127	0.710399	18.5	Medieval	Cronk Keillane	
CK 1581A	M2	121	0.708962	17.7	Medieval	Cronk Keillane	
CK 1769	M2	146	0.709404	17.3	Medieval	Cronk Keillane	
CK 1781	M2	67	0.709956	18.8	Medieval	Cronk Keillane	
AA-114-32	M2	72	0.713270	17.6	Medieval	Dore Abbey	Higher rainfall
DRIF-10	M2	67	0.709563	15.0	Roman	Driffield/York	
DRIF-15	M3	73	0.714202	18.9	Roman	Driffield/York	
DRIF-16	M3	71	0.709407	17.7	Roman	Driffield/York	
DRIF-33	M2	131	0.708920	17.1	Roman	Driffield/York	
DRIF-35	M2	67	0.709401	17.4	Roman	Driffield/York	
DRIF-37	M2	42	0.708924	18.4	Roman	Driffield/York	

DRIF6-01	pM2	79	0.710400	17.0	Roman	Driffield/York	
DRIF6-02	pM2	113	0.711300	17.2	Roman	Driffield/York	
DRIF6-04	pM2	57	0.710000	16.6	Roman	Driffield/York	
DRIF6-06	pM2	68	0.709200	17.5	Roman	Driffield/York	
DRIF6-07	pM2	62	0.709900	18.1	Roman	Driffield/York	
DRIF6-08	pM2	55	0.711000	17.3	Roman	Driffield/York	
DRIF6-09	pM2	43	0.712600	16.9	Roman	Driffield/York	
DRIF6-12	pM2			18.1	Roman	Driffield/York	
DRIF6-14	pM2	60	0.710900	16.7	Roman	Driffield/York	
DRIF6-15	pM2	83	0.711400	16.5	Roman	Driffield/York	
DRIF6-17	pM2	51	0.710300	17.1	Roman	Driffield/York	
DRIF6-18	pM2	62	0.709100	18.6	Roman	Driffield/York	
DRIF6-19	pM2	72	0.709400	18.7	Roman	Driffield/York	
DRIF6-20	pM2	34	0.711400	16.7	Roman	Driffield/York	
DRIF6-21	pM2	90	0.709400	19.8	Roman	Driffield/York	
DRIF6-22	pM2	104	0.709200	18.6	Roman	Driffield/York	
DRIF6-23	pM2	65	0.710900	16.7	Roman	Driffield/York	
DRIF6-24	pM2	56	0.708500	14.7	Roman	Driffield/York	
DH1	I2	68	0.710201	17.9	Neolithic	Duggleby Howe	
DH2	M2	86	0.709570		Neolithic	Duggleby Howe	
DH3	M2	50	0.709138	17.5	Neolithic	Duggleby Howe	
DH4	pM1	44	0.708594	18.9	Neolithic	Duggleby Howe	
DH5	pM2	49	0.709997	17.7	Neolithic	Duggleby Howe	
DH6	M2	72	0.709349	17.8	Neolithic	Duggleby Howe	
DH7	pM1	41	0.709849	18.3	Neolithic	Duggleby Howe	
G318	pM1	56	0.708227	17.9	Roman	Eagle Hotel	
G319	pM1	91	0.708482	18.9	Roman	Eagle Hotel	
G326	pM1	80	0.708629	18.2	Roman	Eagle Hotel	
G339A	M3	93	0.709147	18.2	Roman	Eagle Hotel	
G339B	pM2	79	0.709310	18.3	Roman	Eagle Hotel	
Morgan-1	pM?1/2	78	0.710755	18.3	Anglo-Saxon	Easington	
Morgan-2	M2	74	0.710714	18.1	Anglo-Saxon	Easington	
Morgan-3	M2	112	0.712142	18.0	Anglo-Saxon	Easington	
Morgan-4	M2	98	0.709479	18.1	Anglo-Saxon	Easington	
Morgan-5	M2	119	0.710144	17.9	Anglo-Saxon	Easington	
EAS-051	pM2	77	0.708638	17.3	Anglo-Saxon	Eastbourne	
EAS-057	pM2	61	0.709669	17.6	Anglo-Saxon	Eastbourne	
EAS-061	pM2	80	0.708819	18.4	Anglo-Saxon	Eastbourne	
EAS-064	pM2	65	0.711291	18.2	Anglo-Saxon	Eastbourne	
EAS-067	pM2	66	0.709193	18.1	Anglo-Saxon	Eastbourne	
EAS-111	pM2	43	0.708818	18.2	Anglo-Saxon	Eastbourne	
EAS-157	pM2	94	0.708640	18.7	Anglo-Saxon	Eastbourne	
EAS-190	M2	69	0.709084	18.6	Anglo-Saxon	Eastbourne	
EAS-233	pM2	49	0.709030	18.5	Anglo-Saxon	Eastbourne	
EAS-264	pM2	63	0.710084	17.9	Anglo-Saxon	Eastbourne	
EAS-270	pM2	60	0.710514	17.3	Anglo-Saxon	Eastbourne	
EAS-309	pM2	52	0.710002	17.3	Anglo-Saxon	Eastbourne	
EAS-355	pM2	73	0.709336	17.1	Anglo-Saxon	Eastbourne	
EAS-381	pM2	77	0.708681	18.2	Anglo-Saxon	Eastbourne	
EAS-481	pM2	73	0.710079	17.7	Anglo-Saxon	Eastbourne	
EAS-650	pM2	81	0.709080	18.1	Anglo-Saxon	Eastbourne	
EAS-681	pM2	89	0.708898	18.0	Anglo-Saxon	Eastbourne	
EAS-753	pM2	95	0.708683	18.8	Anglo-Saxon	Eastbourne	
EAS-796	pM2	89	0.708835	18.2	Anglo-Saxon	Eastbourne	
EMP -039	no record	83	0.709593	16.3	Anglo-Saxon	Empingham	Lower rainfall

Emp -046	no record	35	0.709677	17.0	Anglo-Saxon	Empingham	Lower rainfall
EMP -049	no record	55	0.710481	17.2	Anglo-Saxon	Empingham	Lower rainfall
Emp -081	no record	55	0.709476	16.9	Anglo-Saxon	Empingham	Lower rainfall
EMP -110	no record	45	0.710113	16.8	Anglo-Saxon	Empingham	Lower rainfall
EMP- 115	no record	51	0.710488	17.1	Anglo-Saxon	Empingham	Lower rainfall
EMP -119	no record	58	0.709567	17.1	Anglo-Saxon	Empingham	Lower rainfall
EMP-003	no record			16.4	Anglo-Saxon	Empingham	Lower rainfall
EMP-026	no record	35	0.709478	17.1	Anglo-Saxon	Empingham	Lower rainfall
EMP-030	pM2	63	0.709514		Anglo-Saxon	Empingham	Lower rainfall
EMP-031B	no record			16.1	Anglo-Saxon	Empingham	Lower rainfall
EMP-031C	no record			17.7	Anglo-Saxon	Empingham	Lower rainfall
EMP-037	no record			17.5	Anglo-Saxon	Empingham	Lower rainfall
EMP-050	no record	82	0.710030	17.3	Anglo-Saxon	Empingham	Lower rainfall
Emp-094	no record	76	0.710463	16.9	Anglo-Saxon	Empingham	Lower rainfall
EMP-095	no record			17.0	Anglo-Saxon	Empingham	Lower rainfall
FCR03-M1	M1			17.4	Anglo-Saxon	Filingham	
FCR03-M2	M2			16.7	Anglo-Saxon	Filingham	
FCR03-M3	M3			17.4	Anglo-Saxon	Filingham	
FCR04-M1	M1			17.7	Anglo-Saxon	Filingham	
FCR04-M2	M2			17.0	Anglo-Saxon	Filingham	
FCR04-M3	M3			17.5	Anglo-Saxon	Filingham	
Gals-93	pM1	71	0.713033	16.1	Iron Age	Galson	
Gals-96	pM1	337	0.709345	17.8	Iron Age	Galson	
Gals-II	pM1	233	0.709417	17.0	Iron Age	Galson	
Gals-IV	pM1	82	0.711860	17.0	Iron Age	Galson	
Gals-74	C	174	0.709379	16.9	Iron Age	Galston	
GLR1103	M3	114	0.709440	18.4	Roman	Gloucester	
GLR1127	M3	121	0.709669	17.2	Roman	Gloucester	
GLR1131	M3	133	0.711428	17.1	Roman	Gloucester	
GLR1181	M2	76	0.710574	17.6	Roman	Gloucester	
GLR1216	M3	93	0.709407	19.2	Roman	Gloucester	
GLR1238	M3	52	0.708912	17.1	Roman	Gloucester	
GLR1328	M3	57	0.710559	18.0	Roman	Gloucester	
GLR1340	M2	104	0.709581	17.9	Roman	Gloucester	
GLR1360	M2	133	0.708996	19.0	Roman	Gloucester	
GLR1364	M3	104	0.711380	18.2	Roman	Gloucester	
GLR1518	M2	72	0.712980	17.9	Roman	Gloucester	
GLR1520	M3	130	0.709707	18.6	Roman	Gloucester	
GLR1539	M3	66	0.708780	17.5	Roman	Gloucester	
GLR1541	M3	51	0.712175	17.1	Roman	Gloucester	
GLR1544	M3	102	0.709944	18.2	Roman	Gloucester	
GLR1546	M3	177	0.710864	19.1	Roman	Gloucester	
GLR1553	M3	84	0.709243	17.4	Roman	Gloucester	
GLR1560	M3	114	0.709461	18.7	Roman	Gloucester	
GLR1561	M3	67	0.713443	18.7	Roman	Gloucester	
GLR1565	M2	104	0.709748	19.0	Roman	Gloucester	
GLR1596	M2	105	0.709042	17.7	Roman	Gloucester	
44-77-I46	pM2	70	0.710900	16.0	Roman	Gloucester	
44-77-I46	M3	54	0.711010	15.2	Roman	Gloucester	
P16379	pM1	86	0.710443	17.9	Bronze Age	Great Orme	Higher rainfall
3061	pM2?	115	0.708810	17.4	C18th -19th	Greenwich	
GRIS	M2	66	0.710723	17.2	Bronze Age	Gristhorpe	
HAUG-1	M2	307	0.709340	18.0	Neolithic	Haugabost	Higher rainfall
HFRD-140	M2	90	0.712377		Medieval	Hereford	
HFRD-1798	M2	64	0.712861		Medieval	Hereford	

HFRD-221	M2	92	0.709334		Medieval	Hereford	
HFRD-2374	M2	138	0.712372		Medieval	Hereford	
HFRD-2656	M2	87	0.713255		Medieval	Hereford	
HFRD-3265	M2	44	0.712754		Medieval	Hereford	
HFRD-341	M2	53	0.712866		Medieval	Hereford	
HFRD-3661	M2	66	0.712479		Medieval	Hereford	
HFRD-869	M2	46	0.712711		Medieval	Hereford	
HFRD-869	M2	42	0.714008		Medieval	Hereford	
HFRD-905	M2	62	0.712523		Medieval	Hereford	
HFRD-1517	M2	70	0.712482	18.5	Medieval	Hereford	Higher rainfall
HFRD-1774	M2	124	0.710539	17.7	Medieval	Hereford	Higher rainfall
HFRD-2006	M2	55	0.712607	17.9	Medieval	Hereford	Higher rainfall
HFRD-3850	M2	66	0.713292	17.8	Medieval	Hereford	Higher rainfall
HFRD-410	M2	111	0.711875	17.7	Medieval	Hereford	Higher rainfall
HFRD-713	M2	57	0.712857	18.6	Medieval	Hereford	Higher rainfall
HFRD-911	M2	60	0.713023	17.9	Medieval	Hereford	Higher rainfall
HFRD-959	M2	91	0.712951	16.9	Medieval	Hereford	Higher rainfall
HPCS-100	dC1	140	0.709085	17.4	Iron Age	High Pasture Cave	
HPCS-101	M1	172	0.709317	17.7	Iron Age	High Pasture Cave	Higher rainfall
HPCS-102	M2	128	0.709081	17.6	Iron Age	High Pasture Cave	Higher rainfall
HPCS-103	M3	151	0.709061	17.5	Iron Age	High Pasture Cave	Higher rainfall
Inch	M1	75	0.709928	18.2	Bronze Age	Inchmarnock	
KCC-Roman-2	no record			18.2	Roman	Ketton	
KCC-Roman-3	no record			17.5	Roman	Ketton	
KCC 98 57	deciduous	44	0.709553	18.2	Anglo-Saxon	Ketton	
KCC 98 71	deciduous	86	0.709358	17.5	Anglo-Saxon	Ketton	
KCC 007	adult	66	0.708966	16.3	Anglo-Saxon	Ketton	Lower rainfall
KCC 014	adult	153	0.712663	17.2	Anglo-Saxon	Ketton	Lower rainfall
KCC 017	adult	58	0.709505	16.8	Anglo-Saxon	Ketton	Lower rainfall
KCC 047	adult	72	0.709372	16.2	Anglo-Saxon	Ketton	Lower rainfall
KCC 049	adult			17.2	Anglo-Saxon	Ketton	Lower rainfall
KCC 058	adult	67	0.709392	16.8	Anglo-Saxon	Ketton	Lower rainfall
KCC 064	adult	105	0.711407	16.4	Anglo-Saxon	Ketton	Lower rainfall
KCC 065	adult	60	0.710489	15.5	Anglo-Saxon	Ketton	Lower rainfall
KCC 066	adult	81	0.709375	17.3	Anglo-Saxon	Ketton	Lower rainfall
KCC 067	adult	123	0.710261	17.2	Anglo-Saxon	Ketton	Lower rainfall
KCC 98 13	permanent (child)	44	0.709460	17.2	Anglo-Saxon	Ketton	Lower rainfall
KCC 98 32	permanent (child)	51	0.709244	16.6	Anglo-Saxon	Ketton	Lower rainfall
KCC 98 34	adult	62	0.709213	16.7	Anglo-Saxon	Ketton	Lower rainfall
KCC 98 40	permanent (child)	79	0.709564	16.2	Anglo-Saxon	Ketton	Lower rainfall
KCC 98 52	adult	60	0.709535	16.8	Anglo-Saxon	Ketton	Lower rainfall
KCC 98 54	adult	126	0.709835	16.1	Anglo-Saxon	Ketton	Lower rainfall
KCC 98 55	adult	75	0.710566	16.9	Anglo-Saxon	Ketton	Lower rainfall
KCC 98 56	adult	97	0.710997	18.3	Anglo-Saxon	Ketton	Lower rainfall
KCC 98 6	permanent (child)	104	0.709275	16.8	Anglo-Saxon	Ketton	Lower rainfall
KCC 98 63	adult	86	0.710267	17.2	Anglo-Saxon	Ketton	Lower rainfall
KCC 98 68a	permanent (child)	53	0.709588	17.4	Anglo-Saxon	Ketton	Lower rainfall
KCC 98 68b	permanent (child)	58	0.709878	17.2	Anglo-Saxon	Ketton	Lower rainfall
KCC 98 9	adult	69	0.709349	16.1	Anglo-Saxon	Ketton	Lower rainfall
K1	M1	126	0.709206	17.2	Iron Age	Kilpheder	
K2	M2	130	0.708876	17.8	Iron Age	Kilpheder	
KH49-M1	M1			18.2	Anglo-Saxon	Kilton Hill	
KH49-M2	M2			17.8	Anglo-Saxon	Kilton Hill	

KH49-M3	M3			18.0	Anglo-Saxon	Kilton Hill	
KH54-M1	M1			17.7	Anglo-Saxon	Kilton Hill	
KH54-M2	M2			17.6	Anglo-Saxon	Kilton Hill	
KH54-M3	M3			17.4	Anglo-Saxon	Kilton Hill	
CIKNO-08-SK1403	M1	58	0.709620	18.7	Bronze Age	Kings Hill North/Cirencester	
CIKNO-08-SK1403	PM2	44	0.708939	18.1	Bronze Age	Kings Hill North/Cirencester	
CIKNO-08-SK8656	M2	36	0.708720	17.5	Bronze Age	Kings Hill North/Cirencester	
CIKNO-08-SK8656	PM2	37	0.708566	17.1	Bronze Age	Kings Hill North/Cirencester	
Ay21-0012	pM2	103	0.708173	18.2	Roman	Lankhills	
Ay21-0084	M2	79	0.708599	18.8	Roman	Lankhills	
Ay21-0119	M2	100	0.708707	19.5	Roman	Lankhills	
Ay21-0212	pM2	66	0.708712	18.3	Roman	Lankhills	
AY21-0271	M2	139	0.710227	19.4	Roman	Lankhills	
AY21-0281	M2	92	0.711497	16.8	Roman	Lankhills	
AY21-0435	M2	53	0.708946	17.5	Roman	Lankhills	
Ay21-0489	M2	72	0.711242	17.8	Roman	Lankhills	
AY21-0566	M2	169	0.709516	18.8	Roman	Lankhills	
Ay21-0661	pM1	54	0.708481	18.1	Roman	Lankhills	
Ay21-0683	M3	132	0.709382	18.9	Roman	Lankhills	
AY21-0776	M2	86	0.709647	17.8	Roman	Lankhills	
AY21-0806	pM2	88	0.708734	19.3	Roman	Lankhills	
AY21-0812	M2	128	0.708674	19.0	Roman	Lankhills	
Ay21-0861M3	M3	54	0.709811	18.0	Roman	Lankhills	
Ay21-0861P2	pM2	54	0.709822	18.2	Roman	Lankhills	
AY21-0862	M2	118	0.708197	17.8	Roman	Lankhills	
Ay21-0874	M2	81	0.708752	18.0	Roman	Lankhills	
AY21-0926	M2	104	0.708615	18.3	Roman	Lankhills	
Ay21-0932	M2	67	0.708414	17.9	Roman	Lankhills	
Ay21-1026	M1	78	0.708504	17.9	Roman	Lankhills	
Ay21-1084	M2	105	0.709169	18.2	Roman	Lankhills	
AY21-1091	M2	105	0.709081	18.1	Roman	Lankhills	
AY21-1094	M2	42	0.708343	17.0	Roman	Lankhills	
AY21-1114	M2	121	0.708862	19.0	Roman	Lankhills	
Ay21-1119	M2	87	0.709416	15.8	Roman	Lankhills	
Ay21-1133	M1	51	0.709190	18.5	Roman	Lankhills	
AY21-1134	pM2	65	0.708624	18.0	Roman	Lankhills	
Ay21-1197	pM2	59	0.710993	17.8	Roman	Lankhills	
AY21-1207	M2	108	0.708898	17.9	Roman	Lankhills	
AY21-1227	M2	73	0.708304	18.3	Roman	Lankhills	
AY21-1244	M2	61	0.708586	18.4	Roman	Lankhills	
Ay21-1271	M2	67	0.708331	17.7	Roman	Lankhills	
AY21-1277	M2	87	0.711478	18.2	Roman	Lankhills	
Ay21-1289	M2	58	0.708723	18.1	Roman	Lankhills	
AY21-1517	pM2	81	0.709040	18.7	Roman	Lankhills	
Ay21-1697	M2	95	0.708971	18.8	Roman	Lankhills	
Ay21-1761	M2	80	0.708575	18.3	Roman	Lankhills	
Ay21-1870	M2	79	0.708716	17.6	Roman	Lankhills	
AY21-1894	pM2	46	0.711794	18.1	Roman	Lankhills	
Lankhills 053	pM	81	0.708500	17.9	Roman	Lankhills	
Lankhills 055	pM	120	0.709200	16.4	Roman	Lankhills	
Lankhills 057	pM	136	0.708700	17.3	Roman	Lankhills	
Lankhills 117	pM	106	0.708400	17.7	Roman	Lankhills	
Lankhills 357	C	206	0.709100	16.2	Roman	Lankhills	
Lankhills 382	M2	107	0.708600	18.5	Roman	Lankhills	

Lankhills 398	pM	82	0.708500	17.0	Roman	Lankhills	
Lankhills 437	M1	57	0.708400	17.7	Roman	Lankhills	
Lankhills 443	M2	75	0.708300	18.0	Roman	Lankhills	
Ay21-0118	dI1	77	0.708848	19.1	Roman	Lankhills	
Lankhills 013	C	255	0.706400	15.8	Roman	Lankhills	
Lankhills 081	M2	92	0.709300	14.7	Roman	Lankhills	
Lankhills 322	M	76	0.711600	17.3	Roman	Lankhills	
Lankhills 323	dM2	146	0.708600	18.9	Roman	Lankhills	
Lankhills 326	M3?	105	0.708700	18.2	Roman	Lankhills	
Lankhills 333	dM2	84	0.708600	18.8	Roman	Lankhills	
Lankhills 351	C	139	0.709000	16.0	Roman	Lankhills	
Lankhills 426	pM	123	0.709400	15.1	Roman	Lankhills	
SHY004	M2?	75	0.708517	18.2	C16th	London/Tilney	
B2S2	no record	234	0.709429		Bronze Age	Lunan bay	
Lund-1	M2	88	0.708816	17.3	Bronze Age	Lundin Links	
SK1a	C	190	0.709890	17.7	Roman	Mangotsfield, Bristol	
Sk1b	C		0.710165	17.6	Roman	Mangotsfield, Bristol	
SK2a	pM2	37	0.709949	17.7	Roman	Mangotsfield, Bristol	
SK2b	C		0.709795	17.1	Roman	Mangotsfield, Bristol	
MH04-897	pM1	419	0.709407	17.7	Iron Age	Mine Howe	Higher rainfall
MH05-1861	M2	406	0.709403	17.6	Iron Age	Mine Howe	Higher rainfall
F23E	P1	85	0.708037	18.5	Bronze Age	Monkton	
F23A	M1	71	0.708776	18.6	Neolithic	Monkton	
F23B	pM1	57	0.709277	18.4	Neolithic	Monkton	
F23C	pM2	55	0.710072	18.8	Neolithic	Monkton	
F23D	C	54	0.708965	19.6	Neolithic	Monkton	
Mull 1	M1	124	0.709173	18.1	Bronze Age	Mull	
PH SK 16	M2	341	0.709160	17.0	Medieval	Parliament House	
PH SK 45	M2	219	0.709690	17.1	Medieval	Parliament House	
PH SK 58	M2	91	0.710060	18.8	Medieval	Parliament House	
PH SK 60	M2	87	0.709830	17.3	Medieval	Parliament House	
PH SK 71	M2	77	0.716460	17.4	Medieval	Parliament House	
PH SK 92	M2	92	0.709050	17.7	Medieval	Parliament House	
Rame-1	pM2	120	0.711062	17.2	Bronze Age	Rameldry Farm	
G295	pM1	157	0.708980	17.9	Medieval	Repton	
G511	pM2	110	0.709600	17.9	Medieval	Repton	
G529	M2	113	0.711850	16.4	Medieval	Repton	
G97	C	54	0.711950	18.9	Medieval	Repton	
X17	pM1	72	0.712000	16.7	Medieval	Repton	
X23	pM1	69	0.710510	17.1	Medieval	Repton	
X3	pM2	43	0.710960	18.3	Medieval	Repton	
X70	pM1	75	0.709900	17.3	Medieval	Repton	
1974-121-SK1	pM2		0.708747	17.0	Medieval	Riccall	
1974-121-SK18	pM2		0.710968	18.2	Medieval	Riccall	
1974-121-SK23	pM2		0.709789	17.5	Medieval	Riccall	
1974-121-SK4	pM2		0.709891	18.4	Medieval	Riccall	
1985.11.SK11/SK16	pM1	143	0.709988	18.4	Medieval	Riccall	
1985.11.SK15	pM1	78	0.710535	18.4	Medieval	Riccall	
1985.11.SK18	pM1	87	0.710939	18.4	Medieval	Riccall	
1985.11.SK22	pM1	74	0.710837	17.8	Medieval	Riccall	
1985.11.SK7	pM1	75	0.711648	17.8	Medieval	Riccall	
1985.11.SK9	pM1	85	0.711261	18.4	Medieval	Riccall	
1985-11-SK1	pM2		0.709935	17.7	Medieval	Riccall	
1985-11-SK9	pM2		0.710600	18.3	Medieval	Riccall	
RING008	M2	42	0.708707	18.7	Anglo-Saxon	Ringlemere	

RING018	M2	125	0.708846	17.6	Anglo-Saxon	Ringlemere	
RING025	M2	98	0.709052	18.2	Anglo-Saxon	Ringlemere	
RING030	M2	91	0.709069	18.4	Anglo-Saxon	Ringlemere	
RING039	M2	68	0.709560	18.7	Anglo-Saxon	Ringlemere	
RING040	M2	78	0.709330	18.1	Anglo-Saxon	Ringlemere	
RING041	M2	105	0.708888	18.2	Anglo-Saxon	Ringlemere	
SOU 1355-445e	M2	131	0.710661	18.2	Medieval	Southampton Friary	
SOU 1355-448e	M2	137	0.709342	18.1	Medieval	Southampton Friary	
SPR-1	pM2	106	0.709897	19.1	Roman	Spitalfields	
Bees 10e	no record	82	0.709815		Medieval	St Bees	
PH 81 SK 4	M2	109	0.711430	17.5	Medieval	St Giles	
PH 81 SK 10	M2	173	0.709360	18.4	Medieval	St Giles	
PH 81 SK 11	M2	347	0.709760	17.1	Medieval	St Giles	
PH 81 SK 16	M2	133	0.709580	18.2	Medieval	St Giles	
PH 81 SK 18	M2	168	0.709450	19.8	Medieval	St Giles	
PH 81 SK 21	M2	146	0.709620	18.4	Medieval	St Giles	
PH 81 SK 48	M2	223	0.709610	17.7	Medieval	St Giles	
SK001	M2	268	0.709513	17.9	Medieval	St Thomas Kirk	Higher rainfall
SK002	M2	363	0.709437	18.3	Medieval	St Thomas Kirk	Higher rainfall
SK004	M2	254	0.709303	18.6	Medieval	St Thomas Kirk	Higher rainfall
SK005	M2	373	0.709456	18.0	Medieval	St Thomas Kirk	Higher rainfall
SK008	M2	283	0.709340	19.2	Medieval	St Thomas Kirk	Higher rainfall
SK014	M2	264	0.709494	18.3	Medieval	St Thomas Kirk	Higher rainfall
SK016	M2	264	0.709585	18.4	Medieval	St Thomas Kirk	Higher rainfall
SK019	M2	381	0.709604	18.1	Medieval	St Thomas Kirk	Higher rainfall
4.10.4	pM1	56	0.708370	17.0	Anglo-Saxon	Stonehenge	
ET54	M1	68	0.714447	18.0	Bronze Age	Toremore	
TP15	C	82	0.709195		Bronze Age	Towthorpe	
TP16	C	72	0.709227	19.0	Bronze Age	Towthorpe	
TP17	pM2	56	0.710458		Bronze Age	Towthorpe	
TP18	M2			18.3	Bronze Age	Towthorpe	
S105-20	M2	71	0.710758	18.6	Medieval	Towyn Y Capel	Higher rainfall
S105-32	M3	95	0.710548	18.6	Medieval	Towyn Y Capel	Higher rainfall
SF8658-M2	M2	85	0.709970	18.0	Roman	Vindolanda	
WASP-001e	pM1	52	0.711775	18.0	Anglo-Saxon	Wasperton	
WASP-006e	M2	139	0.710348	17.8	Anglo-Saxon	Wasperton	
WASP-008e	M2	124	0.710697	18.0	Anglo-Saxon	Wasperton	
WASP-024e	pM1	119	0.710614	18.2	Anglo-Saxon	Wasperton	
WASP-027e	pM2	115	0.710310	18.2	Anglo-Saxon	Wasperton	
WASP-028e	M1	127	0.710196	17.2	Anglo-Saxon	Wasperton	
WASP-035e	pM2	78	0.711775	18.2	Anglo-Saxon	Wasperton	
WASP-042e	M2	64	0.712394	17.7	Anglo-Saxon	Wasperton	
WASP-043e	M?	197	0.710464	18.0	Anglo-Saxon	Wasperton	
WASP-046e	pM1	75	0.709324	19.2	Anglo-Saxon	Wasperton	
WASP-048e	M?	75	0.710737	17.4	Anglo-Saxon	Wasperton	
WASP-055e	pM2	93	0.709609	17.7	Anglo-Saxon	Wasperton	
WASP-115e	pM2	146	0.710346	18.3	Anglo-Saxon	Wasperton	
WASP-138e	M3	205	0.710503	17.3	Anglo-Saxon	Wasperton	
WASP-143e	M1	132	0.710561	18.4	Anglo-Saxon	Wasperton	
WASP-153e	pM1	90	0.710719	18.3	Anglo-Saxon	Wasperton	
WASP-167e	pM2	149	0.710475	17.5	Anglo-Saxon	Wasperton	
WASP-173e	M2	99	0.710484	17.7	Anglo-Saxon	Wasperton	
WASP-174e	pM2	92	0.709650	18.7	Anglo-Saxon	Wasperton	
WASP-180e	M2	180	0.711190	18.8	Anglo-Saxon	Wasperton	
WASP-190e	pM1	71	0.708822	18.7	Anglo-Saxon	Wasperton	

WASP-191e	pM1	69	0.708818	18.8	Anglo-Saxon	Wasperton	
WASP-193e	pM1	82	0.710088	18.0	Anglo-Saxon	Wasperton	
WASP-194e	pM1	103	0.710634	18.1	Anglo-Saxon	Wasperton	
WASP-195e	M2	76	0.710396	17.8	Anglo-Saxon	Wasperton	
G100	M1	50	0.709002	17.8	Anglo-Saxon	West Heslerton	
G101	M2	56	0.708757	17.9	Anglo-Saxon	West Heslerton	
G102	pM2	74	0.710339	18.0	Anglo-Saxon	West Heslerton	
G109	M1	42	0.709532	18.0	Anglo-Saxon	West Heslerton	
G113	M2	100	0.708228	18.1	Anglo-Saxon	West Heslerton	
G114	M1	70	0.709364	17.2	Anglo-Saxon	West Heslerton	
G115	M2	65	0.708664		Anglo-Saxon	West Heslerton	
G117	M2	34	0.708480	16.5	Anglo-Saxon	West Heslerton	
G122	M2	66	0.709767	17.8	Anglo-Saxon	West Heslerton	
G132	M3	72	0.709132	16.9	Anglo-Saxon	West Heslerton	
G133	pM1	50	0.710228	16.6	Anglo-Saxon	West Heslerton	
G139	M2	77	0.709189	17.2	Anglo-Saxon	West Heslerton	
G144	pM1	84	0.709064	17.2	Anglo-Saxon	West Heslerton	
G145	M	101	0.709549	18.1	Anglo-Saxon	West Heslerton	
G149	pM1	58	0.710570	16.9	Anglo-Saxon	West Heslerton	
G151	M3	79	0.708610	16.9	Anglo-Saxon	West Heslerton	
G154	M1	79	0.708857		Anglo-Saxon	West Heslerton	
G158	C	67	0.709937		Anglo-Saxon	West Heslerton	
G159	M2	72	0.708990	16.7	Anglo-Saxon	West Heslerton	
G162	M1	118	0.709014		Anglo-Saxon	West Heslerton	
G164	pM1	47	0.710808	17.7	Anglo-Saxon	West Heslerton	
G166	M2	172	0.708796		Anglo-Saxon	West Heslerton	
G169	M1	70	0.709032	15.9	Anglo-Saxon	West Heslerton	
G173	M3	111	0.710482	17.2	Anglo-Saxon	West Heslerton	
G73	M2	62	0.709101	17.8	Anglo-Saxon	West Heslerton	
G74	M1	76	0.710061	17.6	Anglo-Saxon	West Heslerton	
G75	M2	50	0.709865	18.2	Anglo-Saxon	West Heslerton	
G78	pM2	49	0.709502	19.1	Anglo-Saxon	West Heslerton	
G84	M3	102	0.709485	18.0	Anglo-Saxon	West Heslerton	
G89	pM1	54	0.709792	18.1	Anglo-Saxon	West Heslerton	
G97	M2	48	0.709606	17.8	Anglo-Saxon	West Heslerton	
G97	M2	68	0.709895	17.7	Anglo-Saxon	West Heslerton	
G98	M2	79	0.708498	17.8	Anglo-Saxon	West Heslerton	
2BA229	M1	256	0.711080	17.5	Bronze Age	West Heslerton	
2BA283	M3	64	0.709572	17.0	Bronze Age	West Heslerton	
2BA589	M3	56	0.708973	17.1	Bronze Age	West Heslerton	
WHIA-1	pM1	20	0.708465	16.9	Iron Age	West Heslerton	
WHIA-2	pM1	50	0.711006	17.8	Iron Age	West Heslerton	
IR266	pM1	34	0.708849	17.1	Bronze Age	West Heslerton	Lower rainfall
IR271	pM1	47	0.709057	17.3	Bronze Age	West Heslerton	Lower rainfall
IR304	pM1	37	0.709010	17.1	Bronze Age	West Heslerton	Lower rainfall
WEY08 SK3704	M2	70	0.711560	15.2	Medieval	Weymouth	
WEY08 SK3706	M2	84	0.710320	15.9	Medieval	Weymouth	
WEY08 SK3707	M2	82	0.713060	15.1	Medieval	Weymouth	
WEY08 SK3710	M2	74	0.710600	16.6	Medieval	Weymouth	
WEY08 SK3711	M2	95	0.713770	13.7	Medieval	Weymouth	
WEY08 SK3720	M2	117	0.712940	15.6	Medieval	Weymouth	
WEY08 SK3724	M2	58	0.720510	15.8	Medieval	Weymouth	
WEY08 SK3730	M2	98	0.710130	16.1	Medieval	Weymouth	
WEY08 SK3739	M2	61	0.710890	15.4	Medieval	Weymouth	
WEY08 SK3744	M2	85	0.710720	15.8	Medieval	Weymouth	

WCL22-M1	M1			17.5	Anglo-Saxon	Whitton	
WCL22-M2	M2			16.8	Anglo-Saxon	Whitton	
WCL22-M3	M3			16.5	Anglo-Saxon	Whitton	
WCL30-M1	M1			17.5	Anglo-Saxon	Whitton	
WCL30-M2	M2			17.6	Anglo-Saxon	Whitton	
WCL30-M3	M3			17.5	Anglo-Saxon	Whitton	
Castle yard 9	pM2	46	0.709340	18.2	Roman	York	
Clifton 9	pM2	71	0.709950	17.9	Roman	York	
Hospitium 58	M2	77	0.708970	18.3	Roman	York	
Mount vale a	pM2	146	0.708710	17.5	Roman	York	
Mount vale c	pM2	112	0.711750	18.1	Roman	York	
RE02	pM2	458	0.708080	18.3	Roman	York	
RE10	pM2	94	0.709960	18.0	Roman	York	
RE10	M3	63	0.710670	17.5	Roman	York	
RE11	pM2	96	0.710150	18.6	Roman	York	
RE13	M2	57	0.710090	17.3	Roman	York	
RE14	M3	98	0.709700	17.5	Roman	York	
RE16	M2	65	0.709990	18.8	Roman	York	
RE17	M3	68	0.710120	18.4	Roman	York	
RE17	pM2	101	0.709180	17.7	Roman	York	
RE18	pM2	71	0.709940	17.6	Roman	York	
RE21	pM2	45	0.710310	17.3	Roman	York	
RE22	M2	93	0.709070	18.4	Roman	York	
RE23	pM2	226	0.709310	17.5	Roman	York	
RE25	pM2	108	0.709800	19.4	Roman	York	
RE26	pM2	87	0.709140	18.3	Roman	York	
RE27	pM2	174	0.708240	18.0	Roman	York	
RE28	M1	74	0.708410	18.2	Roman	York	
RE3	M2	107	0.709390	16.9	Roman	York	
RE31	pM2	52	0.710450	18.9	Roman	York	
RE31	M2	52	0.710440	18.6	Roman	York	
RE33	M3	105	0.709960	18.1	Roman	York	
RE36	M1	76	0.709360	18.6	Roman	York	
RE37	M1	42	0.710600	16.7	Roman	York	
RE37	M2	55	0.710380	16.4	Roman	York	
RE4	pM2	161	0.709670	18.4	Roman	York	
RE41	M2	112	0.709520	17.4	Roman	York	
RE43	M2	65	0.708330	17.4	Roman	York	
RE45	pM2	117	0.709320	18.4	Roman	York	
RE46	M2	190	0.708780	17.1	Roman	York	
RE47	pM2	79	0.709240	18.4	Roman	York	
RE48	M2	88	0.711170	18.2	Roman	York	
RE51	pM2	117	0.709060	18.9	Roman	York	
RE7	pM2	120	0.710070	18.1	Roman	York	
TDC04	M2	49	0.710410	16.9	Roman	York	
TDC153	pM2	93	0.709550	18.4	Roman	York	
TDC157	pM2	162	0.708740	17.1	Roman	York	
TDC173	M2	338	0.708480	17.5	Roman	York	
TDC288	M3	170	0.708320	17.9	Roman	York	
TDC314	M2	56	0.709270	17.2	Roman	York	
TDC411	pM2	51	0.713120	17.6	Roman	York	
TDC466	M2	146	0.710000	17.8	Roman	York	
TDC513	M2	160	0.710180	18.6	Roman	York	
TDC516	pM2	284	0.708960	19.5	Roman	York	
TDC608	M2	165	0.712930	18.3	Roman	York	

TDC708	pM2	92	0.710660	18.0	Roman	York	
TDC710	pM2	103	0.713550	19.7	Roman	York	
TDCR38	M2	103	0.713080	17.4	Roman	York	
The Mount	pM2	175	0.709310	17.8	Roman	York	

sample code	source of water	d180(VSMOW)
ECM-001	shallow well	-5.6
ECM-002	shallow well	-5.5
ECM-003	borehole	-5.3
ECM-004	spring	-5.1
ECM-005	shallow well	-5.3
ECM-006	borehole	-3.3
ECM-007	borehole	-5.2
ECM-008	borehole	-6.1
ECM-009	borehole	-4.8
ECM-010	borehole	-4.7
ECM-011	borehole	-4.8
ECM-012	lake	-2.4
ECM-013	spring	-5.6
ECM-014	borehole	-7.8
ECM-015	borehole	-7.6
ECM-016	borehole	-7.5
ECM-017	borehole	-7.5
ECM-018	borehole	-8
ECM-019	borehole	-7.6
ECM-020	borehole	-2.5
ECM-021	borehole	-7.2
ECM-022	borehole	-7.3
ECM-023	borehole	-7.2
ECM-024	borehole	-7.2
ECM-025	borehole	-7.8
ECM-026	borehole	-7.5
ECM-027	borehole	-7.9
ECM-028	borehole	-7.1
ECM-029	borehole	-7.1
ECM-030	borehole	-7.7
ECM-031	borehole	-7.8
ECM-032	borehole	-8.1
ECM-033	borehole	-7.9
ECM-034	borehole	-7.4
ECM-035	borehole	-7.8
ECM-036	borehole	-7.8
ECM-037	borehole	-8.4
ECM-038	borehole	-7.9
ECM-039	borehole	-7.6
ECM-040	borehole	-8.4
ECM-041	borehole	-8.5
ECM-042	borehole	-7.8
ECM-043	borehole	-8.1

ECM-044	borehole	-7.8
ECM-045	borehole	-8.2
ECM-046	borehole	-8.5
ECM-047	borehole	-7.5
ECM-048	borehole	-8.4
ECM-049	borehole	-8.1
ECM-050	borehole	-7.3
ECM-051	borehole	-7.8
ECM-052	borehole	-7.9
ECM-053	borehole	-8.4
ECM-054	borehole	-7.6
ECM-055	borehole	-8
ECM-056	borehole	-8.6
ECM-057	borehole	-8.2
ECM-058	borehole	-7.7
ECM-059	borehole	-7.7
ECM-060	borehole	-8.1
ECM-061	borehole	-7.8
ECM-062	borehole	-7.7
ECM-063	borehole	-8
ECM-064	borehole	-8.1
ECM-065	borehole	-8
ECM-066	borehole	-7.9
ECM-067	pumped sample	-6.6
ECM-068	pumped sample	-6.6
ECM-069	pumped sample	-6.6
ECM-070	pumped sample	-6.6
ECM-071	pumped sample	-6.5
ECM-072	pumped sample	-6.5
ECM-073	pumped sample	-5.9
ECM-074	pumped sample	-5.9
ECM-075	pumped sample	-6.1
ECM-076	pumped sample	-6.1
ECM-077	pumped sample	-6
ECM-078	pumped sample	-6
ECM-079	pumped sample	-6.1
ECM-080	pumped sample	-6.1
ECM-081	pumped sample	-6.8
ECM-082	pumped sample	-6.8
ECM-083	pumped sample	-6.3
ECM-084	pumped sample	-6.3

ECM-085	pumped sample	-6.4
ECM-086	pumped sample	-6.4
ECM-087	pumped sample	-6.2
ECM-088	pumped sample	-6.2
ECM-089	pumped sample	-6.4
ECM-090	pumped sample	-6.2
ECM-091	pumped sample	-6.5
ECM-092	borehole	-8.2
ECM-093	borehole	-7.5
ECM-094	borehole	-7.5
ECM-095	borehole	-8.1
ECM-096	borehole	-7.5
ECM-097	borehole	-8.6
ECM-098	borehole	-8.4
ECM-099	borehole	-7.6
ECM-100	borehole	-7.4
ECM-101	borehole	-8.1
ECM-102	borehole	-7.7
ECM-103	borehole	-7.1
ECM-104	borehole	-7.5
ECM-105	borehole	-6.5
ECM-106	borehole	-7.7
ECM-107	borehole	-8
ECM-108	borehole	-7.8
ECM-109	borehole	-8.2
ECM-110	borehole	-8.2
ECM-111	borehole	-8
ECM-112	borehole	-8.1
ECM-113	borehole	-8.6
ECM-114	borehole	-8.2
ECM-115	pumped sample	-5.8
ECM-116	pumped sample	-6.7
ECM-117	pumped sample	-6.3
ECM-118	pumped sample	-6.4
ECM-119	pumped sample	-6.7
ECM-120	borehole	-7.4
ECM-121	borehole	-7.2
ECM-122	borehole	-7.5
ECM-123	borehole	-7.9
ECM-124	borehole	-7.6
ECM-125	borehole	-8
ECM-126	borehole	-7.6

ECM-127	borehole	-7.7
ECM-128	spring	-7.8
ECM-129	borehole	-8.1
ECM-130	borehole	-7.6
ECM-131	borehole	-8.1
ECM-132	borehole	-8
ECM-133	borehole	-8
ECM-134	borehole	-8.1
ECM-135	borehole	-8.1
ECM-136	borehole	-7.8
ECM-137	borehole	-7.9
ECM-138	borehole	-8.3
ECM-139	shallow well	-7.6
ECM-140	borehole	-7.4
ECM-141	borehole	-8.1
ECM-142	borehole	-7.3
ECM-143	borehole	-7.2
ECM-144	borehole	-7.4
ECM-145	borehole	-7.3
ECM-146	borehole	-7.1
ECM-147	borehole	-7.2
ECM-148	borehole	-7.4
ECM-149	stream	-6.9
ECM-150	borehole	-7.2
ECM-151	borehole	-7.6
ECM-152	borehole	-7.5
ECM-153	borehole	-7.1
ECM-154	borehole	-7.07
ECM-155	borehole	-7.17
ECM-156	spring	-7.08
ECM-157	borehole	-6.91
ECM-158	stream	-7.26
ECM-159	borehole	-7.16
ECM-160	borehole	-7.27
ECM-161	borehole	-7.47
ECM-162	borehole	-7.15
ECM-163	borehole	-7.5
ECM-164	borehole	-7.01
ECM-165	borehole	-7.1
ECM-166	borehole	-7.05
ECM-167	borehole	-7.15
ECM-168	spring	-7.18
ECM-169	borehole	-7
ECM-170	borehole	-7.2
ECM-171	borehole	-6.99

ECM-172	spring	-7.08
ECM-173	borehole	-7.01
ECM-174	borehole	-6.89
ECM-175	borehole	-6.72
ECM-176	river	-6.21
ECM-177	stream	-6.52
ECM-178	borehole	-6.95
ECM-179	borehole	-7.47
ECM-180	borehole	-7.42
ECM-181	borehole	-7.5
ECM-182	stream	-6.65
ECM-183	stream	-6.62
ECM-184	stream	-6.81
ECM-185	stream	-6.24
ECM-186	borehole	-7.32
ECM-187	borehole	-6.787
ECM-188	borehole	-6.98
ECM-189	borehole	-7.09
ECM-190	borehole	-7.36
ECM-191	borehole	-7.3
ECM-192	borehole	-6.58
ECM-193	borehole	-6.58
ECM-194	borehole	-8.18
ECM-195	stream	-7.01
ECM-196	river	-6.99
ECM-197	spring	-7.67
ECM-198	spring	-7.7
ECM-199	spring	-7.12
ECM-200	borehole	-7.39
ECM-201	borehole	-7.23
ECM-202	borehole	-7.49
ECM-203	borehole	-7.16
ECM-204	borehole	-7.71
ECM-205	borehole	-7.14
ECM-206	borehole	-7.08
ECM-207	borehole	-8.18
ECM-208	stream	-6.59
ECM-209	river	-7.11
ECM-210	spring	-6.97
ECM-211	pumped sample	-7.38
ECM-212	pumped sample	-6.48
ECM-213	pumped sample	-7.15
ECM-214	borehole	-7.14
ECM-215	borehole	-6.83

ECM-216	stream	-7.05
ECM-217	borehole	-6.27
ECM-218	borehole	-6.67
ECM-219	spring	-6.97
ECM-220	borehole	-7.56
ECM-221	stream	-6.22
ECM-222	stream	-6.68
ECM-223	river	-7.01
ECM-224	borehole	-5.78
ECM-225	borehole	-5.5
ECM-226	borehole	-6.1
ECM-227	borehole	-7.28
ECM-228	borehole	-6.93
ECM-229	borehole	-7.02
ECM-230	spring	-7.09
ECM-231	borehole	-7.38
ECM-232	stream	-6.02
ECM-233	stream	-6.37
ECM-234	river	-6.9
ECM-235	borehole	-7.17
ECM-236	borehole	-6.87
ECM-237	borehole	-7.1
ECM-238	borehole	-7.56
ECM-239	borehole	-6.73
ECM-240	borehole	-7.22
ECM-241	borehole	-8.14
ECM-242	borehole	-7.87
ECM-243	borehole	-6.46
ECM-244	borehole	-6.9
ECM-245	borehole	-6.97
ECM-246	spring	-7
ECM-247	river	-6.47
ECM-248	borehole	-6.61
ECM-249	borehole	-7.25
ECM-250	borehole	-7.4
ECM-251	pumped sample	-7.34
ECM-252	pumped sample	-7.13
ECM-253	pumped sample	-6.28
ECM-254	pumped sample	-7.25
ECM-255	pumped sample	-7.05
ECM-256	pumped sample	-7.04
ECM-257	pumped sample	-6.95
ECM-258	pumped sample	-7.46

ECM-259	pumped sample	-6.98
ECM-260	pumped sample	-7.45
ECM-261	pumped sample	-7.35
ECM-262	pumped sample	-7.57
ECM-263	borehole	-7.7
ECM-264	borehole	-7.71
ECM-265	borehole	-7.99
ECM-266	borehole	-7.91
ECM-267	borehole	-7.33
ECM-268	borehole	-7.19
ECM-269	borehole	-7.08
ECM-270	borehole	-7.37
ECM-271	borehole	-7.23
ECM-272	borehole	-7.71
ECM-273	borehole	-7.74
ECM-274	borehole	-7.7
ECM-275	borehole	-7.56
ECM-276	borehole	-7.54
ECM-277	borehole	-7.43
ECM-278	borehole	-7.2
ECM-279	borehole	-7.64
ECM-280	borehole	-7.72
ECM-281	borehole	-7.68
ECM-282	borehole	-7.71
ECM-283	borehole	-7.95
ECM-284	borehole	-7.41
ECM-285	borehole	-7.56
ECM-286	borehole	-7.58
ECM-287	borehole	-7.36
ECM-288	borehole	-7.56
ECM-289	borehole	-7.57
ECM-290	spring	-7.17
ECM-291	borehole	-7.78
ECM-292	borehole	-7.31
ECM-293	borehole	-7.66
ECM-294	spring	-7.3
ECM-295	borehole	-7.56
ECM-296	borehole	-7.57
ECM-297	borehole	-7.21
ECM-298	borehole	-7.38
ECM-299	spring	-7.14
ECM-300	borehole	-7.23
ECM-301	borehole	-7.37
ECM-302	river	-7.03

ECM-303	borehole	-7.06
ECM-304	borehole	-7.13
ECM-305	borehole	-6.84
ECM-306	borehole	-8.8
ECM-307	borehole	-7.6
ECM-308	river	-7.01
ECM-309	river	-6.53
ECM-310	river	-5.96
ECM-311	river	-6.56
ECM-312	river	-6.15
ECM-313	river	-6.4
ECM-314	river	-6.44
ECM-315	borehole	-7.36
ECM-316	borehole	-7.24
ECM-317	borehole	-7.21
ECM-318	borehole	-7.3
ECM-319	borehole	-8.06
ECM-320	borehole	-8.36
ECM-321	borehole	-8.39
ECM-322	borehole	-8.4
ECM-323	borehole	-8.34
ECM-324	borehole	-8.13
ECM-325	borehole	-8.4
ECM-326	borehole	-8.2
ECM-327	borehole	-8.06
ECM-328	borehole	-8.36
ECM-329	spring	-7.801
ECM-330	borehole	-8.02
ECM-331	borehole	-8.14
ECM-332	borehole	-8.42
ECM-333	borehole	-7.79
ECM-334	borehole	-8.38
ECM-335	borehole	-6.8
ECM-336	spring	-7.04
ECM-337	borehole	-6.79
ECM-338	borehole	-6.73
ECM-339	spring	-6.16
ECM-340	spring	-6.5
ECM-341	shallow well	-6.4
ECM-342	borehole	-7.03
ECM-343	borehole	-6.7
ECM-344	spring	-6.09
ECM-345	spring	-6.18
ECM-346	borehole	-7.29
ECM-347	borehole	-7.31

ECM-348	borehole	-7.41
ECM-349	borehole	-7.59
ECM-350	borehole	-7.68
ECM-351	borehole	-7.51
ECM-352	borehole	-7.75
ECM-353	borehole	-7.27
ECM-354	borehole	-7.64
ECM-355	borehole	-7.51
ECM-356	borehole	-7.11
ECM-357	borehole	-7.47
ECM-358	borehole	-7.47
ECM-359	borehole	-7.12
ECM-360	borehole	-6.84
ECM-361	borehole	-6.9
ECM-362	borehole	-7.09
ECM-363	borehole	-7.35
ECM-364	borehole	-7.23
ECM-365	borehole	-7
ECM-366	river	-6.46
ECM-367	river	-7.15
ECM-368	river	-6.57
ECM-369	river	-7.37
ECM-370	borehole	-7.23
ECM-371	borehole	-6.88
ECM-372	borehole	-7.43
ECM-373	borehole	-7.02
ECM-374	borehole	-7.69
ECM-375	borehole	-7.34
ECM-376	borehole	-6.54
ECM-377	borehole	-6.97
ECM-378	borehole	-7.05
ECM-379	borehole	-7.09
ECM-380	borehole	-7.01
ECM-381	borehole	-7.4
ECM-382	pumped sample	-7.18
ECM-383	pumped sample	-6.79
ECM-384	pumped sample	-6.85
ECM-385	pumped sample	-7.25
ECM-386	pumped sample	-7.27
ECM-387	shallow well	-6.96
ECM-388	shallow well	-7.07
ECM-389	pumped sample	-7.05
ECM-390	pumped sample	-7.68

ECM-391	river	-6.98
ECM-392	river	-7.09
ECM-393	river	-7.14
ECM-394	river	-7.22
ECM-395	river	-7.04
ECM-396	river	-6.96
ECM-397	river	-7.21
ECM-398	river	-7.11
ECM-399	borehole	-7.31
ECM-400	borehole	-7.12
ECM-401	borehole	-7.07
ECM-402	borehole	-7.32
ECM-403	borehole	-7.27
ECM-404	borehole	-6.7
ECM-405	borehole	-6.67
ECM-406	borehole	-6.88
ECM-407	borehole	-6.85
ECM-408	borehole	-6.92
ECM-409	artesian	-6.41
ECM-410	borehole	-6.63
ECM-411	borehole	-6.92
ECM-412	stream	-6.85
ECM-413	borehole	-6.94
ECM-414	borehole	-7.38
ECM-415	borehole	-7.2
ECM-416	borehole	-7.27
ECM-417	borehole	-7.68
ECM-418	borehole	-7.98
ECM-419	borehole	-7.48
ECM-420	borehole	-7.28
ECM-421	borehole	-7.39
ECM-422	borehole	-7.14
ECM-423	borehole	-7.52
ECM-424	borehole	-7.73
ECM-425	borehole	-7.05
ECM-426	borehole	-7.111
ECM-427	borehole	-7.66
ECM-428	borehole	-7.23
ECM-429	borehole	-7.42
ECM-430	borehole	-7.42
ECM-431	borehole	-7.14
ECM-432	borehole	-7.07
ECM-433	borehole	-7.48
ECM-434	borehole	-7.48
ECM-435	borehole	-7.92

ECM-436	borehole	-8.11
ECM-437	borehole	-7.03
ECM-438	borehole	-7.95
ECM-439	borehole	-8.82
ECM-440	borehole	-7.79
ECM-441	borehole	-7.17
ECM-442	borehole	-8.05
ECM-443	borehole	-7.44
ECM-444	spring	-7.02
ECM-445	borehole	-7.21
ECM-446	spring	-7.18
ECM-447	borehole	-7.32
ECM-448	spring	-7.1
ECM-449	borehole	-7.11
ECM-450	borehole	-5.87
ECM-451	borehole	-7.52
ECM-452	borehole	-7.48
ECM-453	borehole	-8.15
ECM-454	borehole	-8.07
ECM-455	pumped sample	-7.55
ECM-456	pumped sample	-7.44
ECM-457	pumped sample	-7.91
ECM-458	pumped sample	-6.44
ECM-459	pumped sample	-7.51
ECM-460	spring	-6.27
ECM-461	spring	-4.92
ECM-462	borehole	-4.99
ECM-463	borehole	-5.23
ECM-464	spring	-5.29
ECM-465	borehole	-5.42
ECM-466	shallow well	-4.94
ECM-467	spring	-4.87
ECM-468	borehole	-4.86
ECM-469	spring	-4.8
ECM-470	borehole	-4.81
ECM-471	spring	-5.97
ECM-472	borehole	-5.63
ECM-473	borehole	-6.28
ECM-474	borehole	-5.71
ECM-475	borehole	-7.16
ECM-476	spring	-7.22
ECM-477	spring	-7.1
ECM-478	borehole	-7.26

ECM-479	borehole	-6.54
ECM-480	borehole	-6.31
ECM-481	borehole	-6.63
ECM-482	borehole	-7.66
ECM-483	borehole	-7.26
ECM-484	borehole	-5.82
ECM-485	borehole	-7.54
ECM-486	borehole	-7.44
ECM-487	borehole	-7.45
ECM-488	borehole	-7.59
ECM-489	borehole	-7.34
ECM-490	borehole	-7.29
ECM-491	borehole	-7.19
ECM-492	borehole	-7.27
ECM-493	borehole	-7.48
ECM-494	borehole	-7.35
ECM-495	borehole	-7.21
ECM-496	borehole	-7.24
ECM-497	borehole	-7.16
ECM-498	stream	-7.45
ECM-499	borehole	-7.24
ECM-500	borehole	-7.57
ECM-501	borehole	-7.31
ECM-502	borehole	-7.41
ECM-503	borehole	-7.38
ECM-504	borehole	-7.04
ECM-505	borehole	-7.07
ECM-506	borehole	-7.3
ECM-507	borehole	-7.42
ECM-508	borehole	-7.51
ECM-509	borehole	-7.56
ECM-510	borehole	-7.25
ECM-511	borehole	-7.48
ECM-512	borehole	-7.31
ECM-513	borehole	-7.32
ECM-514	borehole	-7.29
ECM-515	borehole	-7.75
ECM-516	borehole	-7.77
ECM-517	borehole	-7.71
ECM-518	borehole	-7.65
ECM-519	borehole	-7.29
ECM-520	borehole	-7.24
ECM-521	borehole	-7.14
ECM-522	borehole	-6.89
ECM-523	borehole	-7.2

ECM-524	borehole	-7.28
ECM-525	shallow well	-6.37
ECM-526	borehole	-7.69
ECM-527	borehole	-7.73
ECM-528	borehole	-7.47
ECM-529	borehole	-6.7
ECM-530	borehole	-6.94
ECM-531	borehole	-7.89
ECM-532	borehole	-7.55
ECM-533	borehole	-7.65
ECM-534	borehole	-7.52
ECM-535	borehole	-7.6
ECM-536	spring	-6.74
ECM-537	spring	-6.5
ECM-538	spring	-6.38
ECM-539	borehole	-6.53
ECM-540	borehole	-6.64
ECM-541	borehole	-7.69
ECM-542	borehole	-7.56
ECM-543	borehole	-7.11
ECM-544	borehole	-6.8
ECM-545	borehole	-7.1
ECM-546	borehole	-6.98
ECM-547	borehole	-6.6
ECM-548	borehole	-7.03
ECM-549	spring	-7.01
ECM-550	borehole	-7.1
ECM-551	borehole	-7.25
ECM-552	spring	-7.59
ECM-553	borehole	-6.63
ECM-554	borehole	-7.18
ECM-555	borehole	-7.17
ECM-556	borehole	-6.91
ECM-557	borehole	-6.46
ECM-558	borehole	-7.29
ECM-559	borehole	-7.23
ECM-560	borehole	-7.33
ECM-561	borehole	-7.37
ECM-562	borehole	-7.28
ECM-563	borehole	-7.52
ECM-564	borehole	-7.5
ECM-565	borehole	-5.97
ECM-566	borehole	-6.11
ECM-567	borehole	-6.74
ECM-568	stream	-6.19

ECM-569	stream	-7.24
ECM-570	borehole	-7.76
ECM-571	spring	-8.06
ECM-572	spring	-8.41
ECM-573	borehole	-7.63
ECM-574	borehole	-7.54
ECM-575	borehole	-8.57
ECM-576	borehole	-8.71
ECM-577	borehole	-7.13
ECM-578	borehole	-7.66
ECM-579	borehole	-8.06
ECM-580	borehole	-8.78
ECM-581	borehole	-8.71
ECM-582	borehole	-8.71
ECM-583	borehole	-7.77
ECM-584	borehole	-7.77
ECM-585	borehole	-8.23
ECM-586	borehole	-8.225
ECM-587	borehole	-8.55
ECM-588	borehole	-8.545
ECM-589	borehole	-8.94
ECM-590	borehole	-7.33
ECM-591	spring	-6.7
ECM-592	stream	-7.47
ECM-593	borehole	-7.04
ECM-594	borehole	-6.87
ECM-595	borehole	-6.79
ECM-596	borehole	-7.27
ECM-597	borehole	-7.47
ECM-598	borehole	-6.82
ECM-599	borehole	-7.6
ECM-600	borehole	-7.53
ECM-601	borehole	-7.29
ECM-602	borehole	-7.28
ECM-603	borehole	-7.44
ECM-604	borehole	-7.33
ECM-605	artesian	-8.04
ECM-606	artesian	-8.01
ECM-607	artesian	-8.61
ECM-608	artesian	-8.63
ECM-609	pumped sample	-8.36
ECM-610	pumped sample	-8.16
ECM-611	pumped sample	-7.71
ECM-612	artesian	-7.92

ECM-613	pumped sample	-8.12
ECM-614	pumped sample	-7.94
ECM-615	pumped sample	-7.71
ECM-616	artesian	-7.91
ECM-617	artesian	-8.67
ECM-618	artesian	-7.87
ECM-619	artesian	-8.65
ECM-620	artesian	-8.27
ECM-621	artesian	-8.91
ECM-622	pumped sample	-7.89
ECM-623	pumped sample	-8.15
ECM-624	pumped sample	-8.05
ECM-625	pumped sample	-7.76
ECM-626	pumped sample	-7.95
ECM-627	borehole	-7.4
ECM-628	borehole	-7.33
ECM-629	borehole	-7.47
ECM-630	borehole	-7.56
ECM-631	borehole	-7.49
ECM-632	borehole	-7.58
ECM-633	borehole	-7.3
ECM-634	stream	-7.22
ECM-635	spring	-6.85
ECM-636	spring	-6.41
ECM-637	stream	-7.21
ECM-638	spring	-6.28
ECM-639	stream	-6.15
ECM-640	spring	-6.17
ECM-641	shallow well	-6.62
ECM-642	spring	-5.63
ECM-643	borehole	-6.41
ECM-644	shallow well	-7.16
ECM-645	spring	-6.29
ECM-646	shallow well	-6.31
ECM-647	borehole	-6.54
ECM-648	spring	-6.89
ECM-649	spring	-6.67
ECM-650	spring	-6.4
ECM-651	borehole	-6.24
ECM-652	borehole	-6.88
ECM-653	borehole	-6.84
ECM-654	spring	-6.8
ECM-655	spring	-6.63

ECM-656	borehole	-8.06
ECM-657	borehole	-8.34
ECM-658	borehole	-8.5
ECM-659	borehole	-8.21
ECM-660	borehole	-8.49
ECM-661	borehole	-8.5
ECM-662	borehole	-8.66
ECM-663	borehole	-8.25
ECM-664	spring	-8
ECM-665	spring	-7.94
ECM-666	spring	-8.51
ECM-667	spring	-8.38
ECM-668	spring	-7.58
ECM-669	spring	-7.43
ECM-670	spring	-7.79
ECM-671	spring	-7.54
ECM-672	spring	-7.71
ECM-673	spring	-8.8
ECM-674	spring	-8.61
ECM-675	spring	-8.47
ECM-676	spring	-9
ECM-677	spring	-8.73
ECM-678	spring	-9.04
ECM-679	borehole	-7.23
ECM-680	borehole	-7.03
ECM-681	borehole	-7.33
ECM-682	borehole	-8.84
ECM-683	stream	-7.18
ECM-684	pumped sample	-6.9
ECM-685	pumped sample	-7.33
ECM-686	pumped sample	-7.02
ECM-687	pumped sample	-6.96
ECM-688	pumped sample	-7.21
ECM-689	pumped sample	-7.39
ECM-690	pumped sample	-7.08
ECM-691	pumped sample	-7.3
ECM-692	pumped sample	-7.38
ECM-693	pumped sample	-7.23
ECM-694	pumped sample	-7.02
ECM-695	pumped sample	-7.02
ECM-696	pumped sample	-7.61
ECM-697	pumped	-7.82

	sample	
ECM-698	borehole	-8.18
ECM-699	borehole	-8.45
ECM-700	borehole	-8
ECM-701	borehole	-8.1
ECM-702	borehole	-8.89
ECM-703	borehole	-9.14
ECM-704	spring	-8.5
ECM-705	spring	-8.92
ECM-706	borehole	-9.44
ECM-707	borehole	-8.05
ECM-708	borehole	-7.8
ECM-709	borehole	-9.07
ECM-710	borehole	-7.57
ECM-711	borehole	-8.29
ECM-712	borehole	-8.57
ECM-713	borehole	-8.65
ECM-714	spring	-9
ECM-715	spring	-8.71
ECM-716	borehole	-8.56
ECM-717	borehole	-8.51
ECM-718	borehole	-8.76
ECM-719	spring	-8.29
ECM-720	spring	-7.77
ECM-721	borehole	-8.56
ECM-722	borehole	-7.71
ECM-723	borehole	-8.39
ECM-724	borehole	-7.46
ECM-725	spring	-8.46
ECM-726	borehole	-7.61
ECM-727	spring	-7.91
ECM-728	borehole	-7.9
ECM-729	spring	-7.7
ECM-730	spring	-7.93
ECM-731	spring	-7.75
ECM-732	borehole	-7.27
ECM-733	borehole	-8.06
ECM-734	spring	-7.46
ECM-735	spring	-8.14
ECM-736	spring	-7.51
ECM-737	borehole	-7.77
ECM-738	spring	-8
ECM-739	borehole	-8.03
ECM-740	spring	-6.93
ECM-741	borehole	-7.28

ECM-742	borehole	-7.94
ECM-743	borehole	-6.71
ECM-744	borehole	-6.61
ECM-745	borehole	-6.94
ECM-746	borehole	-7.38
ECM-747	borehole	-6.78
ECM-748	borehole	-6.89
ECM-749	borehole	-6.57
ECM-750	borehole	-7.36
ECM-751	borehole	-7.27
ECM-752	borehole	-6.65
ECM-753	borehole	-7.7
ECM-754	borehole	-6.31
ECM-755	borehole	-7.13
ECM-756	borehole	-6.57
ECM-757	borehole	-7.09
ECM-758	borehole	-7.21
ECM-759	shallow well	-7.01
ECM-760	borehole	-5.44
ECM-761	borehole	-7.4
ECM-762	borehole	-6.4
ECM-763	borehole	-6.89
ECM-764	borehole	-6.39
ECM-765	shallow well	-6.25
ECM-766	borehole	-6.31
ECM-767	borehole	-6.31
ECM-768	borehole	-6.79
ECM-769	borehole	-6.79
ECM-770	borehole	-6.59
ECM-771	borehole	-6.59
ECM-772	borehole	-6.66
ECM-773	borehole	-6.66
ECM-774	borehole	-6.98
ECM-775	borehole	-6.98
ECM-776	borehole	-6.63
ECM-777	borehole	-6.63
ECM-778	borehole	-7.38
ECM-779	borehole	-7.38
ECM-780	borehole	-6.98
ECM-781	borehole	-6.98
ECM-782	spring	-7.8
ECM-783	borehole	-8.11
ECM-784	borehole	-8.39
ECM-785	borehole	-8.17
ECM-786	borehole	-8.97

ECM-787	spring	-7.92
ECM-788	borehole	-8.69
ECM-789	borehole	-8.86
ECM-790	borehole	-8.39
ECM-791	borehole	-6.86
ECM-792	borehole	-8.36
ECM-793	borehole	-7.84
ECM-794	shallow well	-7.18
ECM-795	shallow well	-8.02
ECM-796	borehole	-6.61
ECM-797	borehole	-6.64
ECM-798	borehole	-8.27
ECM-799	borehole	-6.71
ECM-800	spring	-6.43
ECM-801	shallow well	-8.2
ECM-802	spring	-8.8
ECM-803	shallow well	-7.64
ECM-804	borehole	-8.17
ECM-805	borehole	-8.06
ECM-806	shallow well	-7.32
ECM-807	borehole	-7.69
ECM-808	borehole	-8.18
ECM-809	spring	-6.94
ECM-810	spring	-7.3
ECM-811	spring	-7.28
ECM-812	spring	-7.44
ECM-813	spring	-7.33
ECM-814	spring	-7.35
ECM-815	spring	-7.87
ECM-816	spring	-7.28
ECM-817	spring	-6.8
ECM-818	spring	-6.82
ECM-819	spring	-7.26
ECM-820	spring	-7.16
ECM-821	borehole	-8.34
ECM-822	borehole	-8.83
ECM-823	borehole	-7.43
ECM-824	borehole	-8.29
ECM-825	borehole	-8.79
ECM-826	borehole	-8.37
ECM-827	borehole	-8.1
ECM-828	borehole	-8.31
ECM-829	borehole	-8.62
ECM-830	borehole	-8.04
ECM-831	borehole	-8.48

ECM-832	borehole	-8.15
ECM-833	borehole	-7.78
ECM-834	borehole	-7.25
ECM-835	river	-7.49
ECM-836	spring	-8.16
ECM-837	borehole	-7.98
ECM-838	borehole	-5.92
ECM-839	borehole	-7.03
ECM-840	borehole	-7
ECM-841	borehole	-7.1
ECM-842	borehole	-6.61
ECM-843	borehole	-6.87
ECM-844	borehole	-7.06
ECM-845	borehole	-8.98
ECM-846	borehole	-8.14
ECM-847	borehole	-9.22
ECM-848	borehole	-8.31
ECM-849	borehole	-8.46
ECM-850	borehole	-8.7
ECM-851	borehole	-8.57
ECM-852	borehole	-8.08
ECM-853	borehole	-8.7
ECM-854	borehole	-8.2
ECM-855	borehole	-8.51
ECM-856	borehole	-8.49
ECM-857	borehole	-8.65
ECM-858	borehole	-8.17
ECM-859	borehole	-8.33
ECM-860	borehole	-8.81
ECM-861	borehole	-8.12
ECM-862	borehole	-7.87
ECM-863	borehole	-8.5
ECM-864	borehole	-8.47
ECM-865	borehole	-8.58
ECM-866	borehole	-8.76
ECM-867	borehole	-8.81
ECM-868	borehole	-8.6
ECM-869	borehole	-8.43
ECM-870	borehole	-8.51
ECM-871	borehole	-8.51
ECM-872	borehole	-8.93
ECM-873	borehole	-8.89
ECM-874	borehole	-8.69
ECM-875	borehole	-8.78
ECM-876	borehole	-8.91

ECM-877	borehole	-8.46
ECM-878	borehole	-8.9
ECM-879	borehole	-8.7
ECM-880	spring	-7.25
ECM-881	spring	-7.19
ECM-882	spring	-7.41
ECM-883	spring	-7.43
ECM-884	spring	-7.58
ECM-885	spring	-6.96
ECM-886	spring	-7.25
ECM-887	spring	-7.48
ECM-888	spring	-7.52
ECM-889	spring	-7.45
ECM-890	borehole	-7.67
ECM-891	borehole	-7.86
ECM-892	borehole	-7.93
ECM-893	borehole	-7.62
ECM-894	borehole	-8.03
ECM-895	spring	-7.38
ECM-896	borehole	-8.95
ECM-897	spring	-9.58
ECM-898	spring	-9.7
ECM-899	spring	-9.88
ECM-900	spring	-9.62
ECM-901	spring	-9.25
ECM-902	spring	-9.67
ECM-903	spring	-9.58
ECM-904	spring	-9.96
ECM-905	spring	-9.78
ECM-906	spring	-9.43
ECM-907	borehole	-7.96
ECM-908	borehole	-7.68
ECM-909	borehole	-8.34
ECM-910	borehole	-8.13
ECM-911	borehole	-8.28
ECM-912	borehole	-8.22
ECM-913	borehole	-7.87
ECM-914	borehole	-7.47
ECM-915	borehole	-7.86
ECM-916	borehole	-9.35
ECM-917	borehole	-7.2
ECM-918	borehole	-7.85
ECM-919	borehole	-8.49
ECM-920	borehole	-7.57
ECM-921	borehole	-7.88

ECM-922	spring	-7.9
ECM-923	borehole	-7.89
ECM-924	borehole	-6.95
ECM-925	borehole	-7.12
ECM-926	borehole	-7.43
ECM-927	borehole	-6.88
ECM-928	borehole	-7.03
ECM-929	borehole	-6.8
ECM-930	borehole	-6.7
ECM-931	borehole	-6.9
ECM-932	borehole	-6.7
ECM-933	borehole	-7.31
ECM-934	borehole	-6.98
ECM-935	borehole	-7.19
ECM-936	borehole	-7.37
ECM-937	borehole	-8.17
ECM-938	spring	-9.39
ECM-939	spring	-9.62
ECM-940	borehole	-7.95
ECM-941	borehole	-8.3
ECM-942	borehole	-8.02
ECM-943	borehole	-8.51
ECM-944	borehole	-8.18
ECM-945	borehole	-8.09
ECM-946	borehole	-8.1
ECM-947	borehole	-8.2
ECM-948	borehole	-8.25
ECM-949	borehole	-8.2
ECM-950	borehole	-7.75
ECM-951	borehole	-8.25
ECM-952	borehole	-8.44
ECM-953	borehole	-8.04
ECM-954	borehole	-8.1
ECM-955	borehole	-7.21
ECM-956	borehole	-7.36
ECM-957	borehole	-7.27
ECM-958	borehole	-7.28
ECM-959	borehole	-7.35
ECM-960	borehole	-8.17
ECM-961	borehole	-7.53
ECM-962	borehole	-7.11
ECM-963	borehole	-6.35
ECM-964	borehole	-7.51
ECM-965	borehole	-7.08
ECM-966	borehole	-7.25

ECM-967	borehole	-7.1
ECM-968	borehole	-6.96
ECM-969	borehole	-7.39
ECM-970	borehole	-7.33
ECM-971	borehole	-7.19
ECM-972	borehole	-7.13
ECM-973	borehole	-7.1
ECM-974	borehole	-7.5
ECM-975	borehole	-8.16

Table 1

Drinking water ranges						
		-4 to -5	-5 to -6	-6 to -7	-7 to -8	-8 to -9
^{87}Sr/^{86}Sr ranges	% coverage	1%	8%	21%	60%	11%
.704 to .708	0.90%	0.01%	0.07%	0.19%	0.54%	0.10%
.708 to .709	14.00%	0.10%	1.12%	2.88%	8.36%	1.55%
.709-.710	39.00%	0.27%	3.12%	8.03%	23.28%	4.33%
.710-.711	2.00%	0.01%	0.16%	0.41%	1.19%	0.22%
.711-.712	19.00%	0.13%	1.52%	3.91%	11.34%	2.11%
.712-.713	17.00%	0.12%	1.36%	3.50%	10.15%	1.89%
.713-.72	8.00%	0.06%	0.64%	1.65%	4.78%	0.89%
>.72	0.30%	0.00%	0.02%	0.06%	0.18%	0.03%

Figures and captions

Figure 1 An outline of Great Britain showing the location of the archaeological sites from which data is presented. Highlighted sites are those used to define the two subsets: low and high rainfall areas.

Figure 2 A scatter diagram of strontium concentrations (ppm) plotted against $^{87}Sr/^{86}Sr$ isotope ratio for all British burials given in Appendix 1. A

Figure 3 Boxplot comparison of the strontium isotope composition of tooth enamel from Britain compared with biosphere data from Britain[29].

Figure 4 An histogram of the best estimate for the distribution of oxygen isotope composition in tooth enamel from Britain excluding 51 individuals deemed unlikely to be of British origin (see main text.).

Figure 5 An histogram of shallow ground, and well water, oxygen isotope composition from Britain. (see Appendix 2)

Figure 6 A boxplot comparison of drinking water values derived from tooth enamel with directly measured values from drinking water sources, both from Britain .

Figure 7 A comparison of $\delta^{18}O_{(VSMOW)}$ in teeth, that formed at different ages, from (7a) 3 teeth from each of 20 individuals[44] and (7b) a comparison of all the data from differing tooth types from across Britain.

Figure 7 A Comparison of $\delta^{18}O_{VSMOW}$ tooth enamel data from different periods. It should be noted that these groups do not all sample the same geographic distributions.

Figure 9 A comparison of normal distributions of oxygen isotope composition of human tooth enamel from British sites where burial assemblages are taken to be predominantly of local origin.

Figure 10 A comparison of the population means (95% CI) of tooth enamel oxygen isotope composition from a Roman site at Catterick, Yorkshire and four individuals from an Anglo Saxon site at Easington, on the east coast of Yorkshire compared with the control data sets for the leeward and windward populations.

Figure 11 A probability density curve for oxygen isotope composition from Roman period burials at the Lankhills cemetery near Winchester. The curve is constructed allocating a blanket error of ± 0.15‰ to all oxygen isotope analyses.

Figure 12 A map of the Roman Empire (excluding Britain) contoured for rainwater composition derived from GNIP data and including a tabulation of the percentage areas assonated with different water compositions. .

Figure 13. Comparison of the population means and 95% confidence intervals of tooth enamel oxygen isotope composition from the Amesbury Archer and Companion against the defining population datasets for high and low rainfall areas.

Table 1 Mathematically combined spatial probability of strontium and oxygen isotope combinations across Britain derived from strontium biosphere[ref] and surface and spring water maps45.

Appendix 1 Strontium and oxygen isotope composition for all data discussed in this paper. Samples in italics are those excluded from the histogram given in Figure 4.

Appendix 2. Oxygen isotope composition of shallow ground water and well water extracted from the British Geological Survey database. The data are tabulated in three parallel sets for compactness and give the type of water source and the measured $\delta^{18}O_{(VMOW)}$ value. Further details can be obtained from BGS.

		:-4 to -5	**:-5 to -6**	**:-6 to -7**	**:-7 to -8**	**:-8 to -9**
strontium isotope range		**1%**	**8%**	**21%**	**60%**	**11%**
.704 to .708	**0.9%**	0.01%	0.07%	0.187%	0.54327%	0.101%
.708 to .709	**14.0%**	0.10%	1.12%	2.88%	8.36%	1.55%
.709-.710	**39.0%**	0.27%	3.12%	8.03%	23.28%	4.33%
.710-.711	**2.0%**	0.01%	0.16%	0.41%	1.19%	0.22%
.711-.712	**19.0%**	0.13%	1.52%	3.91%	11.34%	2.11%
.712-.713	**17.0%**	0.12%	1.36%	3.50%	10.15%	1.89%
.713-.72	**8.0%**	0.06%	0.64%	1.65%	4.78%	0.89%
>.72	**0.3%**	0.00%	0.02%	0.06%	0.18%	0.03%