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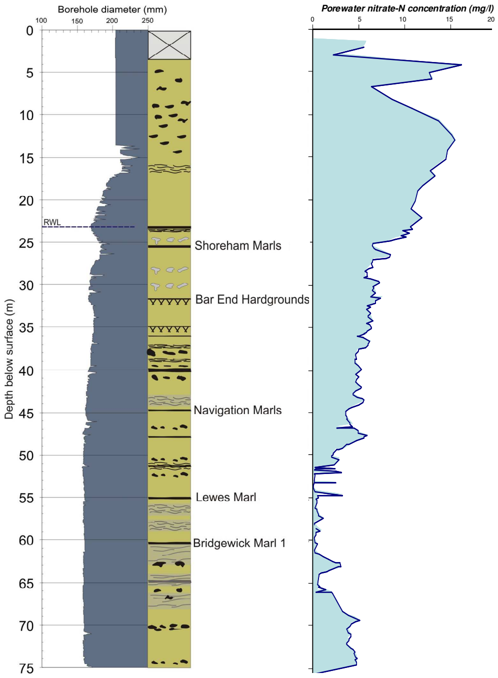
Nitrate concentrations in the Morestead borehole, Twyford

Groundwater Resources Programme

Open Report OR/08/041



BRITISH GEOLOGICAL SURVEY

GROUNDWATER RESOURCES PROGRAMME

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Nitrate concentrations in the Morestead borehole, Twyford

M E Stuart, P J Chilton, A J Newell and A S Butcher

Keywords

Chalk; lithology; nitrate, porewater profile, trace elements

Front cover

Chalk succession and porewater nitrate concentration in the borehole at Morestead, Twyford, Hampshire .

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Foreword

This report is the published product of a study by the British Geological Survey (BGS) on the concentrations of nitrate in groundwater in a borehole at Morestead, Twyford, Hampshire. It forms the output from the BGS project “Nitrate mass balance in the saturated zone”.

The authors are grateful to the following BGS staff who contributed to the project: Adrian Lawrence, Kate Griffiths, Mike Cheetham, Ann Williams, Sally Bourliakas, Peter Williams, Barry Townsend, Daren Gooddy and Jenny Cunningham. Pauline Smedley provided useful comments on the manuscript.

Acknowledgements

In addition to the BGS staff acknowledged in the Foreword, a number of individuals have contributed to the project. We would particularly like to thank the following:

- Mike Packman of Southern Water Services Ltd for provision of water quality data from Twyford Pumping Station;
- Chris Chapman, owner of the Hazeley Estate, for access to the site and provision of agricultural records.

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Summary

This report describes work carried out at Morestead, Twyford as part of a BGS research project "Nitrate Mass Balance in the Saturated Zone". The project aimed to evaluate the role of the diffusive exchange of nitrate between fracture water and porewater in the saturated zone of the aquifer. The approach adopted attempted to obtain a mass balance for the catchment to a public supply borehole by comparing nitrogen released from the soil with nitrogen held in the aquifer and nitrogen pumped to an abstraction borehole.

A new, cored borehole was drilled at Morestead, Twyford in an area of set-aside land on the margins of a field normally used for cereals. The borehole was completed to 75 m depth in the former Upper Chalk penetrating about 25 m of the Seaford Chalk Formation and about 50 of the Lewes Nodular Chalk Formation. The water table lay in the lower part of the Seaford Chalk.

The core obtained was fractured but most of these fractures appeared to be to be parallel to the bedding (e.g. along marl seams) and were probably drilling-induced. Some high-angle fractures with mineralised fracture faces were found in the uppermost 10 m and mineralised fractures with slickensides (possibly associated with a minor fault) were observed at 31 m depth, a few metres below the water table at the time of drilling.

A detailed profile of porewater quality was obtained by centrifugation of core samples. The results indicate that there do not appear to be any zones of unfractured chalk where porewater has retained pre 1960s concentrations of nitrate. Zones close to major fractures did not show steep nitrate concentration gradients, suggesting that there were not large differences in quality between the fracture water and porewater. Porewater concentrations followed a typical nitrate profile for chalk overlain by arable land with elevated concentrations (up to 18 mg N/l) in the unsaturated zone and declining concentrations in the saturated zone (up to 9 mg N/l), except in a 15 m thick zone of the Lewes Nodular Chalk about 25 m below the water table. Here a number of marl bands appear to result in a zone of slow-moving water with low nitrate concentration, but elevated concentrations of a range of trace elements often associated with clay minerals and residence time, particularly Br, Co, Cr, F, Li, Mo, Sb and U.

The results of packer testing of the borehole confirmed that the highest permeabilities were in the zone close to the water table, with low values at depth, consistent with results from boreholes in the nearby Candover catchment. Marl seams appear to be much more important than fractures in controlling groundwater movement to this borehole. Groundwater samples obtained during packer testing were all of similar composition and were interpreted as being drilling water which had not been fully flushed from the borehole before the test. The modelling step of the work was therefore not attempted as this required nitrate concentrations in the mobile water in the aquifer.

The unsaturated zone porewater profile indicates nitrate concentrations mainly at and above the current drinking-water standard of 50 mg/l nitrate (11.3 mg N/l). Annual mean nitrate concentrations at Twyford are rising towards 50 mg/l with seasonal peaks exceeding these concentrations. If this is representative of local conditions, and given the significant proportion of similar arable land in the immediate catchment of the Twyford boreholes then groundwater concentrations are likely to continue rising under the present landuse and agricultural regime. Moreover much of the cultivated land is located in the upper part of the catchment and the nitrate is likely to still be present in the unsaturated and saturated groundwater flow path. Even close to the Twyford borehole, the 'improved grassland' may have significant applications of inorganic fertiliser and organic manure. Present conditions do not therefore suggest any immediate reduction in the upward groundwater nitrate trend.

1 Introduction

1.1 BACKGROUND

Much of the effort in research on the groundwater nitrate problem has been directed towards the unsaturated zone and quantifying solute fluxes moving down to the water table. There is now a considerable body of information but considerable uncertainty remains particularly in relation to the proportion of bypass flow that occurs. However, much less work has been undertaken on nitrate fluxes in the saturated zone of the major UK aquifers.

In dual porosity aquifers the influence of diffusion into the matrix can be considerable in retarding solute transport in fractures. In the Chalk the fracture porosity is typically between 0.1 and 2% and compares with a matrix porosity of 30-40%. This has important implications for both the sustainment of current nitrate trends in groundwater and predicting the impact of land management changes.

Nitrate concentrations observed in abstraction boreholes have increased significantly during the past 30-40 years in response to intensification of farming. It is difficult to predict when nitrate concentrations in groundwater will decline if land use changes are introduced, to reduce the amount of nitrate leached from agricultural soils, unless the retardation of solute transport (due to diffusion-exchange between porewaters and fissure waters) can be quantified. Additionally the long travel times in many UK aquifers mean that the introduction of Programmes of Measures under the Water Framework Directive will require the prediction of such aquifer responses as these cannot be measured directly in the required timescale.

1.2 OBJECTIVES AND LINKS

This project aimed to evaluate the role of diffusive exchange of nitrate between fracture water and porewater in the saturated zone of the Chalk aquifer in response to changes in the concentration of recharge and to apply the results to the predictive modelling of nitrate concentrations in abstracted groundwater in response to future landuse changes.

When attempting to predict the retardation of nitrate in the saturated zone of the Chalk aquifer it is necessary to consider the following parameters:

- matrix block size (fracture spacing) and fracture apertures;
- location of the major flow horizons;
- zone of water table fluctuation (potentially an important zone for transmitting large fluxes of N given that this zone frequently contributes significantly to the overall aquifer transmissivity and that saturated zone groundwater nitrate concentrations are often at a maximum at the water table);
- variability in matrix properties, especially close to fractures, which may control rates of diffusion and exchange between water in the matrix and in the fractures.

The sensitivity of these factors to the retardation of nitrate should be assessed by modelling to identify critical parameters and their uncertainties in order to optimise the research study.

This project is linked to the SB project "Seasonal fluctuations in nitrate concentrations" in use of common infrastructure. It follows on from the present SB project "Nitrate transport in groundwater" and from the nitrate component of unallocated time work.

1.3 APPROACH

The original approach was to attempt to obtain a nitrogen mass balance for a catchment to a public supply borehole, by comparing N released from the soil with N held in the aquifer (unsaturated and saturated zones) and N pumped by an abstraction borehole. This was to be achieved by the following activities:

- selection of a Chalk catchment to a public supply source where good background data existed (long-term agricultural records, aquifer characteristics, pumped nitrate concentrations);
- drilling of a cored borehole in the flow path to the public supply source and obtaining continuous profiles of pore water nitrate concentrations with depth. The borehole would be packer tested to identify flow horizons, and samples were collected to determine permeability distribution with depth and groundwater chemistry (including residence time);
- using the above data, attempt to obtain a nitrogen mass balance (by comparing input N mass with N mass stored in the aquifer and pumped nitrate concentrations with time). Use groundwater head and CFC residence time data to help calibrate the model. This model would consider processes at a scale of kilometres;
- model the transfer of nitrate from fissure water to matrix water (and *vice versa*) for typical fracture spacings/apertures observed in the field and compare with pore water profiles obtained from the field programme. Major flow horizons in the cored boreholes would be identified by a combination of geophysical borehole logging and packer testing. This model would consider processes at a scale of metres;
- if the above steps were successful, use the model developed to predict the impact of land use changes (as nitrate leaching rates) on long-term water quality trends.

In the event the installation and testing of the borehole failed to provide some of the required data and the project objectives were revised. This report sets out the background data collected before field work was started and details the work carried out and an interpretation of the available data, focussed on the relationship between nitrate in the porewater and the geological setting. No attempt has been made to obtain a nitrate mass balance.

1.4 CRITERIA FOR SITE SELECTION

1.4.1 Nitrate mass balance in the saturated zone

The criteria for selection of a suitable research site for the project were determined to be as follows:

- the drilling site should be in the catchment of a currently operating public supply borehole;
- the abstraction borehole should not be too deep to enable the full flow path to be penetrated by the cored borehole without excessive drilling;
- the abstraction borehole should have a good record of N concentration with time and current N concentrations should be significant;
- the aquifer transmissivity (T) should be less than 5000 m^2/d so that it can be assumed that a fraction of groundwater will interact with the matrix;
- the Chalk should be largely drift-free so that the pattern of recharge is simple;

- it should be possible to estimate historical N leaching in the catchment using landuse data and the ADAS NEAP-N model.

The cored borehole site:

- needs to be more than 1 km from the abstraction borehole to minimise the local effects of abstraction and to ensure that the cored borehole is outside groundwater protection Zone I of the abstraction borehole;
- ideally the depth to the water table should be ≤ 10 m to minimize the depth of borehole required;
- some idea of T and its distribution with depth (and spatially) would be helpful (although T with depth should be obtained from the packer testing/borehole logging as part of the project).

1.4.2 Nitrate fluctuations in groundwater

The site selected also needed to meet a second, partly overlapping, set of criteria to allow the use of the borehole for a related project. These were:

- existing visual and statistical evidence of seasonal fluctuations in nitrate from analysis of long-term records (time series datasets) which are related to groundwater level fluctuations (likely to be from a public water supply);
- existing long-term time series of water level fluctuations from nearby observation borehole (needed for the statistical analysis above in any case);
- moderate, average T values in aquifer, (i.e. avoiding very high T).
- chalk at outcrop and largely drift-free;
- knowledge of vertical distribution of T (in general from existing site information and more precisely from the packer testing to be done);
- depth to water level in the range 15 – 25 m (at shallow water table sites low in valleys seasonal fluctuations may be damped, and a mid-slope position is preferable).

1.4.3 Selection of Twyford site

The site at Morestead, close to Twyford, Hampshire was selected as a good compromise between the various criteria. The borehole site selected was on outcrop Chalk and was located away from the valley bottom in order to avoid preferential flow paths. It was in the flowpath of a public supply site with pronounced seasonal fluctuations in nitrate concentration (Figure 1.1, UKWIR, 2002). Determination of the trend at a well on the site by three different methods (ordinary least squares (OLS), Robust and Kendall Test (KT) indicated concentrations (calculated as nitrate in the UKWIR report) increased by about 1 mg/year from 1990 to 2002. Including the month as a factor in an analysis of the variance accounted well for the seasonality (ρ is the likelihood that the series is not seasonal). The regular sampling contributed to the overall acceptable error in the model fit (RSME)

The transmissivity was moderate to high (Allen et al, 1999). The area was located about 1 hour's drive away from the BGS Wallingford Office and was therefore convenient for frequent visits.

The site failed to meet some of the criteria, namely that the water level was anticipated to be about 25 m below the surface in the autumn and perhaps more importantly, some of the public supply boreholes at the abstraction site were quite deep (150 m).

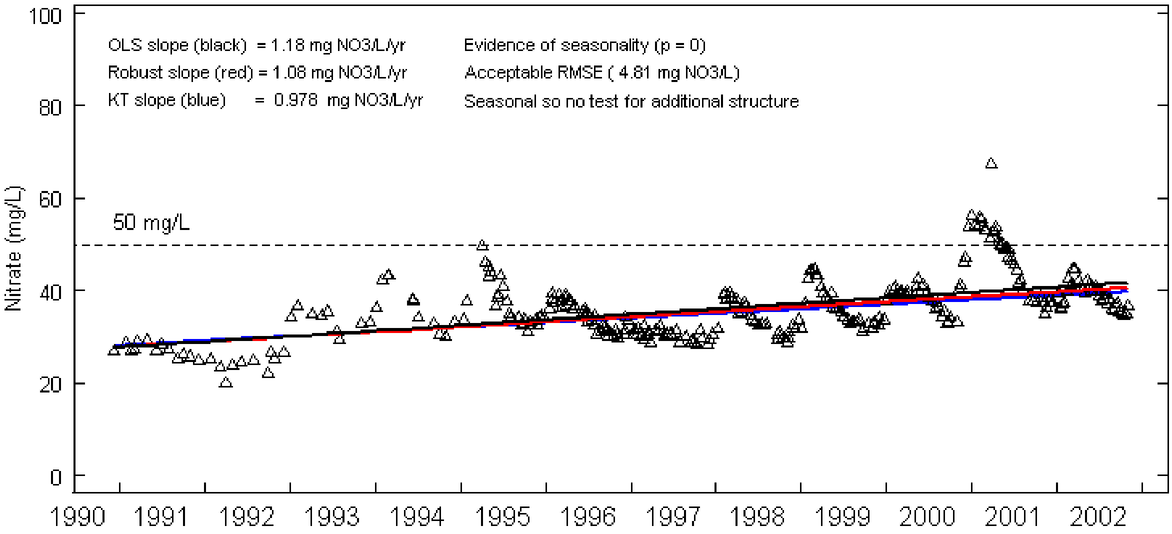

Figure 1.1 Nitrate time series for Twyford Well (from UKWIR, 2003)

2 Site description

2.1 PHYSICAL SETTING

The site selected for the study was about 1.5 km east of the public supply borehole at Twyford, Hampshire on the Chalk of the South Downs (Figure 2.1). The site [SU 5073 2528] was at an elevation of about 55 metres above Ordnance Datum (m aOD) on the southeastern slopes of a dry valley running southwestwards down towards the pumping station which is at about 38 m aOD. The area is drained by the River Itchen which is about 2.7 km to the west at an elevation of about 25 m aOD. The Downs rise to a highpoint at Cheesefoot Head [SU 531 277] about 3.4 km to the northeast of the site.

The landowner’s agent stated that the lowest point of the field, the northwestern corner, was liable to become very water logged during wet winters. On average the area receives about 850 mm of rainfall per year.

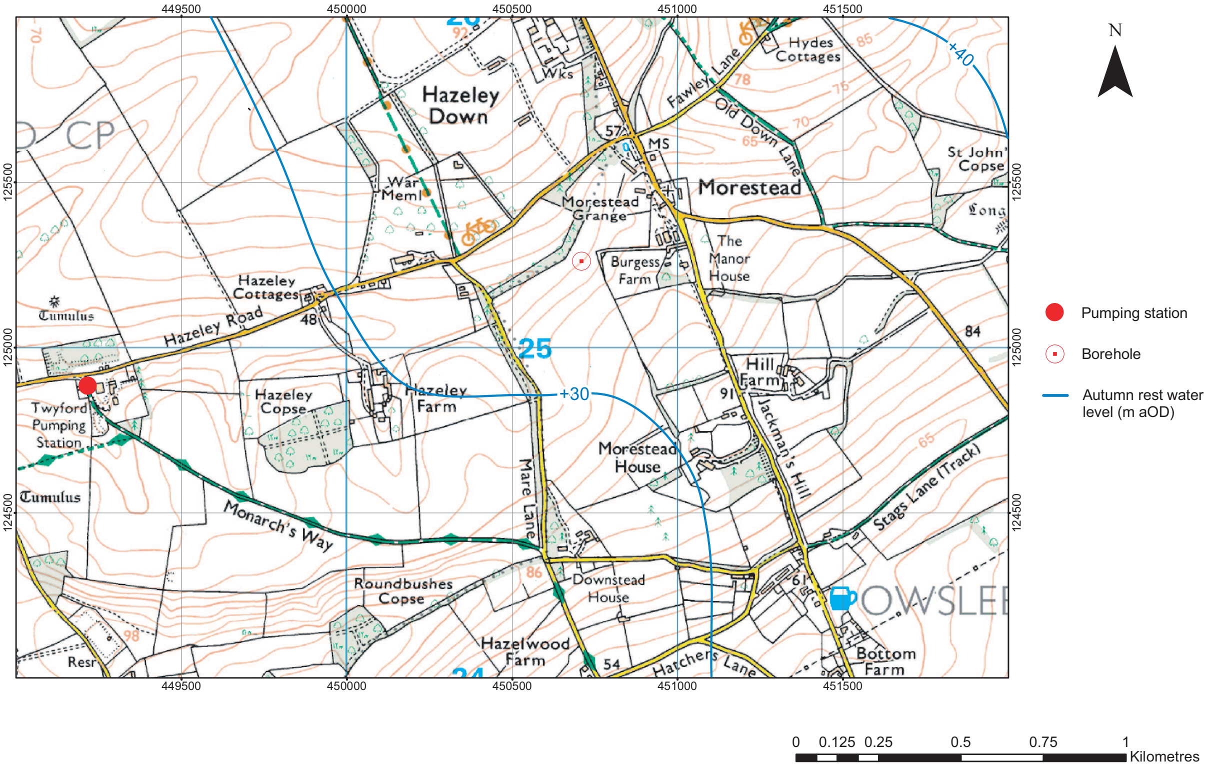

Figure 2.1 Site location and autumn rest water levels (1973) from the hydrological map (IGS, 1979)

2.2 GEOLOGY

The borehole site was into the southern flank of the Winchester Anticline, one of several major west-east trending fold structures that formed in response to compression during Miocene inversion of the Wessex Basin (Figure 2.2). The Winchester Anticline is an asymmetrical structure with strata dipping at approximately 4-5 degrees on the southern limb in the area of the borehole site and up to 10 degrees on the northern limb (Figure 2.3). The central core of the Winchester Anticline is deeply eroded providing an elongate west-east trending window in the Lower Chalk. Steep scarps developed around the eroded core of the anticline expose the overlying Middle and Upper Chalk up to the level of the Seaford Chalk. The remainder of the Chalk succession and the overlying Palaeogene succession of the

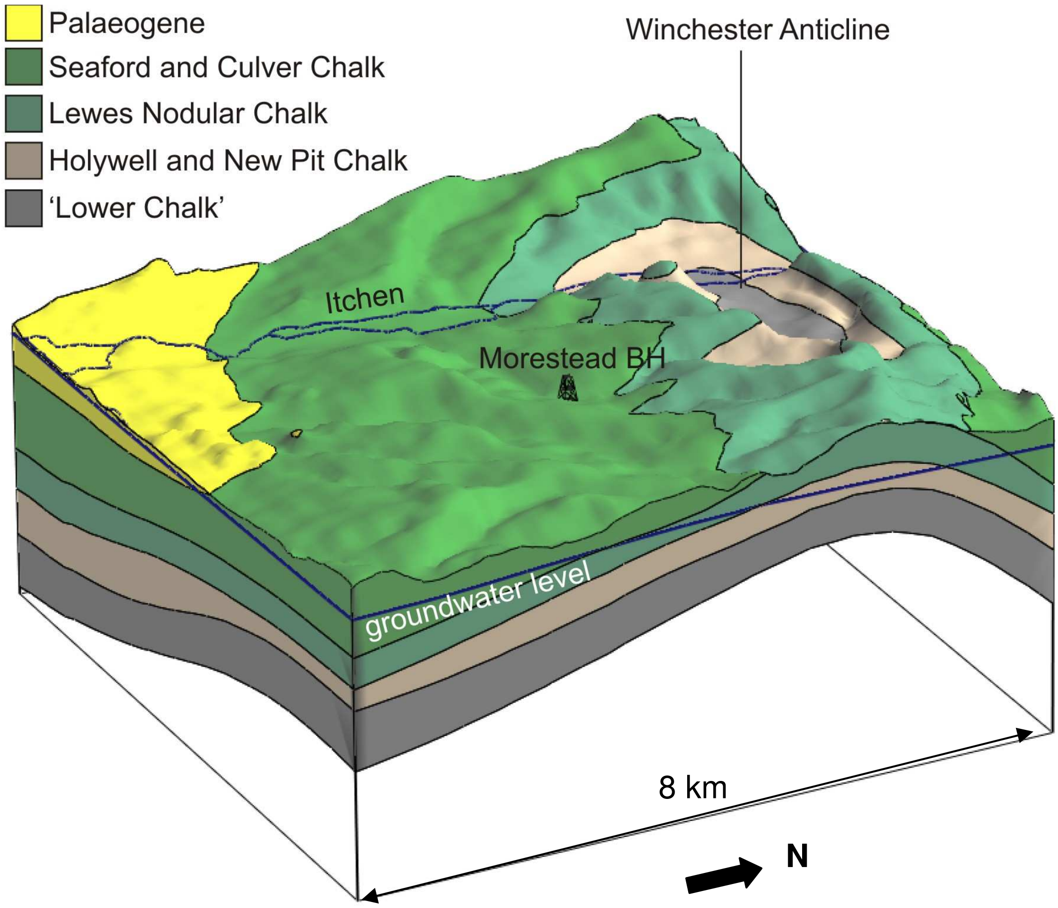

Figure 2.2 3-D model of the Winchester Anticline showing the location of the Morestead borehole

Hampshire Basin are exposed to the south of the anticline. The River Itchen cuts through the core of the Winchester Anticline and flows southward toward the Palaeogene crop.

The Seaford Chalk consists of predominantly soft to firm white Chalk with common flint. The base of the formation and the contact with the Lewes Nodular Chalk is marked by the Shoreham Marls The Lewes Nodular Chalk is a heterolithic formation of soft to very hard nodular chalks, marl seams and flint. The stratigraphy of the formation has been described in detail from large outcrops at the Twyford Down M3 cutting 2.8 km NE of the borehole (Hopson, 2001). The well-developed Bar End Hardgrounds lie just below the Lewes-Seaford Chalk contact. The hardgrounds are extremely hard chalkstone with glauconitic mineralisation. Several marls up to 0.1 m thick occur in the Lewes Nodular Chalk including the Lewes Marl and the Bridgewick Marl. These major marl seams can be traced over much of southern England. Thin, discontinuous flaser marls are common throughout the formation.

Karst features observed in the Twyford cutting, (Hopson 2001) include a partially sediment-filled palaeo-cave system in the centre of the cutting and calcreted karst at the southern end along the main fractures and along the surfaces of the Bar End Hardgrounds and the Belle Tout Marls.

The area immediately around the borehole site is largely free from superficial deposits, with the Seaford Chalk being covered only by a thin, flinty soil. To the west of the borehole, the River Itchen flows across a cover of alluvium and river terrace gravels. To the south and the

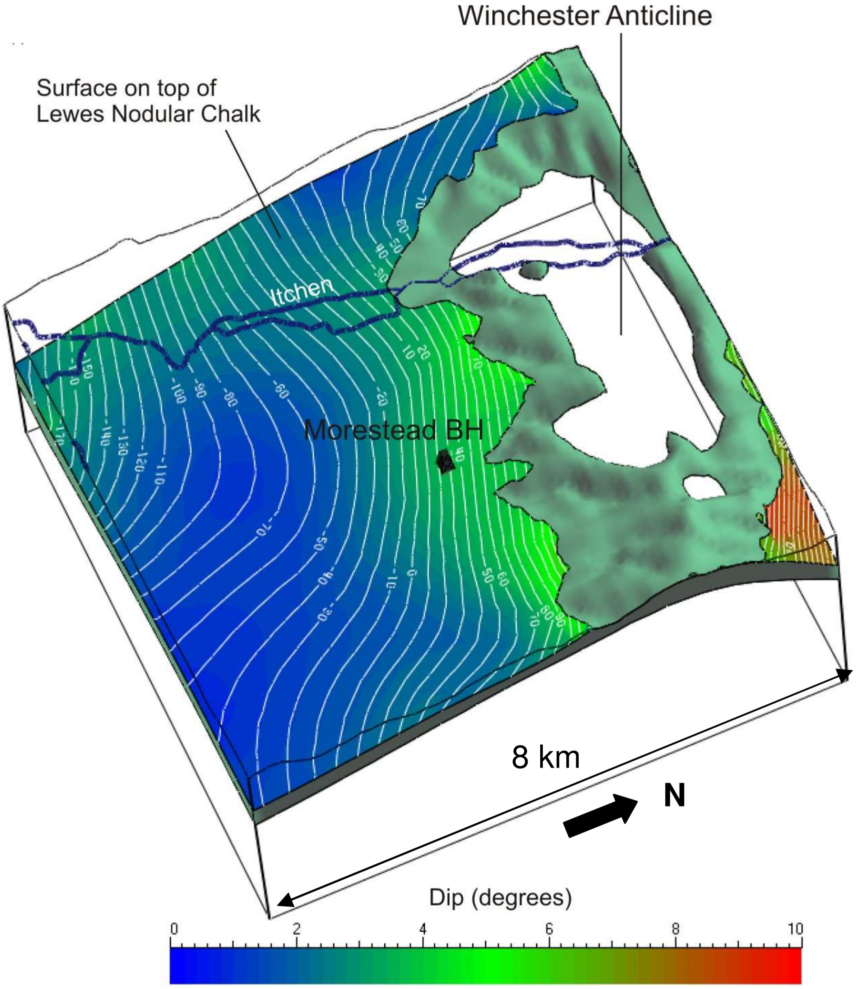

Figure 2.3 Structure contours on angle of dip on the top of the Lewes Nodular Chalk

north of Morestead, hilltops have a cap of Clay-with-flints. Clayey, flinty solifluction deposits (Head) occur in valley bottoms (Figure 2.4).

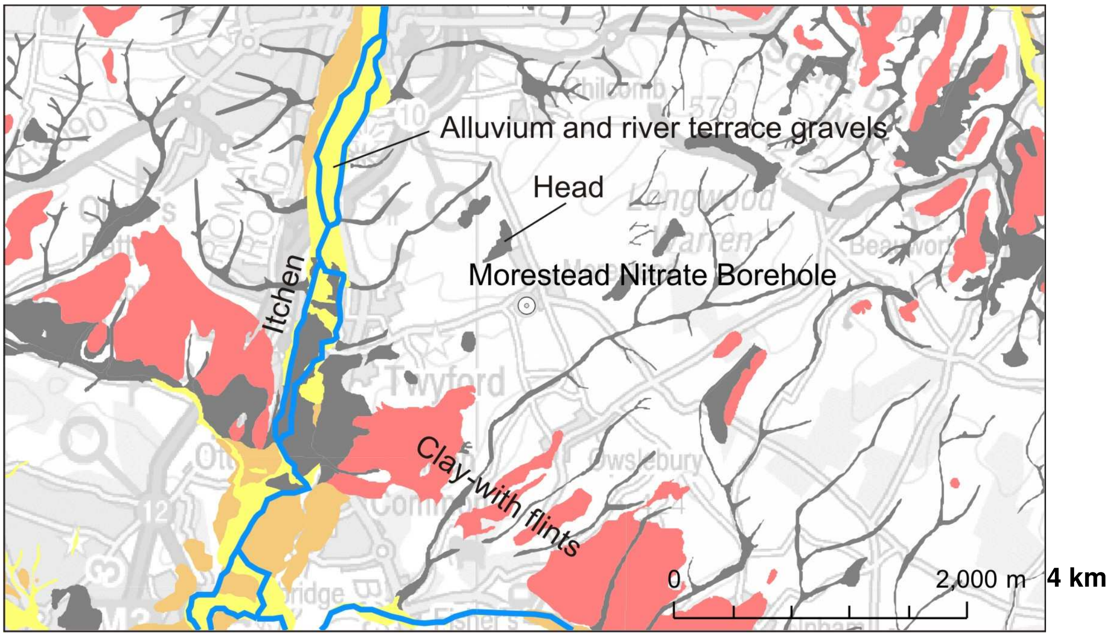

Figure 2.4 Superficial deposits in the Morestead area

2.3 HYDROGEOLOGY

2.3.1 Aquifer

The Chalk forms the major aquifer in southern England. It is a microporous limestone, which yields and transmits water mainly by fracture flow. Borehole yields depend on the number, size and distribution of fractures intercepted. Chalk transmits water more readily in valley localities than it does at interfluve locations due to the presence of a greater number of fractures. The Chalk also becomes less transmissive with depth as fractures become smaller and less common.

2.3.2 Water levels

The water level contours on the Hydrogeological Map (for October 1973) indicate that groundwater flow is to the southwest at the site, generally towards the River Itchen (IGS, 1979). The autumn water level at the site would be predicted to be 20-25 m below the surface. The local direction of groundwater flow will be influenced by abstraction from the pumping station. The groundwater level cuts across the relatively steeply dipping strata of the Winchester Anticline. Water levels show marked seasonal fluctuations over the area, with peak increases in the winter of up to 20 m (Figure 2.6). Minimum water levels at the site are predicted to lie at about 26 to 20 m aOD.

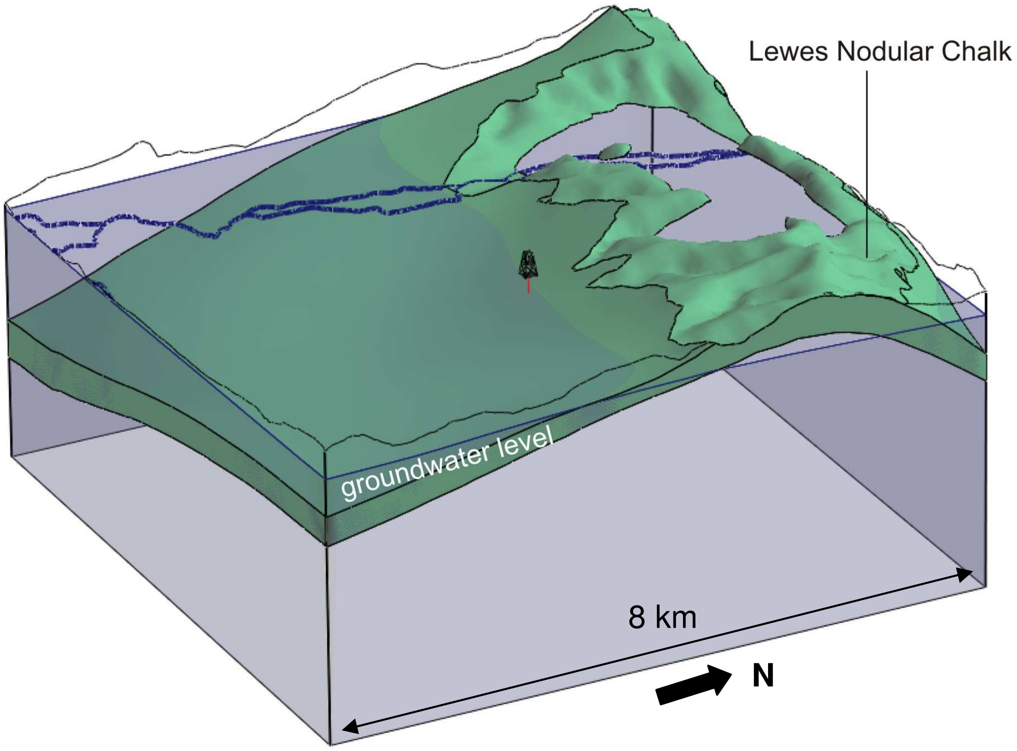

Figure 2.5 December 1990 groundwater level cross-cutting the Winchester Anticline

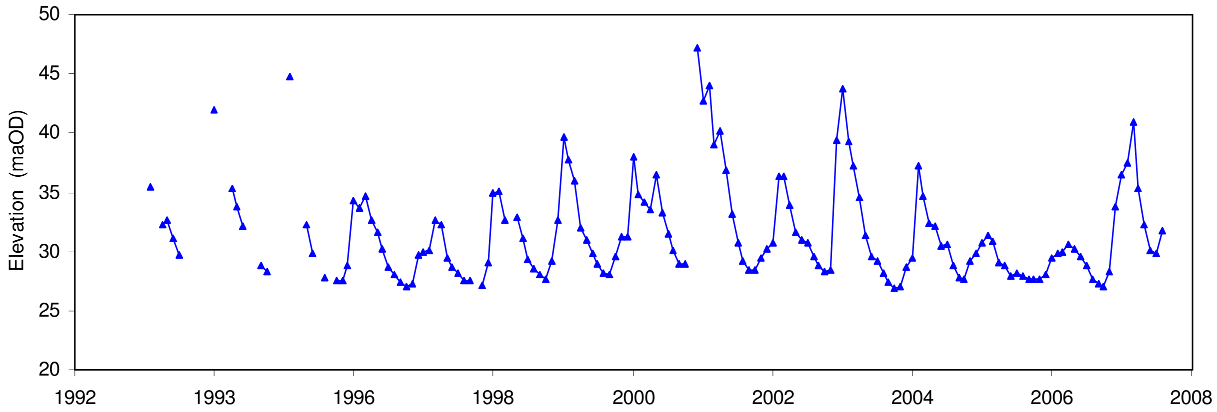

Figure 2.6 Water level fluctuations in the nearby Environment Agency water level monitoring borehole at Hazeley Down Farm

2.3.3 Existing boreholes in area

The Twyford pumping station comprises the original complex 3-well site with adits and 3 newer deep boreholes further to the west. The three wells were constructed in 1897, 1905 and 1933 and are situated beneath the same engine house, which is at about 38 m aOD [SU 490 248]. The first two were originally about 2.4 m in diameter and 50 m deep and the third was 1.1 m in diameter and 41 m deep. They are interconnected by a heading some 39 m below the surface. There are two adits: one at 30 m below the surface running 128 m to the northeast and the second at 38 m below the surface running 174 m to the south.

The three boreholes were drilled in 1962. The first borehole (No. 1) [SU 4895 2509] was 450 mm in diameter and 152 m deep. Water was struck at 40 m, 61 m and 119 m below the surface. At this time the water level was 18.5 m below the surface (about 20 m aOD). After acidisation the borehole provided a yield of 76 l/s for a water level drawdown of 35 m during a 14-day pumping test No. 2 [SU 4880 2471] was similar but was 137 m deep and struck was at 21m and 122 m below the surface. The yield was 60 l/s for a drawdown on the water level of 8 m. No. 3 [SU 4907 2454] was also 137 m deep and struck water at 20 m and 51 m below the surface, and yielding 34 l/s for a water level depression of 49 m.

There are also a number of domestic or farm boreholes in the area (Table 2.1). These indicate that the Chalk may be low yielding in the area to the east of the site, but most of the records are old and incomplete.

The nearest site with aquifer properties data is the public water supply at Easton. Borehole 1 [SU 5013 3229] had a transmissivity of 4700 m^2/day, whilst Borehole 2 [SU 5030 3200] was lower at 2400 m^2/day.

2.3.4 Variation of aquifer properties with depth

Several studies have investigated the variability of aquifer properties with depth in this area. In the Candover catchment to the north a study of artesian boreholes at watercress farms at Alresford found that a narrow zone at the top of the boreholes was contributing the majority of the flow, with the rest of the aquifer providing upwards leakage to this high transmissivity layer (Headworth, 1978).

Table 2.1 Boreholes in the site vicinity

Wellmaster ref.	Site	Grid Reference	Elev. (m aOD)	Date	Depth (m)	Diam. (mm)	Rest level (m aOD)	Yield (l/s)
SU52/17	Hazeley Farm	SU 501 249	55				33-36	
23	Manor Farm	SU 509 257	64	1929	46	150	30	
24	Morestead Hill Cottages	SU 508 257	64			1200	31	
25	Morestead Grove	SU 510 255	68	1934	69			0.07
26	Burgess Farm House	SU 509 254	62.5		52		31.1	
27	Morestead House	SU 511 247	91	1928	85			'Poor'
104	Long Barn	SU 509 254	63	1989	46	203	31	
105	Manor House	SU 511 252	74	1990	59	200	52	0.15
SU42/18	Hensting	SU 498 245	60	1935	45	150		'Good'

A detailed investigation of the River Itchen augmentation scheme showed a decrease in storage with water level. During the prolonged drought period in 1976, an analysis of drawdowns from a group pumping test indicated that the aquifer was multi-layered. The 6-m thick top layer, just below the water table, had high transmissivity and storage. Beneath this was a lower transmissivity and storage layer constituting the remainder of the Upper Chalk. Detailed tests in 3 different boreholes in dry valleys: Abbotstone [SU 558 349], Itchen Down Farm [SU 546 334] and Totford [SU 569 380] in the Candover catchment, included core permeability testing, geophysical logging and packer injection testing (Price et al. 1977). This study showed that:

- throughout the borehole, the permeabilities measured were one or two orders of magnitude greater than the core permeability (Figure 2.7);
- zones that had very high permeability corresponded to fracture locations;
- most of the saturated thickness of the Chalk had very low permeability – only a few fractures were required to give the total transmissivity;
- the most important flow horizons were near the top of the borehole with very little flow below 40 or 50 m;
- there appeared to be little correlation between the high transmissivity layers and the Upper Chalk stratigraphy.

However, in the adjacent Alre catchment the aquifer was not layered in the same manner but large-diameter fractures were observed at various levels in both the Upper and Middle Chalk.

2.3.5 Modelling

Modelling work undertaken in the Wallop Brook catchment required a two-layered model with a top, high transmissivity layer varying in thickness from 30 m near the interfluves to 1 or 2 m at the river. On the interfluves the hydraulic conductivity of the top layer was taken as twice that of the lower layer. Towards the river this ratio increased to 20:1.

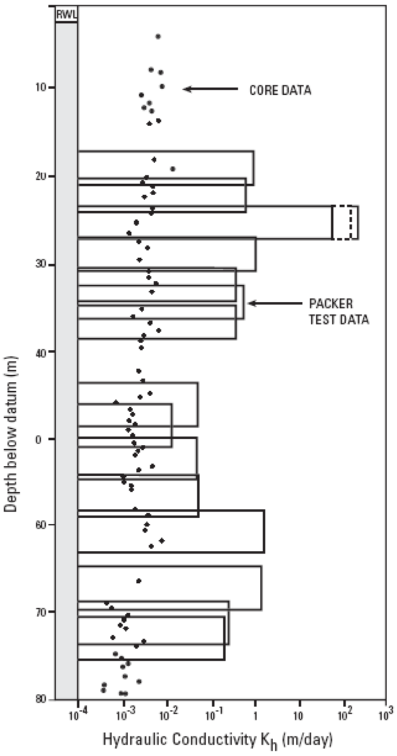

Figure 2.7 Variation of hydraulic conductivity with depth from packer testing and laboratory core measurements for a borehole in the Candover catchment (after Price et al., 1977)

2.4 LANDUSE

The Chalk downland in the Twyford catchment is typical of the area with the wetter valley bottoms used for cattle grazing and the higher slopes used for a mixture of arable and unimproved grass. Figures 2.8 and 2.9 show a summary of land cover from satellite imagery in 1990 and 2000 respectively. For both of these datasets, the classifications have been aggregated (see Table 2) to give simpler and hopefully comparable types. The 1990 data are on a 25-m^2 raster and the classification was originally developed to distinguish between various types of grass. The later 2000 polygon data is much better at distinguishing arable crops. The 2000 Land Cover boundaries correspond well with mapped field boundaries on the 1:10, 000 topographic map which underlies the data in Figure 2.9.

The wooded dry valley and the wide headland strip on which the borehole is sited can be seen on both these maps and is clearer in 2000. These maps indicate that the borehole field was under grass in both 1990 and 2000.

Details of cropping and fertiliser applications were provided by the landowner for the field in which the investigation borehole was sited and are shown in Table 2.3. These data show that the field has been predominantly under cereals since 1992 with a period of setaside in 2001. Fertiliser applications to spring barley have been at a relatively consistent level averaging 160 kg N/ha. Heavier applications were made to oil seed rape in 2004 and winter wheat in 2005.

Table 2.2 Aggregation of landcover classes

1990 Land Cover		**2000 Land Cover**	
Aggregated class	**Classes present**	**Aggregated class**	**Classes present**
Woodland	Deciduous Coniferous	Woodland	Broad-leaved/mixed Coniferous
Tilled land	Tilled land	Cereals Horticulture	Cereals Horticulture Not annual crop
Meadow/verge Mown/grazed turf	Meadow/verge/semi-natural Mown/grazed turf	Improved grassland	Improved grassland
Grass heath	Grass heath	Calcareous grass	Calcareous grass
		Setaside grass	Setaside grass
Scrub/bracken	Moorland grass Bracken Scrub/orchard Open shrub heath		
Inland bare ground	Inland bare ground Felled forest	Inland bare ground	Inland bare ground
Rural development	Suburban/rural develop Urban	Rural development	Suburban/rural develop Urban

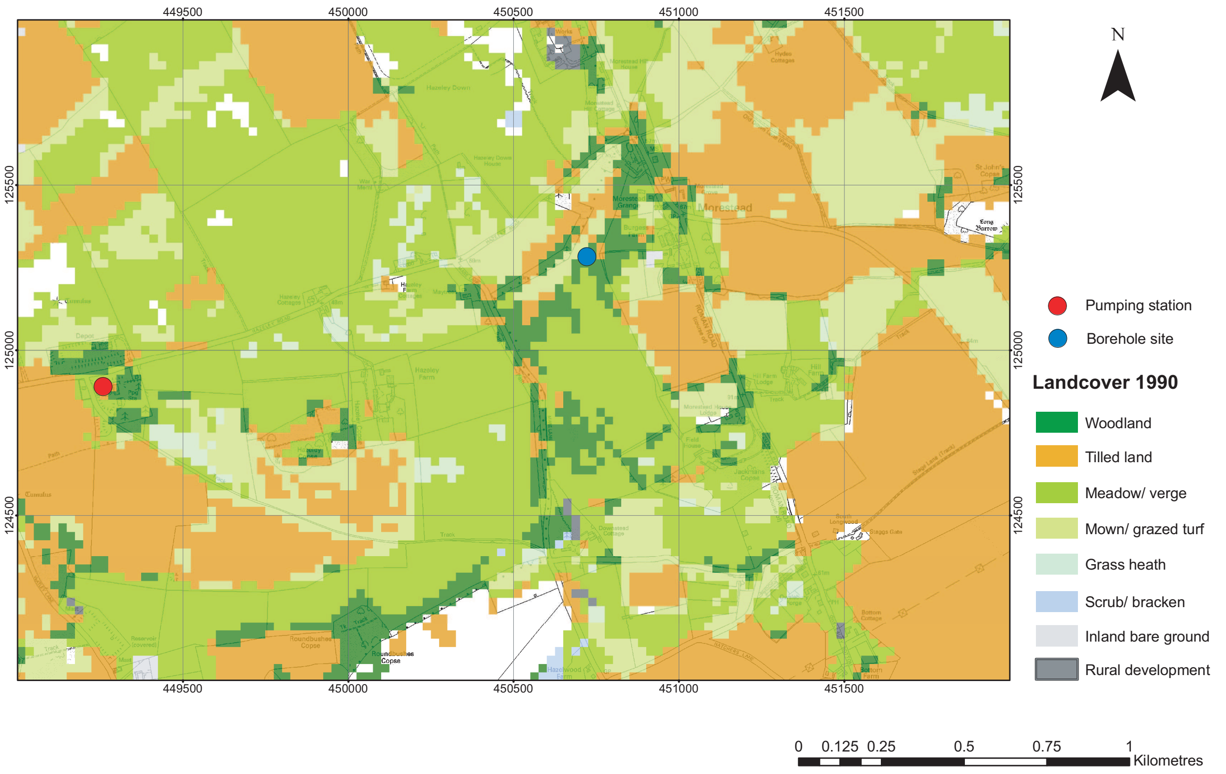

Figure 2.8 Landuse in 1990 simplified from CEH landcover map

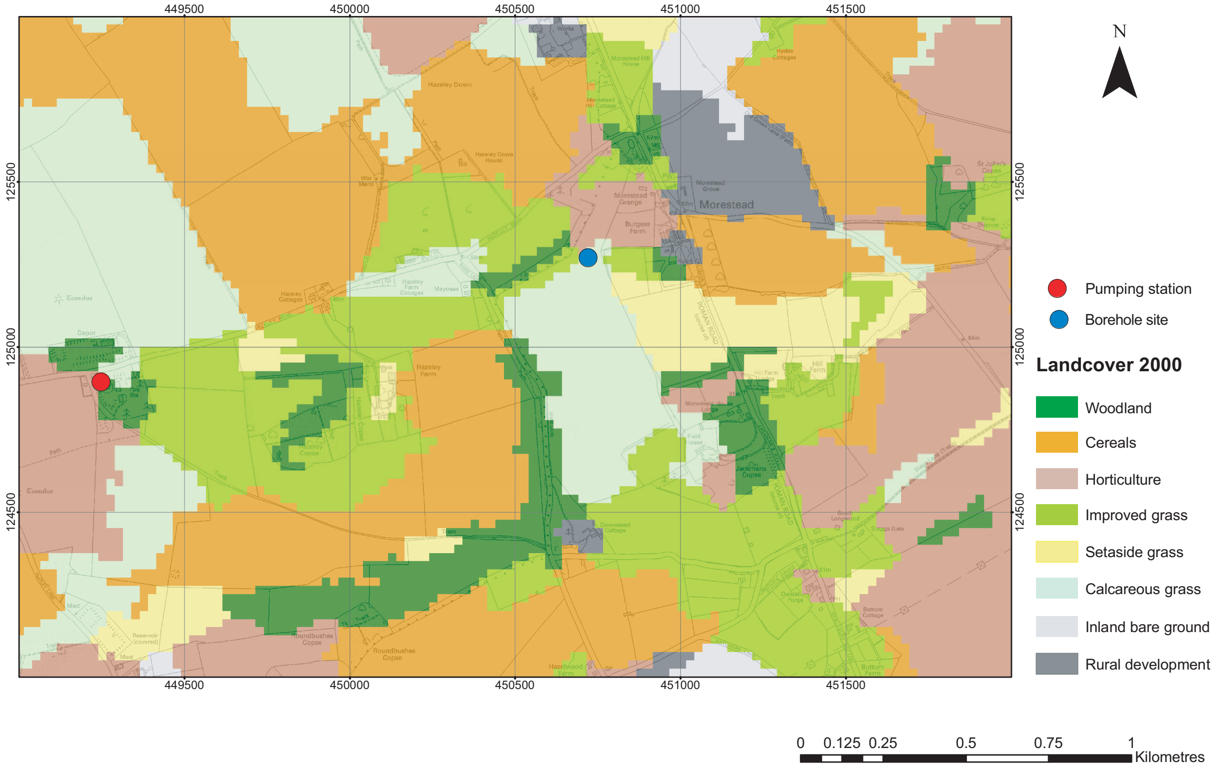

Figure 2.9 Landuse in 2000 simplified from CEH landcover map

Table 2.3 Cropping record for site

Period	Crop	Yield (t/ha fresh)	Planting date	Inorganic fertiliser (kg N /ha)		Other factors affecting N balance
				Aug-Dec	Jan-July	
1992	Winter barley					Straw removed
1993	Winter oil seed rape					Straw incorporated
1994	Winter wheat					Straw removed
1995	Spring barley					Straw removed
1996	Spring barley					Straw removed
1997	Spring barley					Straw removed
1998	Winter wheat					Straw removed
1999	Spring barley	6.1	2/3/99		175	Straw removed
2000	Spring barley		9/3/00			
2001	Set aside					Cut once/sprayed once
2002	Spring barley	5.2	15/2/02		159	Straw removed
2003	Spring barley	6.3	22/2/03		169	Straw removed
2004	Winter oil seed rape	2.5	3/9/03	38	160	Straw incorporated
2005	Winter wheat	8.5	8/9/04		245	Straw incorporated
2006	Spring barley	6.9	5/2/06		162	Straw incorporated

2.5 DATA FROM PUMPING STATION

2.5.1 Abstraction

Daily abstraction data for the Pumping Station up to the beginning of 1997 were provided by Southern Water. Figure 2.10 shows monthly abstraction for the period 1989 to the present. The data show that annual abstraction has been relatively consistent over this period, about 7000Ml/month, apart from 1992-1993 and 2005-2006 where volumes were lower. Maximum abstraction occurs in May to July and minimum in October, November and February (Figure 2.11).

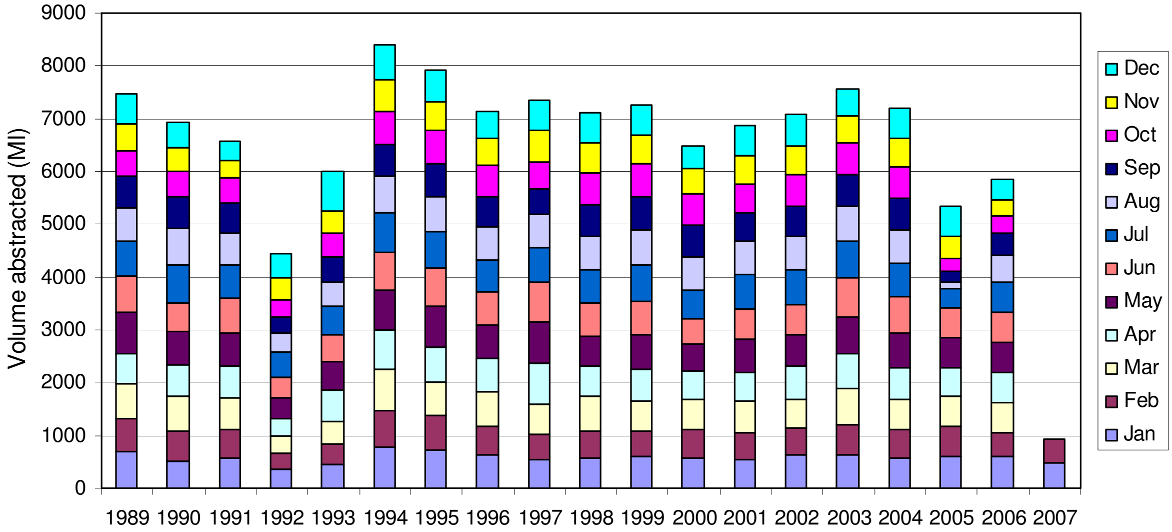

Figure 2.10 Summary of abstraction from Twyford Pumping Station from 1989

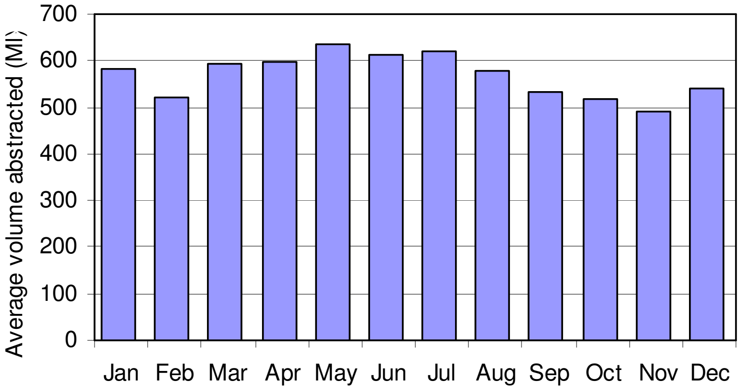

Figure 2.11 Monthly variation in abstraction at Twyford Pumping Station

2.5.2 Nitrate concentrations

Nitrate concentrations at the Pumping Station up to the beginning of 2007 were provided by Southern Water (Figure 2.12). These show:

- the three time series are essentially similar with little difference between the well and the deeper boreholes;
- all three show pronounced seasonal variations;
- all three showed very high concentrations during the wet winter of 2000-2001;

- the winter peak concentrations were very subdued over the years 2004-2005 and 2005-2006 as a result of the sustained period of dry weather;
- the leading edge of the 2006-2007 peak can be seen by the end of December 2006;
- the minimum nitrate concentrations are in the range 20-25 mg/l nitrate in all three series;
- the borehole series both indicate an increasing trend. This is probably an underestimate since the 2004 and 2005 peaks are relatively repressed.

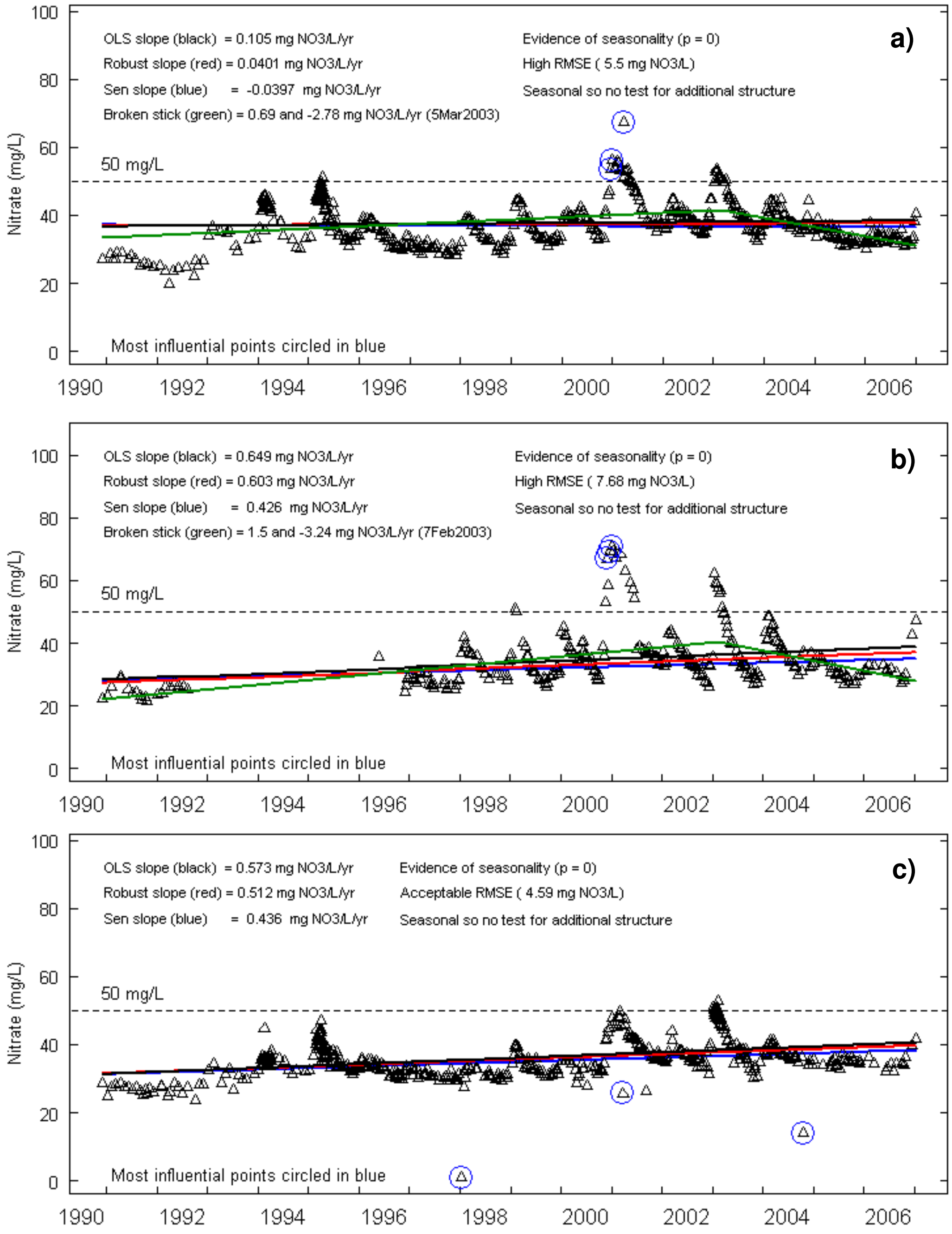

Figure 2.12 Nitrate concentrations at Twyford Pumping Station: a) Well; b) Borehole 1; c) Borehole 2 (note units as nitrate, see Section 1.4.3 for explanation of diagram annotation)

3 Installation of borehole

3.1 DRILLING AND LOGGING

Drilling at the site was started on 10th May 2006. using 150 mm rotary cored drilling with air-flush. After a few metres the tool became stuck and water from the bowser had to be added. The method was then changed to 140 mm wireline Geobore S. This required a water mist to allow the barrel to rotate. Drilling was continued to 50 m below the water table and the hole was completed at 75 m on 17th May 2006.

The borehole was caliper logged prior to testing to check that the hole was of adequate diameter (160 mm) to accept the packer string and to contribute to the identification of suitable intervals to be tested. Some intervals in the lower part of the hole were of insufficient diameter and the borehole was reamed out to 160 mm and developed. The caliper log was run again and the diameter was satisfactory.

Each core run was checked for correct markings (as above), orientation and sequence. The liners were cut open using a vibrating saw. The core was logged broadly following the standard for core logging for engineering purposes, BS5930. The recovered core length was measured and noted on the log sheet. Where core was missing the loss was generally attributed to the end of the core run. A graphic log of the core was made noting any particularly hydrogeologically significant features and fracture depths. Where fractures were clearly drilling-induced these were denoted with a ‘D’. The depth intervals of the physical properties and pore water samples were recorded on a graphic log with sample numbers. Fractures and significant features were photographed.

3.2 SAMPLING

3.2.1 Porewater extraction

Core was removed from the core run between the determined depths, breaking the core if necessary (using a geological hammer or hammer and chisel) if the sampled interval was not determined by natural or drill-induced breakages in the core. In order to avoid contaminated sample being included, a nominal 10-15 mm of the outer core surface was chipped off and discarded. The resultant inner core was kept intact, heat sealed in a bag after as much air as possible has been excluded and refrigerated until immediately before centrifuge processing.

For processing the core was broken into small pieces (approximately pea size), weighed into a Delrin centrifuge bucket with a titanium filter disc and centrifuged for 40 min in a high speed refrigerated centrifuge. The porewater was passed through a 0.45 µm filter and divided into a suitable number of aliquots for analysis. The yield was recorded.

The moisture content was determined by weight loss after oven-drying at 100°C

3.2.2 Aquifer properties sampling

The samples were submitted as nominal 100 mm diameter cores of 1m length. Core samples, believed to be representative of the matrix of the sample cores were processed into plugs suitable for the laboratory testing by the Aquifer Properties Laboratory at the British Geological Survey, Wallingford. Sample preparation involved drilling a 25-mm plug using a diamond coring drill using tap water as a bit coolant. Samples were then oven dried for a minimum of 24 hours at 60°C prior to testing. Permeability, and porosity were determined using these plugs, techniques are summarised below and are described in Butcher (1990). Pore water extraction by centrifugation was undertaken on adjacent samples of core.

3.3 PACKER TESTING

The calliper log for the borehole is shown in Figure 3.1. This was used to check that the borehole was of suitable diameter for testing and to select intervals for packer testing. The hole needed to be reamed to open out the lower part of the hole.

Packers are expanding plugs that can be used to isolate temporarily a section of a borehole. The packer system used at Twyford (Price and Williams, 1993) incorporates a pump to abstract water from the isolated section, and a transducer to measure the pressure within the section. This system allows measurements to be made of the permeability of the isolated section and the head within the section. This latter measurement means that a profile can be determined of the natural head within the formation, undisturbed by vertical flow within the borehole. When the packers are inflated, isolating a section of the aquifer from the borehole, the water level in both the isolated interval and the section of borehole above the interval may change from that which was measured in the open hole. The head below the isolated interval may change as well but it is not possible to monitor this with the present packer system.

The water level in an open borehole represents a 'weighted average' of the head at the different depths penetrated by the hole. The 'average' is weighted by the permeability of the different contributing horizons. For example, if there are two contributing layers A and B of

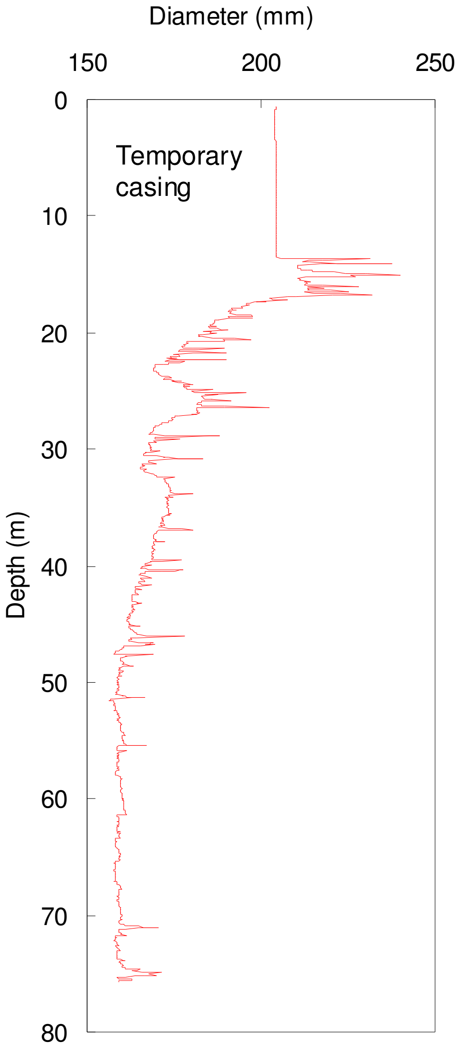

Figure 3.1 Caliper log for the borehole after completion of drilling and reaming

the same thickness with permeabilities of K_A and K_B, and heads of H_A and H_B, the open borehole head (H_O) will be given by:

$$H_O = \frac{K_A H_A - K_B H_B}{K_A - K_B}$$

The head within the aquifer at any depth changes with time. What is measured with a packer system is a 'relative head change'. Within a section this is recorded as the change in water level which occurs in that section when it is isolated. If the interval has a lower head than that present in the borehole then a negative change is noted. The implication of a negative change is that when the packers are not present, water will flow from the borehole into the formation. The rate of this flow can be calculated as the permeability of the isolated section will have been measured during the subsequent packer test (flow rate is proportional to the permeability and the head difference).

Once the packers have inflated isolating the section to be tested, water is pumped out of the isolated interval at a constant rate. The head in the section is monitored using the transducer and pumping is continued until a steady-state drawdown is measured. This usually takes about 20 minutes. The pumping rate is then increased and the head monitored until a new steady-state is reached. The rate is then decreased and a further steady-state achieved. Ideally the permeability calculated for each of these tests will be similar enough for confidence to be placed in the test. After this the packers are deflated and lowered to a new interval. This whole process takes at least two hours (depending on how many pumping rates are used and how long it takes to achieve steady-state) which means that it is difficult to carry out more than three tests in a day.

3.4 ANALYSIS

3.4.1 Gas permeability

Gas permeability tests were performed on samples under steady-state conditions using either a pressurised coreholder (57 samples) or a probe permeameter (3 samples). A full description of the methodologies and discussion of the correlation between gas and liquid permeability can be found in Bloomfield and Williams (1995).

In the standard test, samples are constrained in a core holder and a pressure-regulated supply of nitrogen gas is applied to one end of the sample (the downstream end of the sample is held at atmospheric pressure). A soap-foam flow meter is used to measure the outflow of nitrogen from the downstream end of the sample. Gas permeability is calculated using the measured sample dimensions, differential pressure, and the steady-state gas flow rate as follows:

$$k_g = \mu\, Q\, L\, P_o/[A\, (P_i^2 - P_o^2)]$$

where k_g is gas permeability(in mD), μ is gas viscosity (in cP), Q is the volumetric gas flow rate measured at atmospheric pressure (in cm^3/sec), L and A are the sample length (in cm), and area (in cm^2) respectively P_o is the downstream (atmospheric) pressure (in mB), and P_i is given by $P_i = P_o + P_g$, where P_g is the absolute pressure of the regulated nitrogen permeant. The effective errors associated with the gas permeability measurements are about +/- 2.5% of measured sample permeability.

3.4.2 Porosity

Porosity (with bulk and grain density) was measured using a liquid resaturation method based on the Archimedes principal. The methodology is described in detail in Bloomfield et al. (1995). A sample to be tested is weighed and then placed in a resaturation jar. The jar is evacuated then flooded with propanol. Propanol is used as it is relatively inert with respect to the core and reduces the potential for swelling clays to modify the porosity during testing. The sample is allowed to saturate for at least 24 hours. The saturated sample is then weighed, firstly immersed in the propanol and then, still saturated with propanol, in air. For each sample its dry weight (w), its propanol saturated weight in air (S_1) and its saturated weight immersed in propanol (S_2) are recorded, in addition the density of the propanol (ρ_f) is noted. From these values sample dry bulk density (ρ_b), grain density (ρ_g) and effective porosity (ϕ) can be calculated as follows:

$$\rho_b = (w\rho_f)/(S_1 - S_2) \text{ g/cm}^3$$

$$\rho_g = (w\rho_f)/(w - S_2) \text{ g/cm}^3$$

$$\phi = (S_1 - w)/(S_1 - S_2)$$

The effective errors on the porosity measurements are approximately +/- 0.5 porosity percent.

3.4.3 Analysis of water samples

The porewater samples and packer testing effluent was analysed for a range of inorganic determinands plus residence time indicators and water stable isotopes (Table 3.1). Determinands requiring large or atmosphere-free samples were only possible for packer test samples.

3.5 BOREHOLE COMPLETION

The borehole was completed after sampling was finished as two 50 mm diameter piezometers, both with 6 m screened sections (Figure 3.2). The shallow piezometer was about 30 m deep and was designed to sample the water in the permeable zone close to the water table. The deeper piezometer reached to the base of the borehole.

Table 3.1 Summary of samples for chemical analysis

Method	Determinands	Porewater	Packer testing effluent
Autotitrator	pH & alkalinity	√	√
Ion chromatography	NO3, Cl, F	√	√
ICP-OES	Majors & minors	√	√
ICP-MS	Trace elements	√	√
Colorimetry	Soluble reactive P	√	√
Chromatography	CFC & SF_6		√
Mass spectrometery	H & O stable isotopes		√

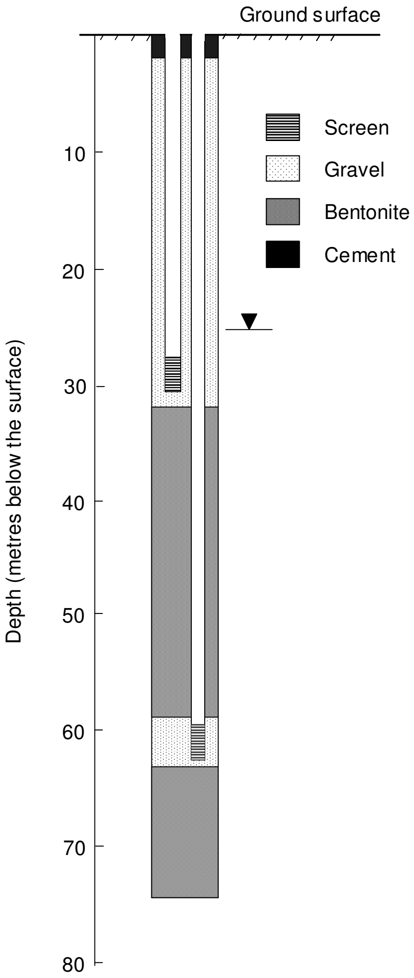

Figure 3.2 Borehole completion as 50-mm piezometers

4 Results

4.1 CORE CHARACTERISATION

4.1.1 Lithological description

The Morestead borehole was located on the outcrop of the lowermost Seaford Chalk and cored 25 m of Seaford Chalk before penetrating 50 m of Lewes Nodular Chalk. The Shoreham Marls were identified at the base of the Seaford Chalk and the well-developed Bar End Hardgrounds just below the Lewes-Seaford Chalk contact were clearly seen (Figure 4.1). In the Lewes Nodular Chalk the Lewes Marl at 55 m below the surface and the Bridgewick Marl at 60 m were prominent.

There was no evidence for large-scale solution enlargement of fractures in the borehole core unlike those observed in the Twyford cutting.

The rest water level in the borehole at the time of drilling was close to the base of the Seaford Chalk Formation just above the Shoreham Marls.

4.1.2 Fracturing

The core was fractured but most of these appeared to be to be bedding parallel (e.g. along marl seams) and were considered to be probably drilling-induced. In the unsaturated zone some high angle fractures with mineralised fracture faces were found in the uppermost 10 m of the core. Mineralised fractures with slickensides (possible associated with a minor fault) were observed in the zone about 31 m depth, corresponding to the zone identified in the caliper log and selected as an interval for Packer testing.

It was not possible to determine one way or the other whether there were zones of the core without natural fractures, corresponding to a large matrix block size where penetration of recent high nitrate water may be limited.

4.2 PERMEABILITY

The results of aquifer properties testing indicated that the permeability (hydraulic conductivity) of the chalk matrix was in the anticipated range, about 6 to 8 × 10^{-3} m/d in the upper part of the borehole and declining with depth to 2 × 10^{-3} m/d at the base of the hole (Figure 4.2). Figure 4.3 shows that relationship between the two datasets There is a noticeable fall in permeability below 50 m below the surface corresponding to a series of marl bands. Porosity values are in the range anticipated for the Upper Chalk and decline with depth. For both datasets there are large changes over a small depth interval between 40 and 50 m below the surface.

Packer testing in the saturated zone of the borehole found that the zone to about 10 m below the water table contained the most important flow horizons tested with low values below this (Figure 4.4). Permeabilities were similar to, to those found in the Candover boreholes (Allen et al, 1999) but less variable with permeabilities measured being two or more orders of magnitude greater than the core permeability.

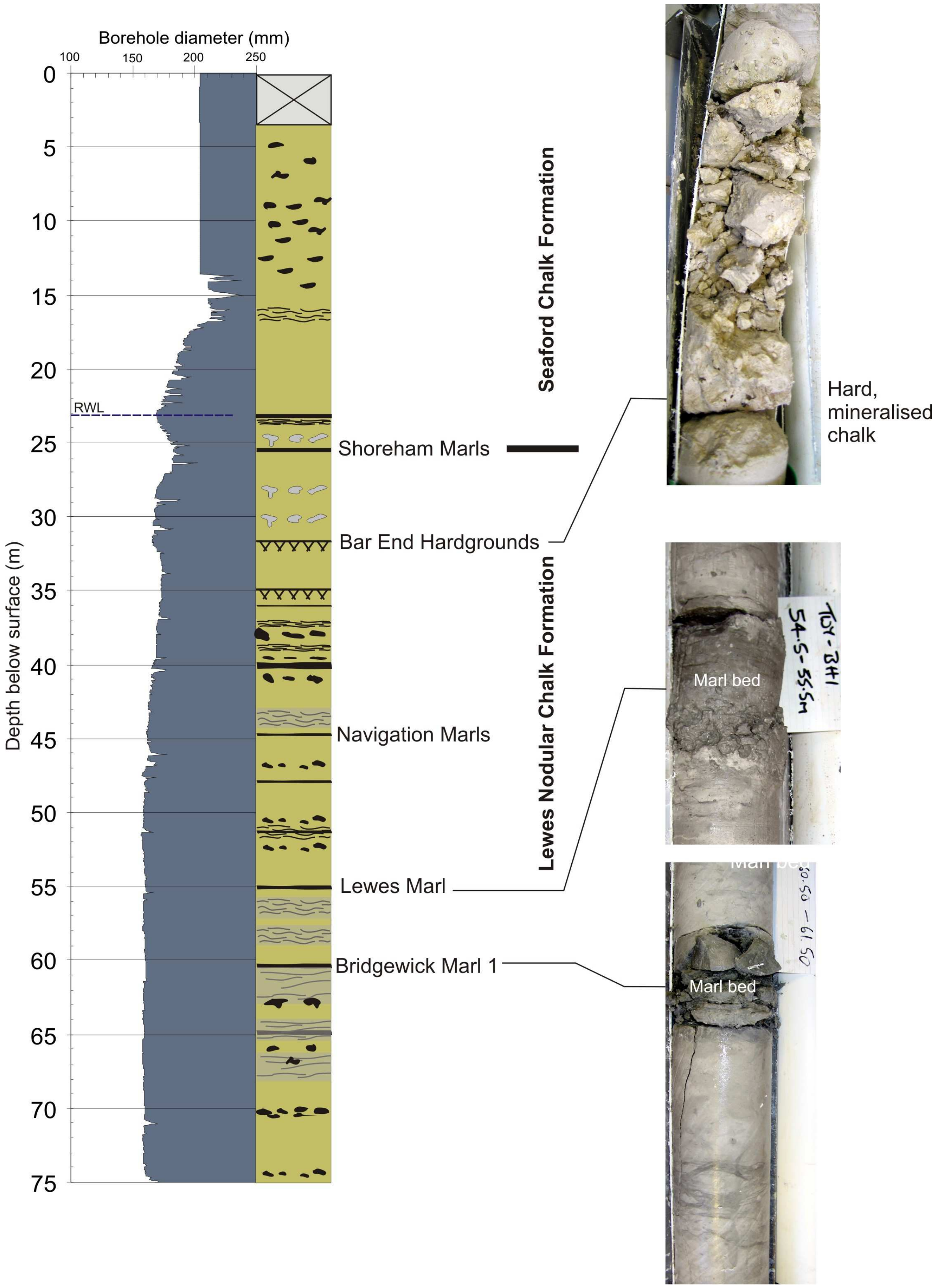

Figure 4.1 Chalk succession of the Morestead Borehole

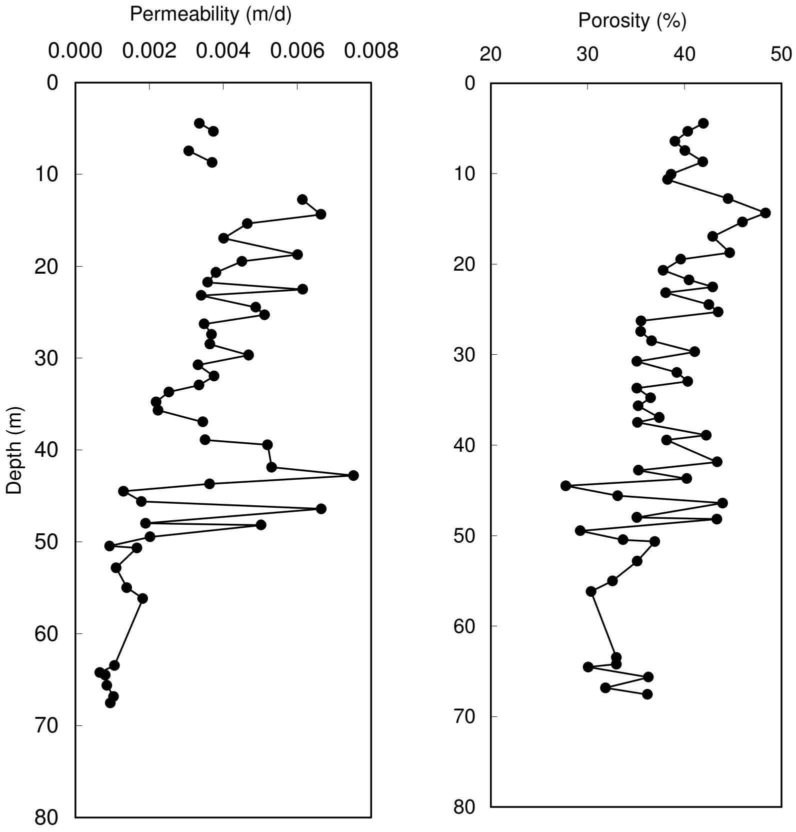

Figure 4.2 Permeability and porosity profiles of the chalk core

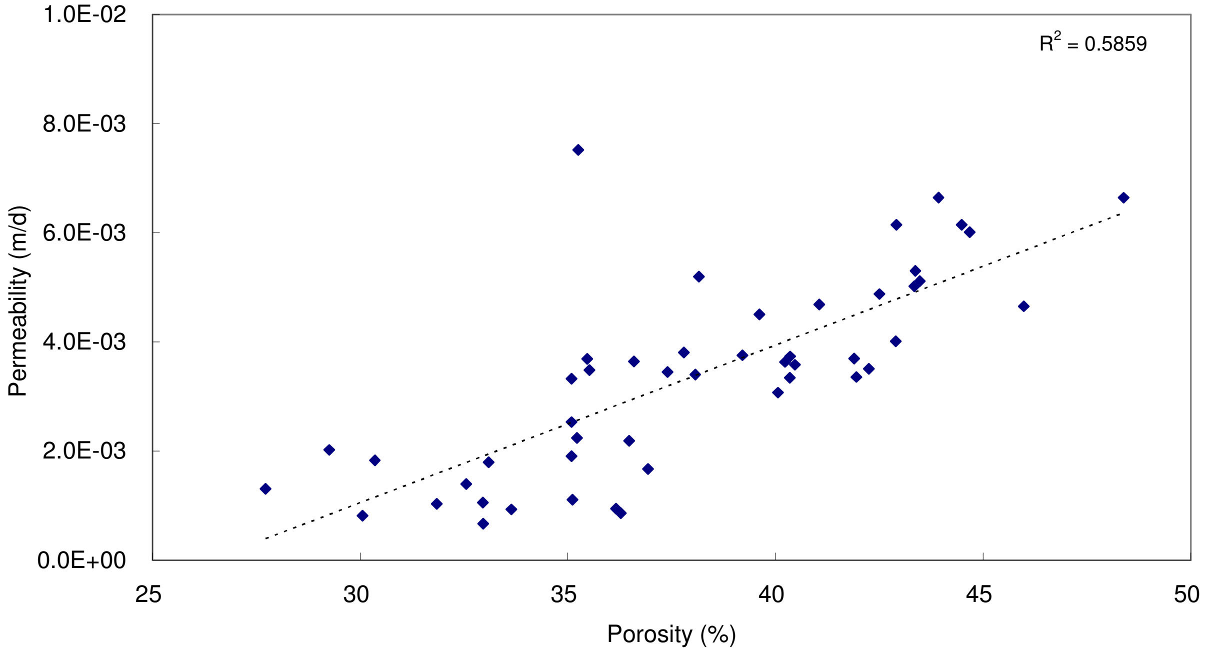

Figure 4.3 Crossplot of permeability and porosity

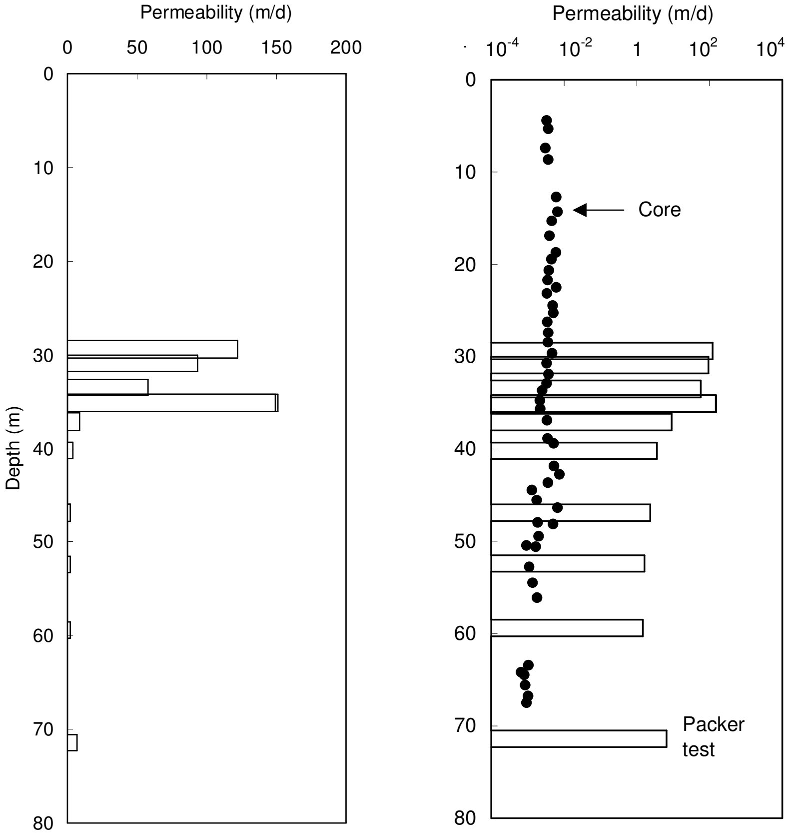

Figure 4.4 Permeability from packer testing and comparison of permeability results from core measurements and packer testing (note log scale)

4.3 WATER QUALITY

4.3.1 Introduction

Groundwater quality varied considerably within the porewaters from the borehole profile. In contrast very similar data were obtained for the packer test discharges. The results are discussed below for nitrate and a series of determinand groups based on their variation within the porewater profile. Factors influencing the geochemical behaviour of individual elements in the Chalk aquifer are summarised from Shand et al. (2007).

4.3.2 Nitrate-N

The porewater profile can be divided into three zones (Figure 4.5):

- above the water table the unsaturated zone shows elevated concentrations up to 16 mg/l;
- in the saturated zone concentrations generally show a steady decline from about 10 mg/l at the water table;
- the lowest concentrations (typically 1) mg/l are found in the zone 52-65 m.

Water from the bowser used for supplying the drilling water mist varied in concentration at different times but was generally about 5 mg/l. Water samples collected during packer testing were all very similar, about 6.3 mg/l.

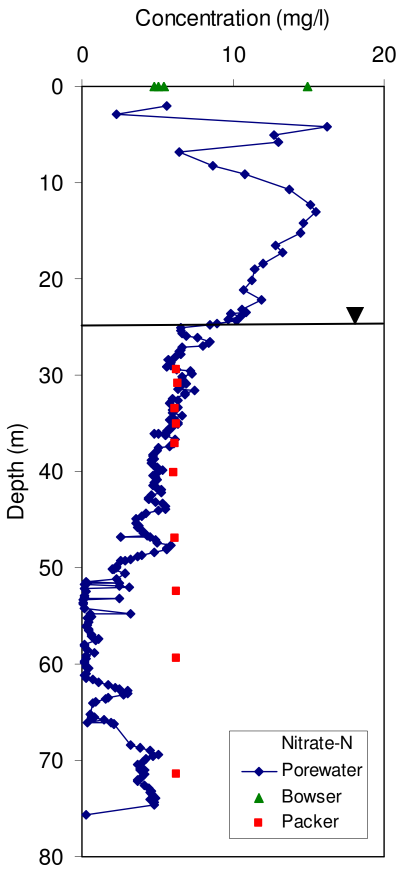

Figure 4.5 Nitrate profile

The porewater profile is consistent with:

- the leaching of nitrate from the surface and held in pore spaces in the unsaturated zone;
- the flushing of nitrate in the permeable zone in the vicinity of the water table with concentrations decreasing with depth to about 50 m below the surface;
- a zone of low permeability, low redox potential or both in the vicinity of the Lewes Marl and the Bridgewick Marl 1 resulting in very low concentrations;
- lateral transmission of water/aerobic conditions towards the base of the borehole.

The unsaturated zone distribution was similar in conformation to that observed at Bridgets Farm beneath ley (grazing land) in 1994 (Coleby et al, 1998) although much lower in concentration. Concentrations of similar magnitude but of much more spiky and irregular distribution beneath cereals and ley at Bridgets Farm were reported by Young et al in 1976.

4.3.3 Major ions

Profiles for calcium, sodium, chloride and bicarbonate were very similar in shape, with elevated concentrations in the unsaturated zone and a steady reduction in concentration in the saturated (Figure 4.6). Calcium and bicarbonate both had pronounced low concentrations at about 54.3 and 60.3 m depth.

Concentrations in the bowser water and the packer samples were in the same range as the porewater. The agreement between porewater concentration and packer testing water was better for Cl than for Na or Ca.

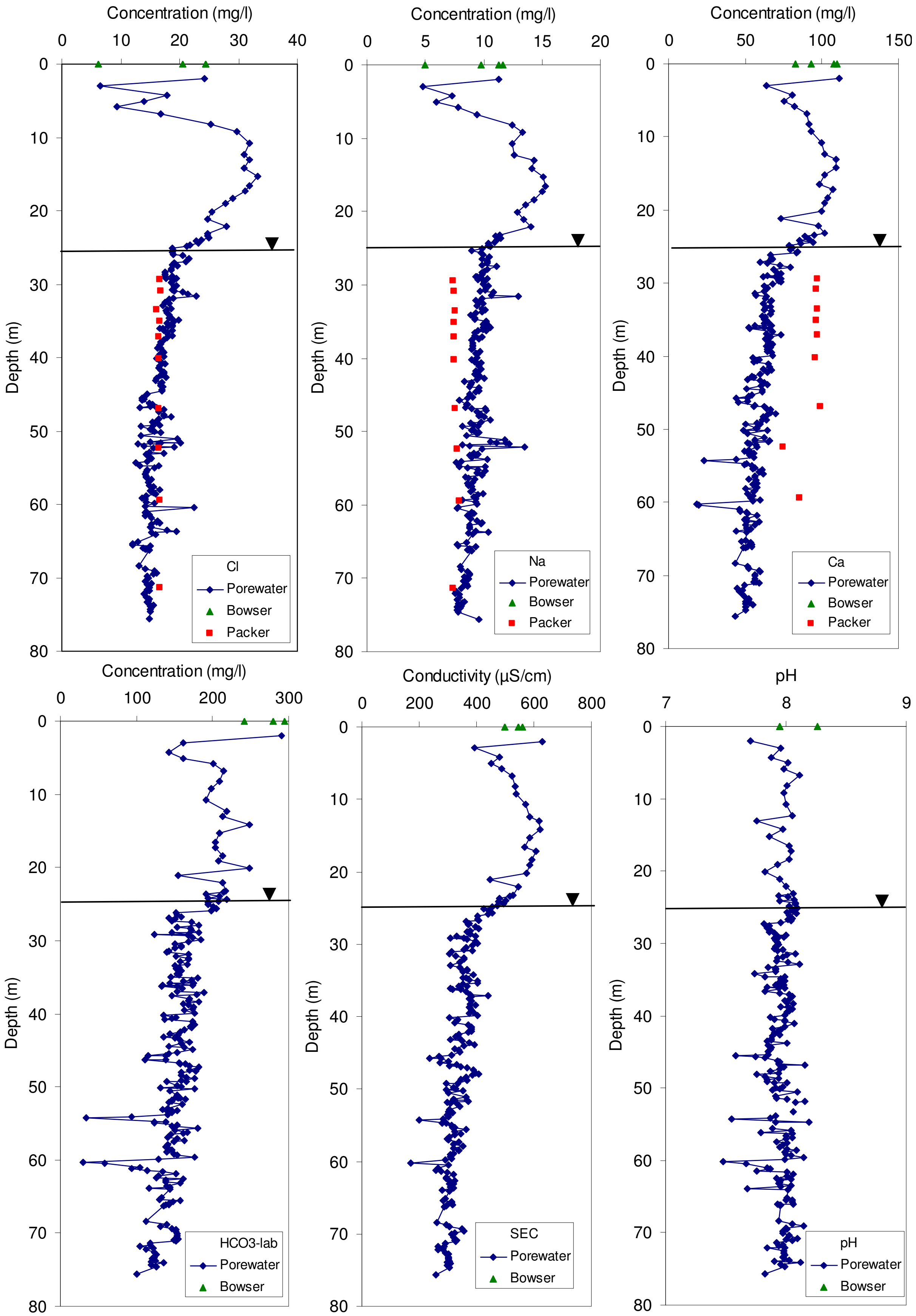

Figure 4.6 Profiles of chloride, sodium, calcium, bicarbonate, conductivity and pH

In general Ca concentrations in the Chalk are controlled by equilibration with calcite. At this site they are probably almost all saturated with respect to calcite. Calculation of the calcite saturation index suggests oversaturation but this is likely to be an artefact of the loss of carbon dioxide during porewater extraction. The Na concentration distribution is fairly normal for unconfined chalk. It demonstrates the influence of maritime rainfall (8 mg/l). Higher concentrations are usually observed in confined zones where ion exchange has occurred and Na has been released. The Cl concentration is influenced by the concentration in modern rainfall (15 mg/l). Bicarbonate concentrations in Chalk groundwater usually reflect the strong buffering of groundwater due to rapid saturation with respect to calcite.

The negative peaks for Ca and bicarbonate suggest that there may be water of a different type migrating along the top of the marl bands at 54 and 60 m. This water is unsaturated with respect to calcite.

4.3.4 Sulphate, potassium and rubidium

These ions all show a broad peak in the unsaturated zone and a spiky peak in the saturated zone, mainly between 50 and 65 m depth (Figure 4.7). In general, sulphate can be derived from atmospheric sources (16 mg/l) or from sulphide minerals in the Chalk, such as pyrite or marcasite. Potassium may be derived from fertilisers, from mixing with saline water or from clays. Rubidium is a constituent of potassium-bearing minerals and is strongly sorbed on clay surfaces.

The distribution of these elements below the top few metres is similar to that of nitrate in the unsaturated zone and upper saturated zone and suggests a fertiliser origin but in the marl band area these ions may be associated with the clay minerals in the marl bands.

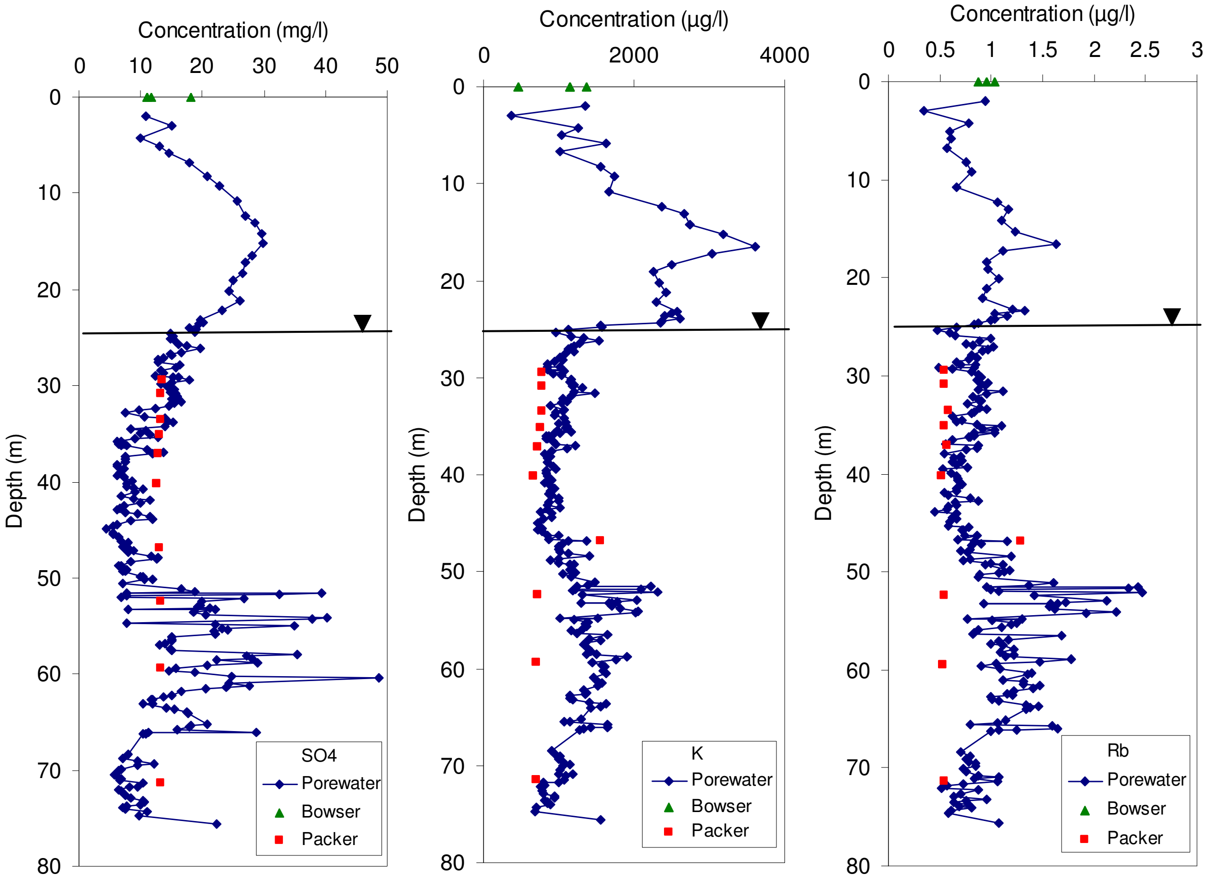

Figure 4.7 Profiles of sulphate, potassium and rubidium

4.3.5 Bromide and trace metals

Concentrations of Br, Co, Mo Sb and U are low throughout the profile with the exception of the clay-rich horizon at 52-65 m depth (Figure 4.8). The increases at this depth are most likely associated with release by desorption and dissolution from clay minerals, metal oxides and organic matter which are more concentrated in marl horizons. Concentrations of these elements in the packer samples are low throughout other than an elevated Pb concentration at about 38 m and a Co peak at the base of the hole.

Bromide is often associated with chloride or derived from organic sources. Co is usually associated with ferromagnesian minerals. The highest concentrations are often found associated with iron and manganese oxides implying reductive dissolution. Mo is usually associated with oxidising groundwater and is sorbed by oxides and clays. Sb may be derived from sulphide deposits, pollution or ferric hydroxides. U is broadly soluble under oxidising conditions and can form complexes with sulphate and chloride. It is generally low in all limestone aquifers other than those heavily impacted by NPK fertilisers.

The profiles for Pb and W differ from the others in that they show peaks in the range 40 to 50 m depth as well as isolated peaks below this (Figure 4.9). Pb can be associated with K feldspars and micas, limited by sorption onto clays, organic matter and oxyhydroxides. W often associated with Sn. Dissolved concentrations would be expected to be very low in the chalk and these results may be suspect.

4.3.6 Indicators of reducing conditions

Fe has variable but low concentrations throughout the profile (Figure 4.10). The packer samples are similar. The highest porewater concentration is at about 66 m. There is an anomalously high packer sample concentration in the bottom test interval. Concentrations in the bowser water are all low. The pattern for Mn is different with variable concentrations up to 20 µg/l in the unsaturated zone, a large and possibly suspect spike at 27 m and very low concentrations below this. Since the porewater samples were extracted by centrifugation under oxic conditions any dissolved Fe and Mn could have been precipitated out during processing.

In general, sources of Fe are likely to be oxyhydroxides, pyrite/marcasite and possibly from the chalk matrix. Mn oxides are very efficient scavengers of Co, Fe, and Ni, and also As, Ba, Cu, Pb and Zn. It is possible for very high concentrations to occur in Mn dendrites on Chalk fracture surfaces. The source of Mn would be anticipated to be the chalk matrix.

At the pH value of Chalk groundwater elevated concentrations of iron and manganese are associated with reducing conditions. However, the distribution of these elements is not consistent with reducing water being present in the marlband zone, although it is possible that any dissolved Fe and Mn could have precipitated out during core processing.

4.3.7 Anion-forming trace elements and copper

These elements show similar profiles with peaks all the way down the profile, large peaks close to the surface and irregular spikes in the saturated zone (Figure 4.11). For all four elements the concentrations in the packer samples was generally lower than the porewaters. For Al and Sn elevated concentrations in packer samples are seen in the upper part of the saturated zone. Concentrations in the drilling water were very low for Al, Cu and Cr. In general Al in Chalk groundwater is generally derived from aluminosilicate minerals, although the solubility of Al minerals is low at neutral pH and Al may possibly be present in extracted porewater in colloidal form.

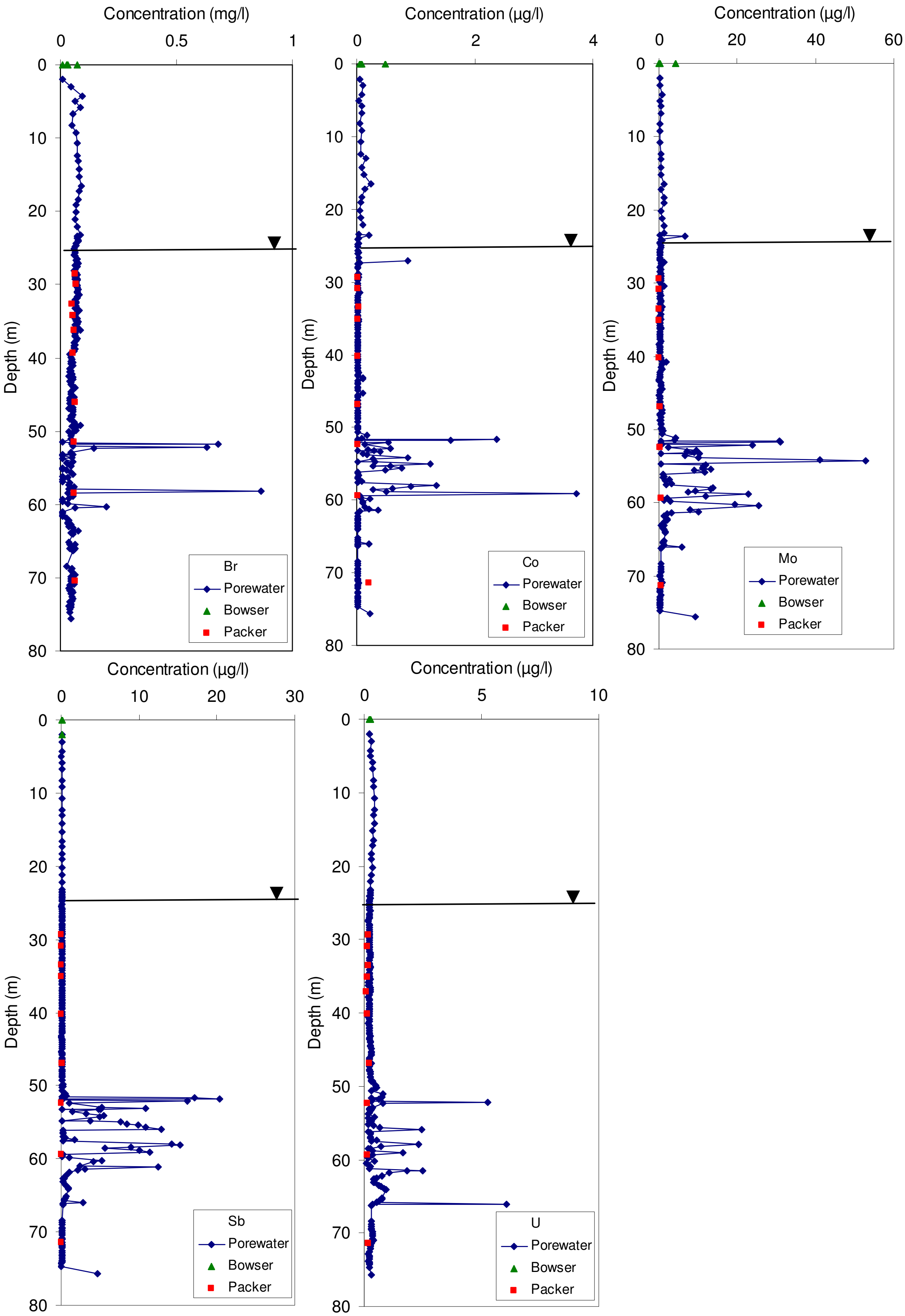

Figure 4.8 Profiles for bromide and trace metals which are found mainly below 50 m

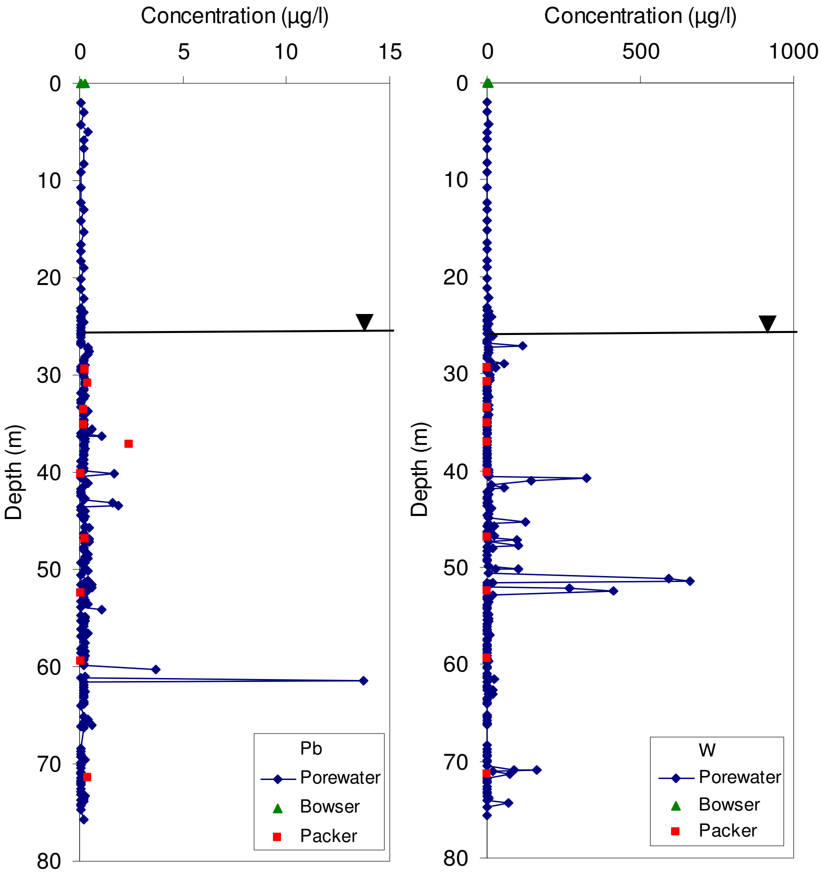

Figure 4.9 Profiles for lead and tungsten which are found below 40 m

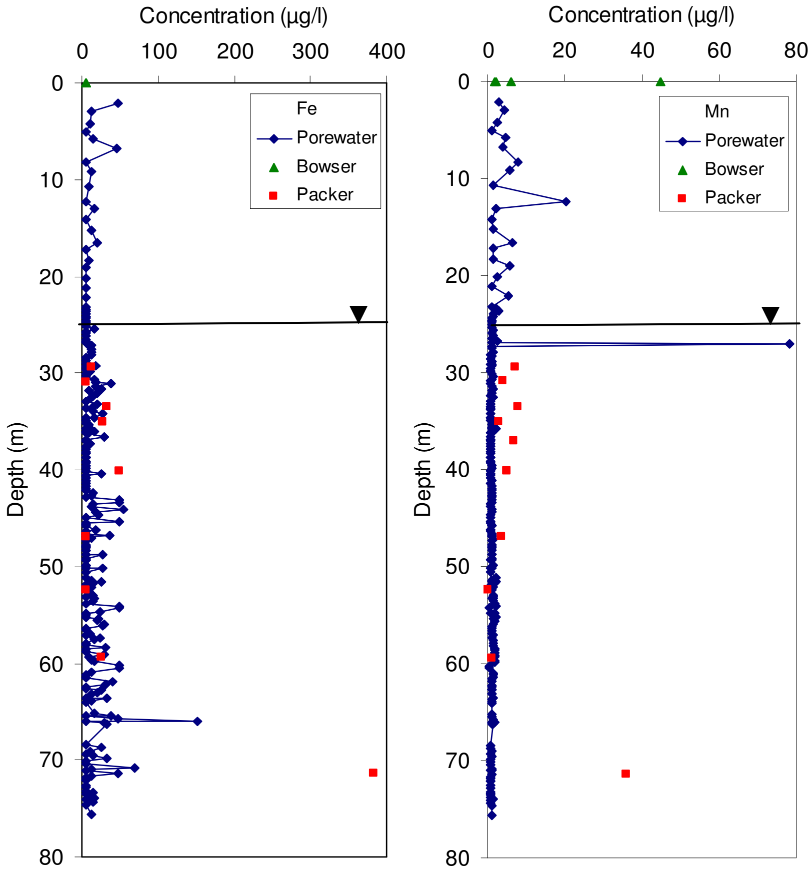

Figure 4.10 Profiles for iron and manganese

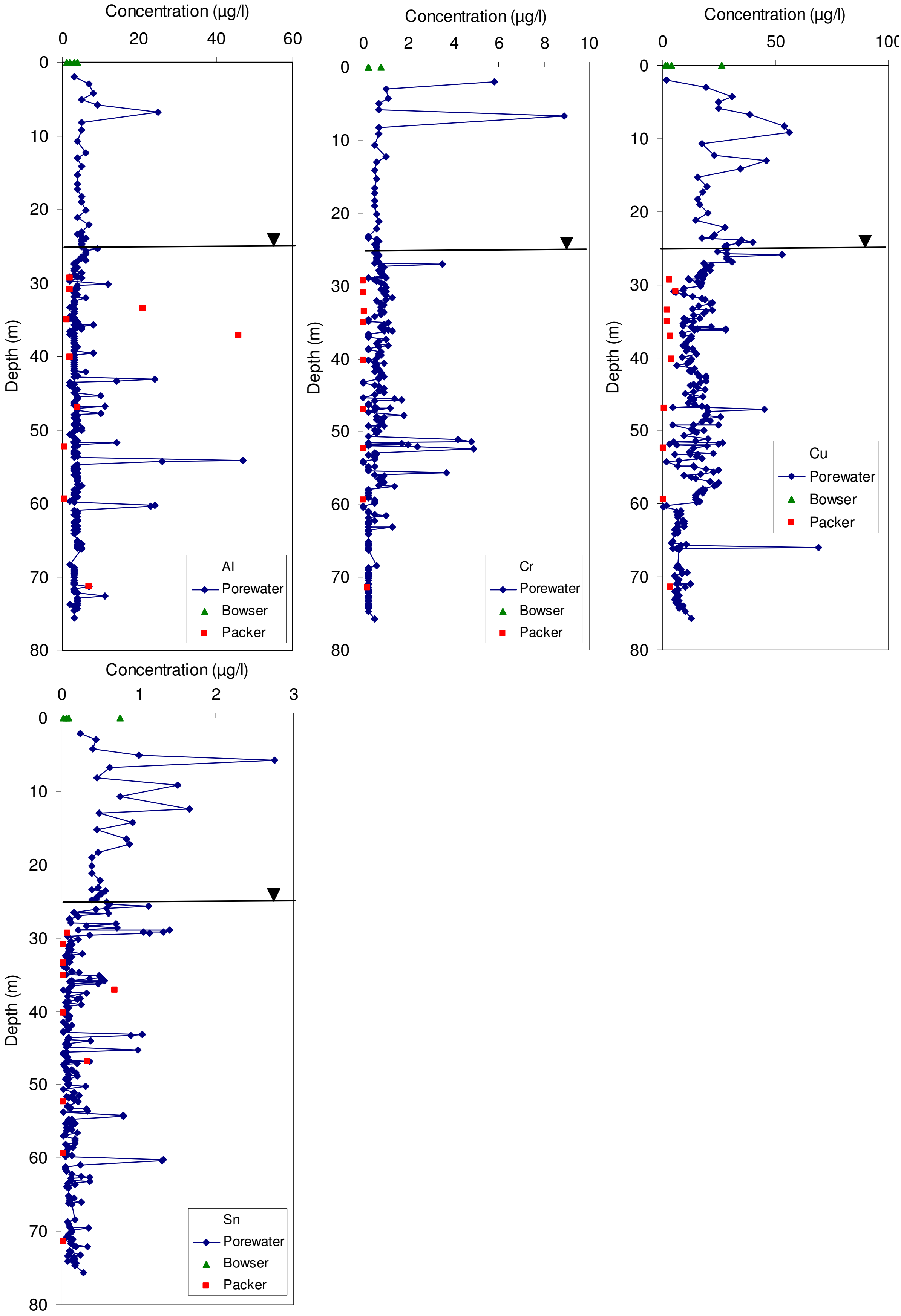

Figure 4.11 Profiles of aluminium, chromium, copper and tin

4.3.8 Trace elements often used as residence time indicators

The elements in Figure 4.12 have very similar shaped profiles with low concentrations on the unsaturated zone and a broad peak between 52 and 65 m depth. In all cases the packer samples have lower concentrations than the porewaters and are similar to the bowser water.

Fluoride in chalk groundwater is normally assumed to be derived from fluoroapatite in hard bands or marl horizons. Lithium and Si are probably derived from clay minerals. Si may also be derived from flint. Lithium and F can be considered to be a residence time indicators. Concentrations of Sr are generally controlled by carbonate reactions (incongruent dissolution) and the Sr/Ca ratio increases with residence time.

4.3.9 Other trace elements

The profiles for Ba, B and Mg have two broad peaks, one in the unsaturated zone and one between 50 and 60 m below the surface (Figure 4.13). Phosphorus is detected only close to the surface, with only two isolated positive detections around 45 m depth and Zn is present at higher concentrations in the saturated zone compared to the unsaturated zone.

In general Ba may be derived from clay minerals or possibly from detrital barite. Boron is enriched in clays and iron oxides, seawater and anthropogenic sources such as WTW effluent and fertilisers. Mg is affected by incongruent dissolution of calcite along flow paths which can lead to a higher Ca/Mg ratio. Phosphorus is derived from both natural and anthropogenic sources. Dominant natural sources are apatite and P sorbed on iron oxides. In chalk the source is likely to be fluoroapatite in hardgrounds. The high concentration in the uppermost sample may be due to anthropogenic inputs. Anthropogenic sources include organic and inorganic fertilisers, WTW effluent and slurry. Phosphorus is often present in particulate or colloidal form. Zinc is a common trace constituent of Chalk and is higher in clays and shales.

4.3.10 Chlorofluorocarbon residence time indicators

The concentrations of CFCs and SF_6 in the packer test water are consistent with the presence of modern water. Concentrations of CFCs are above modern levels indicating contamination (Figure 4.14). Concentrations of SF_6 fluctuate from the equivalent of about 75% modern water at the top to zero at the base of the hole. It is likely that the results have been affected by the ingress of drilling water with a modern signature.

4.3.11 Stable isotopes of water

Results were only available for a short section of the borehole at the top of the saturated zone (Figure 4.14). These indicated that the water composition lies close to the meteoric line (Figure 4.15). It is likely that the results have been affected by the ingress of drilling water.

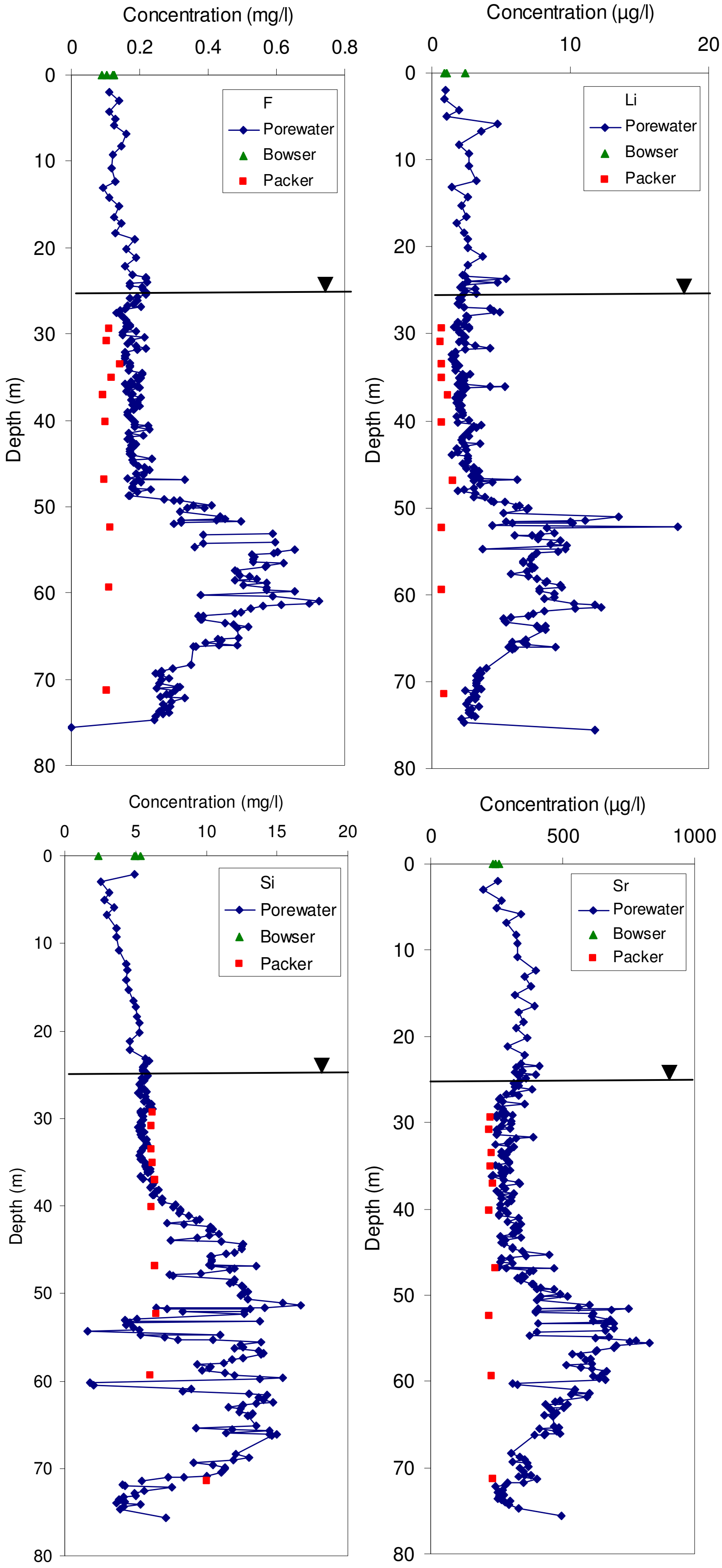

Figure 4.12 Profiles for fluoride, lithium, silicon and strontium

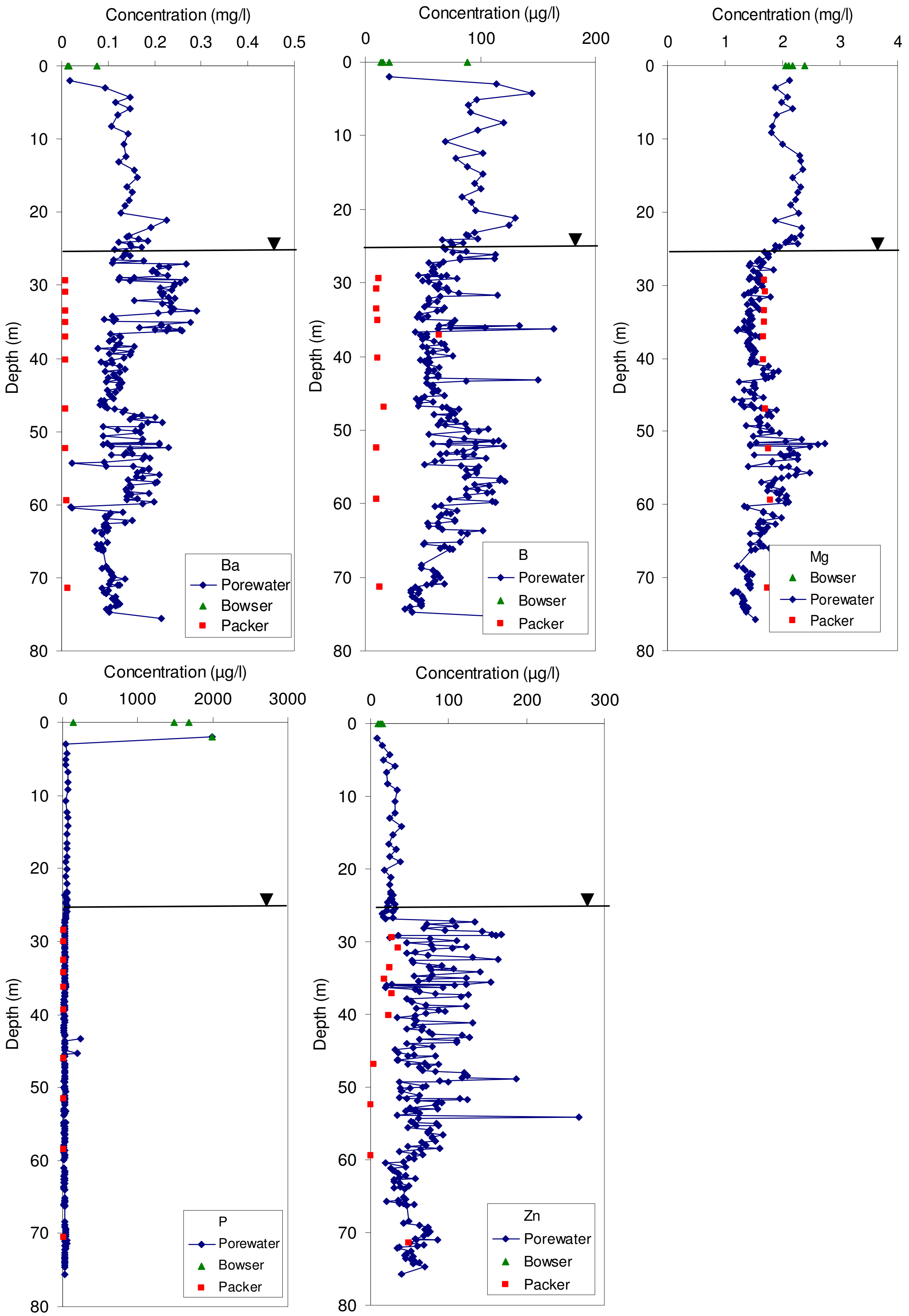

Figure 4.13 Profiles for barium, boron, magnesium, phosphorus and zinc

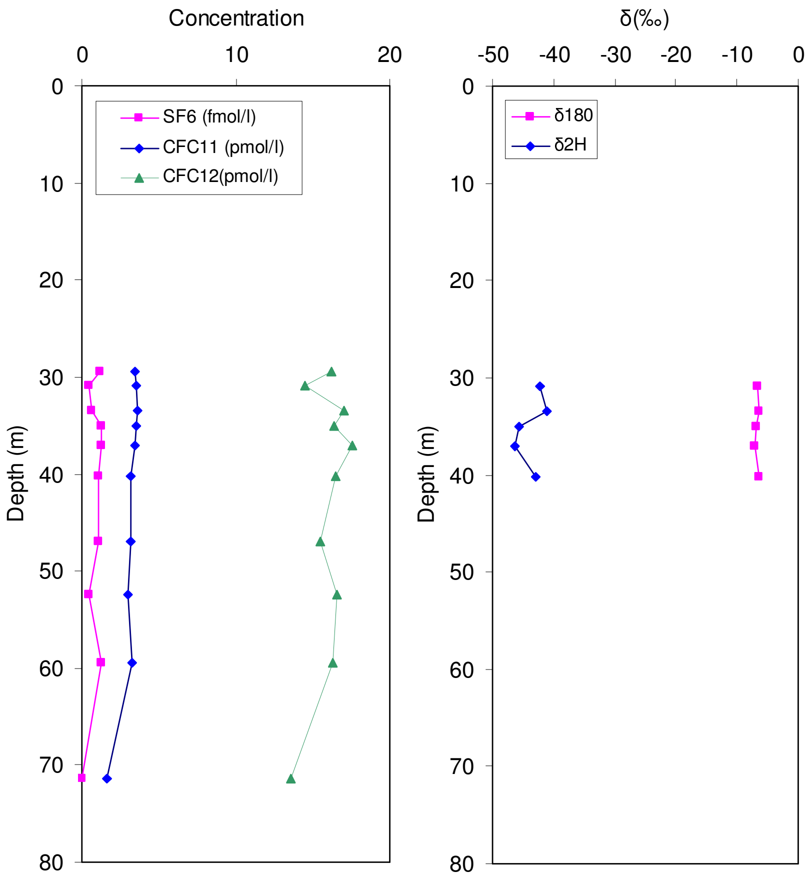

Figure 4.14 Packer test profiles for residence time indicators and OH isotopes

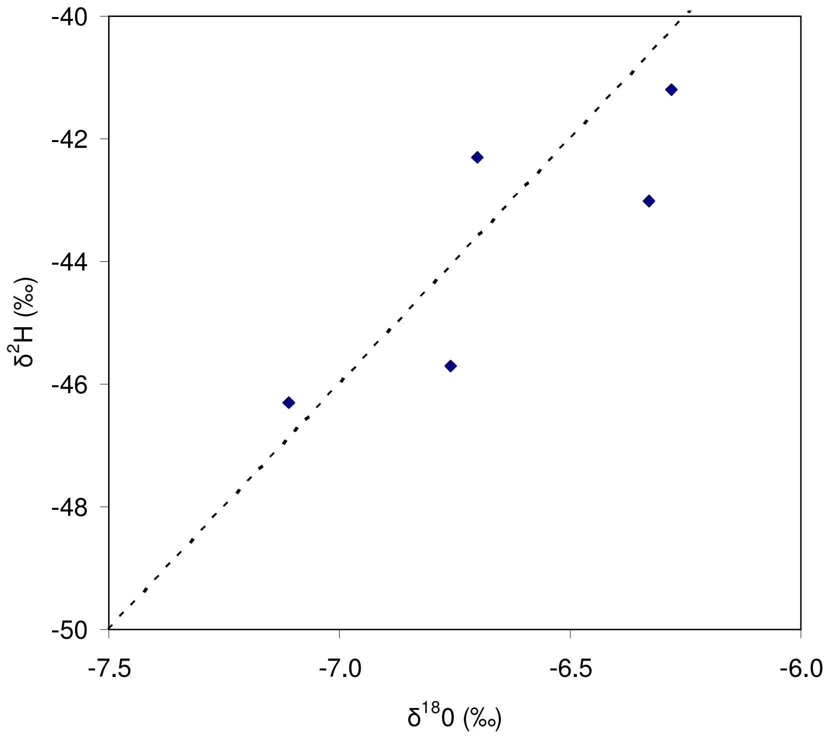

Figure 4.15 Plot of OH isotopes in packer test water relative to the meteoric line

5 Qualitative discussion of results

5.1 NITROGEN INPUTS AT THE BASE OF THE SOIL

Landuse at the site has been consistent over the recorded period (since 1992), with an average of 150-160 kg/ha of nitrogen applied in fertilisers each year since 1999. Under these conditions an average leaching loss in the order of 40 kg/ha might be anticipated (Beaudoin et al., 2005; Grylls et al., 1997; Webster et al., 1999) Assuming an effective rainfall of 250 mm this would correspond to an average concentration in recharge at the site of 16 mg/l N.

5.2 POREWATER PROFILES

5.2.1 Unsaturated Zone

The porewater profiles of the unsaturated zone are typical of profiles measured in areas where the surface landuse leads to a relatively modest peak of nitrate accompanied by chloride, sodium, sulphate, potassium and a very limited suite of trace elements. These ions are likely to be present in artificial fertilisers. Sodium and chloride, and more limited amounts of nitrogen and sulphate are also present in rainfall.

The maximum nitrate-N concentration observed in the unsaturated zone is about 16 mg/l and, if landuse in the catchment were uniform, would represent the maximum limit of the seasonal peak concentration. This in fact corresponds fairly well with the peak concentrations seen in Figure 2.12 (16 mg/l as N is equivalent to about 71 mg/l as nitrate).

5.2.2 Upper saturated zone (30-50 m)

There is a clear change in porewater quality at the water table with a sharp decrease in concentrations of nitrate. In the upper part of the saturated zone concentrations of the major ions decline with depth. The nitrate-N concentration is below 10 mg/l through out this part of the profile and declines to about 5 mg/l at 50 m below the surface. There are small peaks of various trace elements, e.g. W, Sn in this zone.

The water quality in this zone is probably typical of mobile water in the upper, permeable part of the saturated zone and may broadly represent the quality of water abstracted at the pumping station during periods of minimum water level (6 mg/l as N is equivalent to about 27 mg/l as nitrate). The recent minimum concentrations at the pumping station have been in the range 35-40 mg/l nitrate.

5.2.3 Middle saturated zone (50-65 m)

Nitrate concentrations in this zone are very low apart from a peak at about 62 m depth. There is evidence of water with low Ca and bicarbonate concentrations moving along bedding planes or on the surface of marl bands at 52 and 60 m, but these changes are not seen in other elements. Many other solutes, particularly those associated with clay minerals are elevated in this zone. This zone appears to contain immobile water which is sufficiently old to contain only low nitrate and a range of trace elements which may have desorbed from clay minerals and metal oxides.

5.2.4 Lower saturated zone (65-75 m)

Below 65 m the concentration profile of almost all solutes returns to the pattern seen in the upper saturated zone. Concentration of F and Li are slightly elevated. There are a number of anomalous results in the basal sample although the sample has possibly suffered some contamination in the extraction process.

5.3 PACKER TESTING RESULTS

For all analytes there was generally little variation between packer test samples taken at various depths throughout the borehole. Whilst these tests have clearly functioned satisfactorily from a hydraulic properties point of view, they have not produced the desired depth profile of groundwater quality for comparison with the porewater results. The most likely explanation for this is that drilling water was not sufficiently purged from the hole and this was what was being sampled. Packer testing only removes a very small amount of water from the surrounding matrix. A less likely scenario is that at the period of minimum water levels at which the samples were collected the mobile water which is migrating in the fissures is uniform throughout the sampled depth.

5.4 UNAFFECTED BLOCKS AND ROLE OF FRACTURES

Examination of the fracturing of the core did not clearly identify unfractured chalk blocks and the detailed porewater profile collected did not indicate the presence of zones of chalk where the impact of nitrate migrating in the fissures was limited. This may have been due to a lack of suitable fracture distribution or insufficiently closely spaced sampling.

Instead there appeared to be a zone some 15 m thick where there was evidence of the presence of immobile water confined within low permeability marl bands. This appears to be a novel, and unanticipated finding, with little evidence of this type of behaviour from the limited number of other studies of porewater quality in the chalk saturated zone. In Hampshire area, the comprehensive profiling beneath woodland and its edges at Blackwood some 18 km to the north of Twyford was entirely in the unsaturated zone (Kinniburgh and Trafford, 1995). There have also been a series of nitrate profiles measured at Bridgets Farm 9 km to the northwest (Young et al, 1976; Gooddy et al., 1994, Coleby et al. 1998) which also were predominantly in the unsaturated zone, with some penetrating the top few metres of the saturated zone.

6 Conclusions

A new cored borehole was drilled at Morestead, Twyford in an area of set-aside land on the margins of a field normally used for cereals. The borehole was completed to 75 m depth in the former Upper Chalk penetrating about 25 m of the Seaford Chalk Formation and about 50 of the Lewes Nodular Chalk Formation. The water table lay in the Seaford Chalk.

The aims of the work were to obtain porewater and packer test water concentrations which could be used to evaluate the role of diffusive ion exchange between fracture water and pore water in response to changes in the concentration of recharge.

The core obtained was fractured but most of these fractures appeared to be to be parallel to the bedding (e.g. along marl seams) and were probably drilling-induced. Some high-angle fractures with mineralised fracture faces were found in the uppermost 10 m and mineralised fractures with slickensides (possibly associated with a minor fault) were observed at 31 m, a few metres below the water table.

The results from a detailed profile of porewater quality indicate that there do not appear to be any zones of unfractured chalk where porewater has retained pre 1960s concentrations of nitrate. Zones close to major fractures did not show steep nitrate concentration gradients, suggesting that there were not large differences in quality between the fracture water and porewater.

Nitrate porewater concentrations followed a typical profile for chalk overlain by arable land with elevated concentrations (up to 18 mg N/l) in the unsaturated zone and declining concentrations in the saturated zone (up to 9 mg N/l), except in a 15 m thick zone of the Lewes Nodular Chalk about 25 m below the water table. Here a number of marl bands appear to result in a zone of slow-moving water with low nitrate concentration but elevated concentrations of a range of trace elements often associated with clay minerals and residence time.

The results of packer testing of the borehole confirmed that the highest permeabilities were in the zone close to the water table, with low values at depth. It was concluded that marl seams appear to be much more important than fractures in controlling groundwater movement to this borehole. Groundwater samples obtained from packer testing were all of similar composition, interpreted as drilling water which had not been properly flushed from the borehole before the test. The modelling step of the work was therefore not attempted as this required nitrate concentrations in the mobile water in the aquifer.

Nitrate porewater concentrations followed a typical profile for chalk overlain by arable land with elevated concentrations (up to 18 mg/l as N) in the unsaturated zone and declining concentrations in the saturated zone (up to 9 mg/l as N), except in a 15 m thick zone of the Lewes Nodular Chalk about 25 m below the water table. Here a number of marl bands appear to result in a zone of slow-moving water with low nitrate concentration but elevated concentrations of a range of trace elements often associated with clay minerals and residence time.

The unsaturated zone porewater profile indicates nitrate concentrations mainly at and above the current drinking water standard of 50 mg/l nitrate (11.3 mg N/l). Mean nitrate concentrations at Twyford are rising towards 50 mg/l with seasonal peaks exceeding these concentrations. If this is representative of local conditions, and given the significant proportion of similar arable land in the immediate catchment of the Twyford boreholes (as much or more in 2000 as in 1990), then groundwater concentrations are likely to continue rising under the present landuse and agricultural regime. Moreover much of the cultivated land is located in the upper part of the catchment and the nitrate is likely to still be present in the unsaturated and saturated groundwater flow path. Even close to the Twyford borehole, the ‘improved grassland’ may have significant applications of inorganic fertiliser and organic manure. Present conditions do not therefore suggest any immediate reduction of the upward groundwater nitrate trend.

7 References

Most of the references listed below are held in the Library of the British Geological Survey at Keyworth, Nottingham. Copies of the references may be purchased from the Library subject to the current copyright legislation.

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Appendix 1 Tabulated results

Aquifer properties data

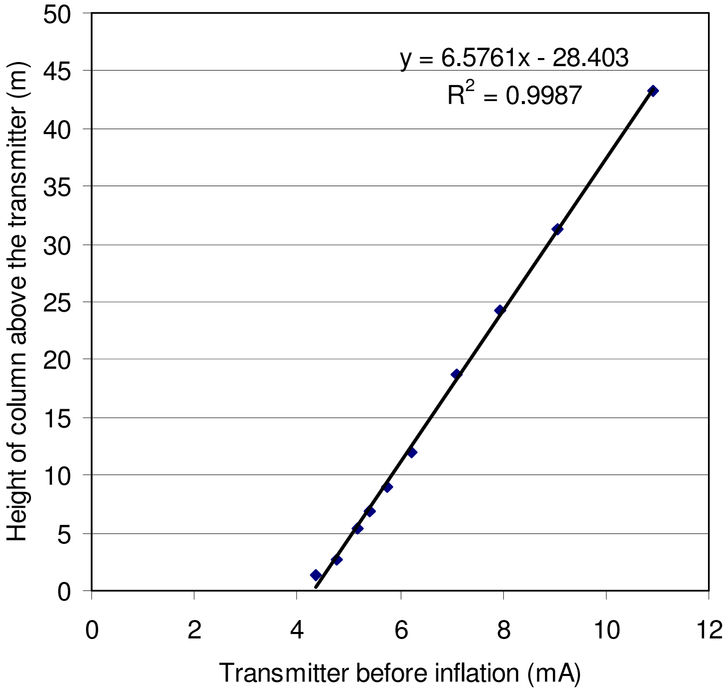
Sample number	Mid depth (m)	Grain density (g/cm3)	Porosity (%)	Gas permeability (mD)	Hydraulic Conductivity, (m/d)
1607/1H		2.65092	44.9		
1607/2H	4.43	2.70452	42.0	5.22	3.36E-03
1607/3H	5.33	2.66835	40.4	5.81	3.73E-03
1607/4H	6.41	2.67402	39.0		
1607/5H	7.45	2.68268	40.1	4.77	3.07E-03
1607/6H	8.70	2.67585	41.9	5.75	3.70E-03
1607/7H	10.08	2.67639	38.6		
1607/8H	10.67	2.68056	38.2		
1607/9H	12.75	2.6706	44.5	9.56	6.15E-03
1607/10H	14.35	2.6853	48.4	10.33	6.64E-03
1607/11H	15.35	2.68728	46.0	7.24	4.65E-03
1607/12H	16.95	2.69113	42.9	6.24	4.01E-03
1607/13H	18.75	2.71677	44.7	9.36	6.02E-03
1607/14H	19.48	2.69301	39.6	7.01	4.51E-03
1607/15H	20.68	2.69313	37.8	5.92	3.81E-03
1607/16H	21.75	2.68521	40.5	5.57	3.58E-03
1607/17H	22.53	2.68334	42.9	9.56	6.15E-03
1607/18H	23.18	2.70162	38.1	5.29	3.40E-03
1607/19H	24.48	2.68878	42.5	7.59	4.88E-03
1607/20H	25.28	2.6897	43.5	7.96	5.11E-03
1607/21H	26.28	2.69266	35.5	5.42	3.48E-03
1607/22H	27.43	2.69101	35.5	5.74	3.69E-03
1607/23H	28.48	2.69233	36.6	5.66	3.64E-03
1607/24H	29.68	2.68397	41.1	7.29	4.69E-03
1607/25H	30.74	2.67748	35.1	5.17	3.32E-03
1607/26H	31.95	2.68378	39.2	5.84	3.75E-03
1607/27H	32.95	2.69291	40.3	5.20	3.34E-03
1607/28H	33.70	2.68711	35.1	3.93	2.53E-03
1607/29H	34.78	2.67341	36.5	3.40	2.19E-03
1607/30H	35.68	2.68709	35.2	3.48	2.24E-03
1607/31H	36.95	2.69312	37.4	5.37	3.45E-03
1607/32H	37.48	2.68889	35.1		
1607/33H	38.90	2.68587	42.3	5.45	3.51E-03
1607/34H	39.45	2.65645	38.2	8.08	5.20E-03
1607/35H	41.88	2.68076	43.4	8.25	5.30E-03
1607/36H	42.79	2.69107	35.3	11.70	7.52E-03
1607/37H	43.70	2.68758	40.2	5.65	3.63E-03
1607/38H	44.52	2.69169	27.7	2.03	1.31E-03
1607/39H	45.60	2.68732	33.1	2.79	1.79E-03
1607/40H	46.42	2.6828	43.9	10.34	6.65E-03
1607/41H	47.99	2.69003	35.1	2.96	1.90E-03
1607/42H	48.18	2.68404	43.3	7.81	5.02E-03
1607/43H	49.48	2.69125	29.3	3.14	2.02E-03
1607/44H	50.47	2.6817	33.6	1.44	9.27E-04
1607/45H	50.65	2.67303	36.9	2.59	1.67E-03
1607/46H	52.83	2.67442	35.1	1.72	1.11E-03
1607/47H	55.00	2.66976	32.6	2.16	1.39E-03
1607/48H	56.17	2.67335	30.4	2.84	1.83E-03
1607/49H	63.47	2.6555	33.0	1.64	1.05E-03
1607/50H	64.23	2.64094	33.0	1.04	6.68E-04
1607/51H	64.53	2.65753	30.1	1.26	8.11E-04
1607/52H	65.64	2.63129	36.3	1.34	8.59E-04
1607/53H	66.83	2.65637	31.8	1.61	1.03E-03
1607/54H	67.55	2.64869	36.2	1.47	9.43E-04

Results of packer testing

	Depth (mbgl)	RWL inside rods	RWL inside annulus	Transmitter (mA)	RWL inside rods	RWL inside annulus	Transmitter (mA)	Inflation pressure (bars)	Final transmitter (mA)	Flow rate (l/min)	Flow rate (l/s)	Initial Transmitter - Final Transmitter	Head Change (m)	Bh radius (m)	K(h) in m/s	K(h) in m/d
1	28.5 to 30.3	24.43	23.3	4.3643	24.4	23.135	4.364	6.5	4.3406	42	0.70	0.0234	0.1539	0.168	0.001417	122.453
2	70.5 to 72.3	24.42	23.34	10.9299	24.455	23.32	10.929	11	10.5063	40	0.67	0.4227	2.7797	0.159	7.59E-05	6.557
3	58.5 to 60.3	24.435	23.39	9.0549	24.42	23.39	9.0564	10	7.2603	38	0.63	1.7961	11.8113	0.16	1.69E-05	1.463
4	51.5 to 53.3	25.43	23.4	7.9585	25.42	23.4	7.9595	9	6.3065	39	0.65	1.653	10.8703	0.158	1.9E-05	1.638
5	46.0 to 47.8	24.95	23.4	7.0912	24.93	23.36	7.0982	8.5	5.954	39	0.65	1.1442	7.5244	0.164	2.71E-05	2.341
6	39.3 to 41.1	24.42	23.42	6.2335	24.39	23.38	6.24	7	5.4907	40	0.67	0.7493	4.9275	0.168	4.22E-05	3.642
7	36.2 to 38.0	24.59	23.42	5.7375	24.61	23.38	5.7362	7	5.4303	41	0.68	0.3059	2.0116	0.172	0.000105	9.083
8a	34.2 to 36.0	26.62	23.43	5.4169	26.62	23.38	5.4153	7	5.3962	42	0.70	0.0191	0.1256	0.173	0.001722	148.774
8b	34.2 to 36.0	26.62	23.43	5.4169	26.79	23.37	5.4134	7	5.3946	42	0.70	0.0188	0.1236	0.173	0.001749	151.148
9	30.0 to 31.8	24.77	23.45	4.7725	24.81	23.33	4.7643	6	4.7328	43	0.72	0.0315	0.2071	0.168	0.001078	93.131
10	32.6 to 34.4	25.18	23.35	5.1752	25.21	23.34	5.1715	6	5.122	42	0.70	0.0495	0.3255	0.172	0.000666	57.501

Packer test calibration

Interval	Depth (mbgl)	Column above transmitter	Transmitter (before inflation)
1	28.5 to 30.3	1.37	4.3643
2	70.5 to 72.3	43.33	10.9299
3	58.5 to 60.3	31.28	9.0549
4	51.5 to 53.3	24.27	7.9585
5	46.0 to 47.8	18.77	7.0912
6	39.3 to 41.1	12.05	6.2335
7	36.2 to 38.0	8.95	5.7375
8a	34.2 to 36.0	6.94	5.4169
8b	34.2 to 36.0	6.94	5.4169
9	30.0 to 31.8	2.72	4.7725
10	32.6 to 34.4	5.42	5.1752



RWL before tests (mbgl) 23.2

Length of test interval (m) 1.8

Transmitter measuring point is 5.07 m below transmitter

Transmitter is 3.83 m above the test interval

Assumed Kh/Kv ratio is 10, thus m = 3.162

All rest water levels are metres below datum. For measurements inside the annulus the datum was the top of casing which was c. 0.1 m above ground level. For the measurements inside the rods the datum was usually the top of the rods (which varied form test to test).

Porewater quality- field data and major and minor elements

Id	Depth (m)	pH-lab	SEC (µS/cm)	Ba (mg/l)	Br (mg/l)	Ca (mg/l)	Cl (mg/l)	F (mg/l)	HCO3-lab (mg/l)	K (mg/l)	Mg (mg/l)	Na (mg/l)	NO_3-N (mg/l)	Si (mg/l)	SO_4 (mg/l)	Sr (mg/l)
S06-00441	2.05	7.70	629	0.018	0.010	111	24.3	0.109	291	1.40	2.13	11.3	5.60	4.95	10.9	0.260
S06-00442	2.95	7.96	393	0.093	0.043	63.8	6.6	0.140	161	0.00	1.88	4.84	2.27	2.55	15.0	0.202
S06-00444	4.25	7.88	480	0.148	0.094	81.1	17.9	0.109	142	1.19	2.09	7.25	16.2	3.12	10.0	0.267
S06-00445	5.05	8.02	452	0.117	0.062	75.5	14.0	0.127	161	1.04	1.99	5.98	12.7	2.78	13.1	0.257
S06-00446	5.83	7.98	486	0.147	0.086	82.4	9.4	0.126	201	1.55	2.18	7.82	13.0	3.47	14.7	0.338
S06-00447	6.75	8.11	525	0.120	0.053	90.1	16.8	0.159	215	1.04	1.89	9.39	6.44	2.97	18.0	0.287
S06-00448	8.25	8.01	533	0.107	0.051	91.8	25.3	0.147	209	1.56	1.83	12.4	8.63	3.66	20.9	0.323
S06-00449	9.20	7.98	540	0.142	0.067	93.1	29.7	0.120	198	1.72	1.81	13.3	10.8	3.63	22.7	0.320
S06-00450	10.75	8.00	572	0.135	0.071	99.6	31.8	0.118	192	1.73	2.00	12.4	13.7	3.79	25.7	0.322
S06-00451	12.35	8.05	584	0.138	0.072	102	30.9	0.127	219	2.30	2.29	12.6	15.1	4.33	26.9	0.397
S06-00452	13.05	7.76	619	0.123	0.076	109	31.9	0.094	213	2.65	2.31	14.3	15.5	4.46	28.6	0.363
S06-00453	14.20	7.97	620	0.157	0.079	109	30.9	0.110	249	2.63	2.35	14.1	14.7	4.33	29.6	0.373
S06-00454	15.25	7.86	584	0.163	0.082	102	33.2	0.138	209	2.98	2.18	15.1	14.5	4.49	29.9	0.327
S06-00455	16.55	8.03	566	0.141	0.089	98.4	31.9	0.124	203	3.55	2.31	15.3	12.8	4.86	28.1	0.401
S06-00456	17.25	8.04	609	0.151	0.081	107	31.2	0.147	204	2.90	2.26	15.0	13.3	5.01	26.9	0.347
S06-00457	18.35	8.03	594	0.146	0.078	104	29.1	0.130	213	2.65	2.22	14.3	12.0	5.13	26.6	0.385
S06-00458	19.05	7.93	584	0.137	0.069	102	27.7	0.187	208	2.41	2.14	13.6	11.4	5.29	25.1	0.345
S06-00459	20.15	7.83	574	0.127	0.069	100	25.4	0.162	248	2.47	2.28	12.9	11.2	5.28	24.3	0.388
S06-00460	21.15	7.95	447	0.226	0.064	73.4	24.8	0.190	155	2.63	1.88	13.4	10.7	4.63	26.2	0.328
S06-00461	22.15	8.00	546	0.191	0.072	97.9	28.0	0.156	213	2.45	2.34	14.0	11.9	4.58	23.2	0.382
S06-00463	23.19	8.06	526	0.145	0.086	102	24.8	0.180	217	2.59	2.31	11.4	10.6	5.71	19.6	0.432
S06-00462	23.41	7.94	517	0.141	0.070	95.1	24.7	0.218	214	2.59	2.16	11.0	10.9	5.96	20.1	0.352
S06-00464	23.62	8.02	480	0.165	0.074	88.6	25.0	0.219	191	2.40	2.21	11.5	9.85	5.78	19.4	0.344
S06-00465	23.95	8.07	501	0.186	0.077	91.4	23.8	0.220	209	2.57	2.11	11.1	10.5	5.65	18.0	0.361
S06-00466	24.16	7.95	476	0.122	0.076	85.2	22.8	0.171	194	2.37	2.06	10.9	9.64	5.53	19.0	0.326
S06-00467	24.37	8.08	495	0.148	0.067	94.1	23.2	0.171	219	2.40	2.26	10.4	10.2	5.52	18.8	0.420
S06-00468	24.63	8.08	473	0.149	0.067	86.4	21.7	0.206	208	1.69	1.88	10.4	8.94	5.55	14.9	0.343
S06-00469	24.80	8.03	455	0.171	0.061	78.7	21.3	0.210	194	1.69	1.95	10.6	8.48	5.78	15.2	0.375
S06-00470	25.12	8.10	426	0.114	0.057	80.7	18.8	0.217	194	1.30	1.86	9.84	6.54	5.85	14.9	0.373
S06-00471	25.41	8.05	444	0.139	0.061	79.5	18.9	0.219	201	1.08	1.69	8.96	6.50	5.48	15.6	0.329
S06-00472	25.70	8.01	454	0.136	0.063	84.1	18.8	0.192	205	1.31	1.76	9.76	6.63	5.59	16.2	0.341
S06-00473	25.91	8.09	439	0.148	0.059	83.7	19.0	0.173	198	1.47	1.74	9.99	6.89	5.40	17.5	0.326
S06-00474	26.13	8.03	403	0.131	0.064	66.8	20.6	0.194	152	1.56	1.76	10.5	7.66	5.29	19.8	0.381
S06-00475	26.51	8.05	405	0.112	0.072	66.9	21.6	0.181	154	1.36	1.59	9.87	8.48	5.47	16.6	0.318
S06-00476	26.70	8.02	407	0.176	0.066	68.2	21.4	0.163	159	1.34	1.57	10.3	8.37	5.59	14.9	0.290
S06-00477	26.90	8.04	364	0.109	0.071	66.8	21.1	0.205	142	1.30	1.67	10.3	7.98	5.75	15.0	0.355
S06-00478	27.08	7.96	375	0.268	0.076	60.0	19.1	0.156	150	1.18	1.43	10.3	6.61	5.18	13.8	0.275
S06-00479	27.34	7.82	370	0.210	0.062	64.2	18.7	0.144	146	1.26	1.42	9.89	6.52	5.40	12.9	0.270
S06-00480	27.52	7.86	396	0.231	0.071	72.3	19.7	0.131	172	1.30	1.61	11.1	6.44	5.73	12.8	0.309
S06-00481	27.89	7.84	407	0.196	0.062	79.6	18.5	0.147	182	1.19	1.84	10.3	6.57	5.82	16.4	0.382
S06-00482	28.12	7.87	379	0.195	0.060	68.6	18.6	0.155	153	1.21	1.49	10.0	6.15	5.65	15.7	0.268
S06-00483	28.37	7.86	367	0.206	0.066	69.6	17.5	0.162	171	1.11	1.56	9.91	5.68	6.11	13.3	0.299
S06-00484	28.64	7.90	379	0.227	0.072	73.1	17.5	0.162	172	0.98	1.59	9.85	5.94	5.93	13.7	0.294
S06-00485	28.94	7.92	395	0.156	0.065	70.5	17.5	0.167	182	1.02	1.62	9.35	5.92	6.22	12.3	0.316
S06-00488	28.94	8.00	330	0.125	0.068	64.5	18.8	0.172	147	0.99	1.44	9.46	5.94	5.97	12.4	0.270
S06-00486	29.19	7.94	355	0.266	0.071	69.6	17.7	0.162	169	1.18	1.55	10.3	5.61	5.65	15.2	0.287
S06-00489	29.19	7.98	310	0.123	0.065	61.5	19.5	0.172	123	1.17	1.42	9.90	5.60	5.40	16.1	0.261
S06-00487	29.36	7.90	366	0.147	0.071	73.5	18.7	0.162	168	1.17	1.66	9.50	6.31	5.35	18.0	0.327
S06-00490	29.63	7.91	396	0.255	0.069	72.2	18.8	0.188	174	1.07	1.58	10.0	7.23	5.42	15.0	0.286
S06-00491	29.82	7.93	404	0.244	0.066	73.6	18.6	0.149	185	1.09	1.63	9.99	7.29	5.53	13.3	0.298
S06-00492	30.16	7.94	386	0.240	0.074	68.0	19.4	0.150	169	1.21	1.65	10.4	6.61	5.53	14.4	0.308
S06-00502	30.42	7.91	363	0.211	0.071	62.7	19.1	0.216	150	1.25	1.52	10.2	6.64	5.34	15.5	0.293
S06-00503	30.72	7.90	357	0.237	0.075	64.6	18.8	0.175	159	1.25	1.53	10.1	6.51	5.44	14.9	0.303
S06-00504	30.90	7.97	387	0.213	0.072	63.6	19.1	0.174	159	1.25	1.45	9.73	6.87	5.42	15.7	0.266
S06-00505	31.06	7.93	313	0.218	0.071	62.7	20.5	0.163	150	1.40	1.41	10.8	6.65	5.23	16.0	0.272
S06-00506	31.40	8.08	307	0.216	0.079	56.4	21.5	0.189	142	1.26	1.33	10.7	6.35	5.25	15.0	0.262
S06-00507	31.63	8.01	329	0.231	0.073	57.0	22.8	0.217	140	1.52	1.79	13.0	7.42	5.65	16.7	0.393
S06-00508	31.85	7.97	357	0.244	0.074	63.9	18.9	0.193	169	1.21	1.59	9.90	6.84	5.38	15.4	0.322
S06-00509	32.10	7.93	358	0.157	0.064	63.4	18.3	0.156	152	1.09	1.46	9.29	6.85	5.42	14.7	0.323
S06-00510	32.42	7.92	340	0.234	0.069	67.3	17.6	0.160	169	1.22	1.49	9.61	5.96	5.78	12.4	0.306
S06-00511	32.56	8.02	341	0.217	0.069	66.5	18.2	0.158	168	1.13	1.39	9.99	6.33	5.72	9.63	0.253
S06-00512	32.90	8.11	310	0.234	0.066	61.9	17.2	0.158	157	1.03	1.55	9.39	5.82	5.78	7.63	0.348

Id	Depth (m)	pH-lab	SEC (µS/cm)	Ba (mg/l)	Br (mg/l)	Ca (mg/l)	Cl (mg/l)	F (mg/l)	HCO3-lab (mg/l)	K (mg/l)	Mg (mg/l)	Na (mg/l)	NO$_3$-N (mg/l)	Si (mg/l)	SO$_4$ (mg/l)	Sr (mg/l)
S06-00513	33.29	7.85	342	0.241	0.063	66.8	18.6	0.152	167	1.20	1.59	9.89	6.34	5.97	10.6	0.310
S06-00514	33.46	7.91	366	0.291	0.082	62.8	17.9	0.172	151	1.14	1.44	10.10	6.23	5.55	14.0	0.286
S06-00515	33.65	7.91	366	0.235	0.075	62.6	17.7	0.171	156	1.04	1.40	9.85	6.02	5.47	14.4	0.288
S06-00516	33.86	7.91	353	0.207	0.071	67.3	17.8	0.172	152	1.01	1.41	9.33	6.02	5.34	15.3	0.274
S06-00517	34.18	7.74	388	0.109	0.061	66.7	18.2	0.169	159	1.09	1.46	8.92	6.60	5.27	13.9	0.284
S06-00518	34.59	7.83	353	0.115	0.071	60.8	18.2	0.207	154	1.15	1.43	9.26	5.85	5.48	8.40	0.285
S06-00519	34.69	7.99	362	0.093	0.062	63.3	18.7	0.207	156	1.06	1.48	9.26	6.20	5.35	10.8	0.296
S06-00520	34.96	7.96	373	0.112	0.068	62.3	19.9	0.190	145	1.23	1.33	10.20	6.38	5.63	10.0	0.253
S06-00493	35.13	7.99	404	0.276	0.075	63.9	19.0	0.204	180	1.14	1.41	10.20	6.40	5.68	11.4	0.256
S06-00494	35.39	7.95	402	0.214	0.074	65.1	17.9	0.197	172	1.04	1.42	9.93	5.97	5.74	12.8	0.294
S06-00495	35.57	7.96	352	0.215	0.064	62.3	18.7	0.174	161	1.27	1.47	10.40	5.85	5.71	9.06	0.315
S06-00496	35.80	7.98	369	0.167	0.071	67.3	18.1	0.158	175	1.02	1.43	9.96	5.62	5.82	6.14	0.278
S06-00499	35.80	7.91	339	0.230	0.067	56.4	18.7	0.178	144	1.08	1.34	10.60	5.70	6.01	6.78	0.286
S06-00497	36.04	7.95	347	0.254	0.064	62.7	16.7	0.165	174	0.91	1.36	9.99	5.05	5.87	6.51	0.279
S06-00500	36.04	7.84	310	0.202	0.061	52.4	17.2	0.192	134	0.98	1.22	9.98	4.83	6.04	7.29	0.270
S06-00498	36.25	7.94	345	0.226	0.070	66.0	17.3	0.167	153	0.87	1.40	9.48	5.51	5.86	6.93	0.283
S06-00501	36.25	7.99	317	0.259	0.084	53.1	18.7	0.199	133	0.94	1.21	10.20	5.53	5.84	7.65	0.247
S06-00521	36.60	7.83	365	0.105	0.064	67.6	17.9	0.162	160	1.01	1.44	9.23	6.21	5.36	11.1	0.275
S06-00522	36.90	7.95	378	0.125	0.062	63.9	18.1	0.179	153	1.03	1.52	9.28	6.05	5.49	13.8	0.326
S06-00523	37.08	8.03	439	0.127	0.062	73.0	18.7	0.174	189	1.32	1.59	9.84	6.08	6.12	12.0	0.353
S06-00524	37.33	8.05	381	0.112	0.070	66.8	17.9	0.202	179	1.25	1.43	9.63	5.78	6.29	7.49	0.295
S06-00525	37.59	8.04	374	0.103	0.066	63.1	17.3	0.176	147	1.06	1.40	9.02	5.07	6.25	7.42	0.299
S06-00526	37.89	7.99	383	0.126	0.058	64.9	16.9	0.194	170	0.93	1.38	9.06	4.97	6.03	7.57	0.272
S06-00527	38.21	8.01	378	0.118	0.062	65.0	16.9	0.179	168	0.97	1.43	9.06	4.72	6.67	6.11	0.327
S06-00528	38.34	8.07	395	0.157	0.060	67.8	16.7	0.199	182	0.95	1.41	9.04	4.72	6.49	6.12	0.282
S06-00529	38.71	8.02	373	0.078	0.057	64.1	16.8	0.184	161	0.96	1.49	9.06	4.76	6.23	7.40	0.329
S06-00530	38.79	7.96	377	0.112	0.065	66.5	16.3	0.181	169	1.00	1.44	8.94	4.62	6.32	7.13	0.296
S06-00531	39.13	8.05	382	0.150	0.057	64.4	17.1	0.163	175	1.06	1.52	9.70	4.60	6.91	6.65	0.329
S06-00532	39.36	8.03	390	0.103	0.050	64.8	17.3	0.163	174	1.05	1.50	9.35	4.80	6.85	6.16	0.303
S06-00533	39.55	8.01	376	0.148	0.041	67.2	16.7	0.168	163	0.95	1.49	9.46	4.99	6.88	7.29	0.288
S06-00534	39.92	7.99	402	0.133	0.047	67.6	17.4	0.180	176	0.94	1.48	9.43	5.33	7.87	8.72	0.279
S06-00535	40.19	7.87	306	0.108	0.049	55.1	16.1	0.185	136	0.94	1.45	8.98	5.00	7.65	7.75	0.301
S06-00536	40.45	7.90	335	0.086	0.043	59.0	16.6	0.185	152	1.00	1.54	9.24	4.70	8.15	7.68	0.314
S06-00537	40.60	7.99	332	0.109	0.052	57.7	16.8	0.225	146	1.05	1.45	9.74	4.90	8.18	8.76	0.287
S06-00538	40.83	7.99	324	0.096	0.046	55.5	17.5	0.184	137	0.91	1.44	9.51	5.00	8.10	10.4	0.270
S06-00539	41.09	8.07	372	0.125	0.054	65.3	16.6	0.228	174	1.00	1.76	9.58	4.81	8.79	9.06	0.342
S06-00540	41.48	7.99	382	0.137	0.042	65.5	16.5	0.167	177	1.08	1.66	9.78	4.68	9.50	6.78	0.317
S06-00544	41.73	7.89	383	0.093	0.045	62.1	16.8	0.211	171	1.00	1.93	9.35	4.98	9.24	8.85	0.363
S06-00545	41.96	7.96	382	0.125	0.042	67.5	17.3	0.173	172	1.00	1.84	9.49	5.28	7.24	11.4	0.341
S06-00546	42.15	7.94	371	0.111	0.050	64.8	17.4	0.163	163	1.01	1.66	9.25	5.26	8.42	9.95	0.323
S06-00547	42.44	7.90	339	0.117	0.036	59.4	16.8	0.180	158	1.11	1.82	9.68	4.64	10.3	7.21	0.358
S06-00548	42.70	7.95	326	0.101	0.052	54.1	17.7	0.191	144	1.16	1.76	10.00	4.41	10.5	6.71	0.332
S06-00549	42.86	7.89	339	0.126	0.055	55.6	16.1	0.176	155	1.02	1.71	9.39	4.43	10.2	6.21	0.323
S06-00550	43.17	7.88	310	0.097	0.042	51.7	15.9	0.177	136	0.84	1.24	8.39	4.88	10.9	7.52	0.236
S06-00551	43.39	7.88	348	0.129	0.047	59.5	17.0	0.170	151	1.01	1.51	9.00	5.39	10.2	9.44	0.313
S06-00552	43.58	7.84	374	0.123	0.044	62.5	16.9	0.171	158	0.89	1.51	8.85	5.56	9.36	11.4	0.297
S06-00553	43.86	8.01	394	0.126	0.055	64.6	16.8	0.172	170	0.79	1.49	8.84	5.54	7.48	12.0	0.276
S06-00555	44.04	7.85	356	0.125	0.064	60.6	17.2	0.178	159	0.99	1.53	9.61	5.06	11.1	8.49	0.326
S06-00554	44.42	7.88	322	0.098	0.054	51.0	17.0	0.236	143	0.94	1.34	9.61	4.27	12.6	6.10	0.289
S06-00556	44.61	7.87	338	0.117	0.043	61.4	17.0	0.180	163	0.88	1.44	9.33	3.94	12.5	5.46	0.320
S06-00557	44.92	7.85	342	0.103	0.043	61.3	14.6	0.181	174	0.78	1.51	8.78	3.63	12.5	4.53	0.372
S06-00558	45.36	7.85	314	0.110	0.058	54.5	14.0	0.195	153	0.78	1.66	9.09	3.56	12.0	5.52	0.433
S06-00559	45.51	7.58	268	0.111	0.040	52.2	13.6	0.214	143	0.86	1.50	8.60	3.66	11.4	5.62	0.394
S06-00560	45.72	7.75	238	0.086	0.041	44.2	14.0	0.227	115	0.84	1.16	7.91	3.77	10.3	6.42	0.294
S06-00561	45.79	7.83	275	0.093	0.047	51.5	13.7	0.220	138	0.91	1.30	7.92	3.73	10.4	6.47	0.324
S06-00562	46.24	7.93	301	0.091	0.040	51.3	14.8	0.188	138	0.96	1.28	8.57	4.03	10.4	6.96	0.289
S06-00563	46.32	7.95	272	0.083	0.046	45.4	15.4	0.210	111	1.15	1.45	8.60	4.07	10.4	7.86	0.325
S06-00564	46.69	7.94	332	0.093	0.043	56.2	15.0	0.166	156	1.01	1.33	8.43	4.34	10.2	7.06	0.283
S06-00642	46.83	8.16	306	0.097	0.056	55.4	13.2	0.333	157	1.44	1.64	8.99	2.60	13.5	7.94	0.450
S06-00565	46.87	7.95	346	0.114	0.035	62.5	16.1	0.198	164	1.32	1.50	10.10	4.52	10.4	7.28	0.325
S06-00566	47.13	7.98	367	0.136	0.056	63.5	17.4	0.204	170	1.35	1.89	10.20	4.92	12.0	8.76	0.460

Id	Depth (m)	pH-lab	SEC (µS/cm)	Ba (mg/l)	Br (mg/l)	Ca (mg/l)	Cl (mg/l)	F (mg/l)	HCO3-lab (mg/l)	K (mg/l)	Mg (mg/l)	Na (mg/l)	NO_3-N (mg/l)	Si (mg/l)	SO_4 (mg/l)	Sr (mg/l)
S06-00567	47.34	7.95	389	0.132	0.052	66.4	16.4	0.181	182	1.13	1.76	9.46	4.98	11.7	7.98	0.419
S06-00568	47.74	7.87	395	0.172	0.055	66.5	17.4	0.179	170	1.16	1.73	9.76	5.93	9.64	11.8	0.359
S06-00569	47.93	7.94	406	0.156	0.045	69.7	17.4	0.178	178	1.20	1.80	9.56	5.61	7.41	12.8	0.388
S06-00570	48.07	7.76	386	0.202	0.048	64.8	18.5	0.231	159	1.27	1.62	10.00	5.63	7.64	12.6	0.340
S06-00571	48.36	7.83	364	0.148	0.042	62.1	16.5	0.193	159	1.54	1.56	10.60	4.81	12.0	8.45	0.349
S06-00572	48.70	7.94	344	0.216	0.058	60.8	16.1	0.167	165	1.13	1.59	9.79	3.95	11.9	6.75	0.406
S06-00573	48.80	7.84	369	0.185	0.059	64.1	15.4	0.173	176	1.05	1.62	8.93	3.67	11.7	6.42	0.403
S06-00574	49.18	7.84	335	0.171	0.086	57.8	16.6	0.272	159	1.20	1.59	9.20	3.21	12.5	7.69	0.428
S06-00575	49.29	7.90	336	0.171	0.074	59.4	15.5	0.301	165	1.33	1.73	9.48	2.89	12.6	7.52	0.466
S06-00643	49.30	8.01	294	0.089	0.050	50.0	13.4	0.319	140	1.22	1.37	8.22	2.58	12.6	7.01	0.383
S06-00576	49.83	7.97	321	0.121	0.062	57.5	15.1	0.409	153	1.33	1.81	9.00	2.28	12.9	10.5	0.496
S06-00577	49.94	7.91	328	0.159	0.068	57.2	15.4	0.357	159	1.34	1.80	9.23	2.26	12.7	9.87	0.500
S06-00578	50.11	7.95	295	0.168	0.035	48.6	15.8	0.390	131	1.39	1.61	9.61	2.10	12.5	11.9	0.445
S06-00579	50.21	7.89	353	0.169	0.056	64.4	16.8	0.339	176	1.25	1.95	9.39	2.07	12.4	10.7	0.534
S06-00644	50.60	8.10	301	0.089	0.043	51.6	13.5	0.319	144	1.22	1.49	8.51	2.90	12.9	7.01	0.399
S06-00580	51.10	7.91	365	0.173	0.046	62.7	19.7	0.437	154	1.77	2.33	11.80	2.30	15.4	16.5	0.635
S06-00581	51.43	7.92	321	0.171	0.010	56.1	15.1	0.449	152	1.56	2.06	10.60	0.295	16.7	18.8	0.577
S06-00638	51.59	8.01	325	0.097	0.052	56.1	20.2	0.321	155	1.33	1.55	11.10	2.47	14.1	7.76	0.404
S06-00582	51.60		369	0.209	0.048	65.6	16.9	0.424	157	2.37	2.74	11.90	0.39	6.51	39.4	0.763
S06-00583	51.75		371	0.209	0.680	64.9	16.4	0.498	164	2.35	2.62	12.20	0.17	7.26	32.5	0.753
S06-00641	51.82	8.16	299	0.090	0.051	51.5	12.9	0.320	146	1.21	1.44	8.21	2.52	13.1	7.84	0.373
S06-00640	52.02	8.08	308	0.108	0.052	53.2	14.0	0.299	146	1.22	1.44	8.78	3.14	12.7	6.95	0.371
S06-00584	52.13		333	0.230	0.629	56.9	19.1		143	2.53	2.47	13.50	0.203	8.31	26.8	0.665
S06-00585	52.40		343	0.147	0.145	57.7	15.6		160	1.46	2.12	9.91	0.277	12.7	20.0	0.586
S06-00586	52.92		306	0.138	0.044	52.2	14.8		141	2.17	2.19	9.12	0.204	5.08	19.7	0.679
S06-00587	53.05		309	0.152	0.047	49.8	17.3		135	1.89	1.97	9.53	0.171	4.25	19.3	0.621
S06-00588	53.18		302	0.134	0.010	51.5	14.4	0.590	140	1.81	2.13	8.84	0.147	4.38	21.3	0.667
S06-00639	53.22	8.06	315	0.107	0.056	54.0	14.5	0.387	153	1.32	1.50	8.98	2.48	13.8	8.04	0.404
S06-00589	53.28		310	0.179	0.010	55.9	14.5		146	1.83	2.26	9.35	0.137	4.62	22.2	0.707
S06-00590	53.56		298	0.190	0.048	53.1	15.1		146	1.81	2.03	8.97	0.116	4.37	18.5	0.628
S06-00594	53.83	7.91	300	0.174	0.010	55.4	15.3		141	1.99	2.27	10.30	0.109	4.82	20.5	0.733
S06-00672	54.15	7.87	285	0.093	0.053	44.2	14.5	0.595	94.0	1.88	1.83	8.05	0.185	5.24	40.3	0.611
S06-00673	54.26	7.55	199	0.022	0.029	23.0	12.6	0.385	34.0	1.77	1.80	7.63	0.230	1.65	37.8	0.367
S06-00645	54.77	8.19	293	0.096	0.047	50.7	13.2	0.361	139	1.07	1.40	7.93	3.21	11.0	7.71	0.361
S06-00595	54.79	7.91	280	0.153	0.043	49.8	16.4		123	1.67	2.10	10.10	0.564	5.37	22.2	0.703
S06-00591	55.00		313	0.187	0.010	54.5	15.7	0.654	123	1.40	1.99	8.58	0.658	7.10	34.9	0.624
S06-00592	55.25		322	0.187	0.010	56.5	14.5	0.603	153	1.56	2.24	9.48	0.346	7.97	23.3	0.753
S06-00593	55.35		316	0.175	0.028	55.0	14.6	0.594	147	1.59	2.27	10.10	0.421	10.5	24.2	0.797
S06-00596	55.61	7.89	364	0.162	0.047	60.9	14.4	0.527	180	1.53	2.48	9.46	0.484	13.9	22.0	0.824
S06-00597	55.91	8.04	322	0.209	0.054	59.2	14.1	0.537	151	1.53	2.22	9.84	0.342	12.4	22.2	0.736
S06-00598	56.15	7.79	344	0.160	0.010	61.7	14.4	0.533	167	1.33	2.11	8.46	0.261	12.6	15.1	0.663
S06-00599	56.35	8.05	322	0.175	0.033	56.5	14.3	0.532	162	1.36	1.99	8.67	0.436	12.0	15.0	0.623
S06-00600	56.55	8.00	306	0.142	0.010	56.6	15.2	0.620	145	1.71	1.88	9.26	0.492	13.7	15.0	0.597
S06-00601	56.90	8.05	300	0.206	0.010	52.5	14.8	0.571	141	1.50	1.63	9.06	0.648	14.0	14.0	0.530
S06-00602	57.05	8.00	303	0.200	0.041	56.7	14.7	0.568	154	1.62	1.82	8.66	0.605	13.9	13.1	0.579
S06-00603	57.38	7.92	339	0.148	0.035	57.6	14.8	0.477	163	1.40	1.80	8.67	1.13	12.6	14.8	0.564
S06-00604	57.55	8.01	319	0.149	0.058	54.9	15.6	0.487	149	1.40	1.76	9.02	0.919	11.8	15.0	0.553
S06-00605	57.95	7.97	352	0.138	0.038	57.8	16.7	0.492	141	1.47	2.00	9.07	0.176	11.2	35.3	0.592
S06-00606	58.15	7.95	320	0.141	0.866	50.5	15.0	0.522	138	1.41	1.74	8.88	0.155	9.38	27.2	0.498
S06-00607	58.44	8.01	337	0.187	0.032	56.2	15.6	0.542	143	1.56	1.89	9.99		10.3	28.1	0.552
S06-00608	58.55	8.09	338	0.149	0.054	55.8	16.0	0.477	147	1.48	1.94	9.47	0.371	10.2	22.4	0.569
S06-00609	58.85	7.99	319	0.141	0.054	51.6	14.4	0.571	140	1.86	2.07	9.12	0.792	9.72	28.9	0.613
S06-00610	59.12	8.00	310	0.164	0.035	54.8	13.7	0.504	149	1.76	2.05	9.37	0.316	11.3	20.9	0.638
S06-00611	59.35	8.04	308	0.141	0.010	53.7	14.1	0.573	154	1.53	1.93	8.19	0.320	12.0	15.7	0.571
S06-00612	59.65	8.15	311	0.199	0.010	60.0	14.3	0.573	177	1.61	2.11	9.32	0.196	15.4	14.5	0.612
S06-00613	59.85	7.99	290	0.173	0.033	54.9	15.7	0.652	129	1.67	2.06	9.40	0.182	13.8	18.8	0.616
S06-00674	60.25	7.48	171	0.020	0.198	18.6	14.1	0.377	30.0	1.33	1.33	7.85	0.313	1.79	24.8	0.277
S06-00675	60.45	7.67	302	0.022	0.064	19.9	22.4	0.589	58.0	1.42	1.38	7.70	0.496	2.00	48.6	0.285
S06-00615	60.98	7.84	264	0.131	0.010	46.3	14.3	0.724	104	1.47	1.67	8.98	0.257	8.90	24.4	0.503
S06-00616	61.18	7.87	257	0.104	0.010	46.8	14.1	0.696	94.0	1.50	1.66	9.18	0.225	8.34	27.6	0.513
S06-00617	61.44	7.76	277	0.101	0.010	50.9	14.8	0.616	114	1.52	1.83	8.58	0.250	13.00	24.0	0.538

Id	Depth (m)	pH-lab	SEC (µS/cm)	Ba (mg/l)	Br (mg/l)	Ca (mg/l)	Cl (mg/l)	F (mg/l)	HCO3-lab (mg/l)	K (mg/l)	Mg (mg/l)	Na (mg/l)	NO_3-N (mg/l)	Si (mg/l)	SO_4 (mg/l)	Sr (mg/l)
S06-00618	61.55	8.01	299	0.094	0.010	51.8	14.2	0.562	135	1.65	1.84	8.79	0.745	14.3	20.5	0.556
S06-00619	61.85	8.06	319	0.096	0.027	57.5	15.3	0.524	152	1.61	1.98	8.91	1.13	13.7	16.7	0.562
S06-00620	62.20	8.01	295	0.152	0.036	50.9	16.3	0.498	129	1.40	1.61	9.44	1.72	14.0	15.0	0.450
S06-00621	62.45	7.92	294	0.136	0.030	49.3	16.1	0.478	126	1.49	1.67	9.86	2.17	14.7	13.7	0.461
S06-00622	62.62	8.04	325	0.096	0.033	59.2	16.7	0.370	161	1.44	1.87	9.78	2.49	13.5	11.7	0.514
S06-00623	62.72	7.96	306	0.092	0.045	50.7	15.3	0.384	139	1.22	1.58	8.78	3.01	12.6	11.9	0.430
S06-00624	63.05	7.95	305	0.091	0.036	50.2	15.3	0.382	138	1.24	1.58	8.79	3.03	11.6	11.9	0.432
S06-00625	63.15	7.94	321	0.100	0.054	56.4	15.0	0.379	157	1.26	1.73	8.83	2.81	12.4	10.5	0.486
S06-00626	63.55	8.04	310	0.072	0.057	50.7	17.8	0.450	140	1.44	1.65	9.37	1.77	12.3	14.2	0.421
S06-00627	63.65	7.96	319	0.099	0.076	53.8	19.4	0.474	144	1.58	1.69	10.40	1.55	13.3	15.5	0.435
S06-00628	63.90	7.68	278	0.087	0.045	44.0	15.3	0.517	117	1.41	1.43	8.75	0.93	13.2	17.4	0.386
S06-00629	64.05	8.02	305	0.087	0.055	50.8	16.0	0.485	144	1.41	1.62	9.08	0.71	12.9	17.8	0.421
S06-00635	65.18	8.01	291	0.098	0.038	50.0	12.9	0.490	133	1.30	1.59	8.57	0.53	13.5	20.7	0.438
S06-00631	65.44	8.00	284	0.085	0.061	47.5	12.1	0.429	130	1.08	1.44	7.72	0.79	9.28	18.2	0.385
S06-00630	65.50	8.05	311	0.075	0.039	53.8	12.0	0.439	157	1.14	1.61	7.78	0.64	11.8	17.9	0.442
S06-00632	65.74	8.05	312	0.080	0.054	54.1	15.1	0.394	148	1.60	1.66	9.29	1.48	14.5	15.9	0.446
S06-00633	66.03	8.06	317	0.089	0.062	54.6	13.8	0.486	142	1.57	1.77	8.80	0.33	11.4	28.8	0.453
S06-00634	66.06	7.93	299	0.078	0.041	51.3	14.1	0.431	142	1.38	1.52	8.60	1.98	15.0	11.2	0.402
S06-00636	66.17	7.95	295	0.086	0.057	50.4	14.3	0.366	138	1.39	1.52	8.74	2.10	14.5	10.9	0.413
S06-00637	66.27	7.96	289	0.089	0.052	48.8	14.9	0.357	136	1.31	1.45	8.97	2.15	14.6	10.5	0.387
S06-00646	68.41	7.94	262	0.096	0.029	43.4	13.1	0.351	113	1.00	1.21	7.99	3.22	12.1	8.07	0.315
S06-00647	68.75	8.05	293	0.086	0.050	51.9	14.2	0.298	140	1.04	1.31	8.07	3.83	13.0	7.11	0.316
S06-00648	69.05	8.15	306	0.103	0.047	52.6	15.7	0.264	132	1.09	1.35	8.62	4.48	11.9	9.45	0.340
S06-00649	69.35	8.00	348	0.108	0.052	59.3	16.1	0.246	147	1.09	1.43	8.79	5.10	9.12	12.2	0.307
S06-00650	69.55	8.01	355	0.108	0.061	59.9	15.5	0.262	152	1.14	1.47	8.77	4.69	10.5	9.57	0.343
S06-00651	69.85	7.97	323	0.111	0.046	56.6	14.6	0.285	152	1.13	1.38	8.33	4.20	11.3	6.86	0.347
S06-00652	70.10	7.97	312	0.137	0.046	56.2	14.7	0.263	153	1.15	1.38	8.74	4.08	11.3	6.39	0.340
S06-00653	70.43	8.03	319	0.104	0.046	56.1	14.2	0.258	153	1.09	1.42	8.26	3.73	11.1	5.77	0.340
S06-00654	70.85	8.10	330	0.102	0.058	57.2	15.2	0.309	155	1.07	1.44	8.51	3.88	10.0	6.56	0.353
S06-00655	70.95	8.00	324	0.120	0.039	55.4	14.5	0.317	149	1.25	1.41	8.33	3.91	8.44	6.93	0.335
S06-00656	71.05	8.05	328	0.125	0.045	59.3	14.8	0.251	152	1.21	1.44	8.65	4.11	7.32	6.74	0.333
S06-00657	71.40	7.92	291	0.087	0.034	49.7	14.9	0.303	118	1.21	1.43	8.12	4.16	5.42	10.4	0.398
S06-00658	71.70	7.97	287		0.040		14.5	0.288	118				4.00		9.46	
S06-00659	71.80	7.94	267	0.100	0.050	44.9	14.8	0.277	104	0.90	1.18	7.63	3.98	4.10	8.08	0.287
S06-00660	72.05	7.99	282	0.091	0.052	48.3	14.1	0.261	122	0.91	1.22	7.56	3.73	4.27	6.40	0.294
S06-00661	72.15	7.84	265	0.097	0.045	46.3	14.0	0.333	112	1.07	1.14	7.93	3.72	7.55	6.95	0.286
S06-00662	72.60	7.98	292	0.115	0.048	48.3	14.3	0.294	124	1.07	1.29	7.92	4.15	5.61	7.51	0.312
S06-00663	72.85	7.98	301	0.109	0.056	49.8	14.9	0.269	126	1.08	1.32	7.77	4.44	4.96	8.34	0.298
S06-00664	73.18	7.99	302	0.119	0.050	52.1	14.7	0.288	124	1.25	1.34	8.34	4.63	5.06	10.4	0.309
S06-00666	73.55	7.98	301	0.124	0.047	50.5	14.9	0.264	121	0.97	1.29	7.85	4.58	3.84	10.7	0.299
S06-00667	73.78	8.03	304	0.120	0.044	52.7	15.5	0.258	125	1.00	1.35	8.07	4.69	4.23	9.95	0.317
S06-00668	73.93	7.90	297	0.116	0.034	50.4	15.1	0.285	120	0.94	1.31	7.69	4.84	3.67	7.75	0.324
S06-00669	74.08	8.12	311	0.105	0.044	55.1	15.2	0.267	136	1.05	1.41	7.98	4.56	5.34	7.15	0.321
S06-00670	74.33	7.96	298	0.095	0.042	50.0	15.1	0.246	120	0.81	1.33	7.71	4.79	4.21	7.45	0.332
S06-00671	74.68	7.99	304	0.103	0.039	50.0	15.1	0.244	126	0.85	1.36	7.83	4.79	3.92	11.0	0.335
S06-00614	75.65	7.83	258	0.215	0.043	43.7	14.9		101	1.52	1.53	9.56	0.24	7.18	22.3	0.474

Porewater quality- Trace elements

Id	Depth (m)	Al (µg/l)	B (µg/l)	Co (µg/l)	Cr (µg/l)	Cu (µg/l)	Fe (µg/l)	Li (µg/l)	Mn (µg/l)	Mo (µg/l)	Ni (µg/l)	P (µg/l)	Pb (µg/l)	Rb (µg/l)	Sb (µg/l)	Si (µg/l)	Sn (µg/l)	U (µg/l)	V (µg/l)	W (µg/l)	Zn (µg/l)
S06-00441	2.05	3	21	0.06	1.7	1.7	47	1.0	2.68	0.2	4.5	1985	0.10	0.94	0.08	5240	0.24	0.22	0.2	0.01	7.80
S06-00442	2.95	7	114	0.11	19.2	19.2	13	0.9	4.36	0.3	<.2	40	0.20	0.34	0.13	2723	0.45	0.33	0.2	0.77	14.7
S06-00444	4.25	8	145	0.09	31.0	31	11	2.0	2.56	0.8	1.7	51	0.05	0.78	0.10	3456	0.41	0.26	0.2	2.76	24.3
S06-00445	5.05	5	97	0.04	24.8	24.8	5	1.1	1.19	0.2	<.2	47	0.40	0.6	0.06	2891	1.01	0.25	0.2	0.23	16.2
S06-00446	5.83	9	90	0.09	24.8	24.8	15	4.7	4.46	0.6	0.2	45	0.20	0.61	0.11	3835	2.76	0.36	0.2	0.55	31.1
S06-00447	6.75	25	91	0.08	38.7	38.7	45	3.6	4.03	0.4	<.2	74	0.20	0.57	0.08	3249	0.63	0.36	0.2	0.10	19.8
S06-00448	8.25	5	120	0.05	53.8	53.8	5	2.0	7.76	0.3	0.5	75	0.20	0.76	0.10	4112	0.46	0.40	0.3	0.13	22.1
S06-00449	9.20	5	98	0.08	56.4	56.4	12	2.7	5.57	0.3	0.6	72	0.10	0.81	0.09	4050	1.51	0.40	0.3	0.09	34.0
S06-00450	10.75	4	70	0.07	17.4	17.4	10	2.7	1.57	0.3	<.2	48	0.10	0.67	0.09	4123	0.76	0.44	0.4	0.30	30.7
S06-00451	12.35	6	102	0.07	23.2	23.2	5	3.2	20.2	0.4	<.2	57	0.10	1.06	0.10	4546	1.66	0.46	0.4	0.10	30.9
S06-00452	13.05	4	79	0.16	46.3	46.3	17	1.4	2.19	0.4	0.7	64	0.20	1.17	0.11	4688	0.49	0.41	0.4	0.89	24.6
S06-00453	14.20	5	89	0.09	34.4	34.4	5	2.6	1.17	0.5	<.2	67	0.10	1.1	0.07	4739	0.92	0.46	0.4	0.34	39.2
S06-00454	15.25	4	102	0.12	15.7	15.7	12	2.1	1.51	0.4	<.2	53	0.20	1.23	0.08	4873	0.46	0.37	0.4	0.07	29.0
S06-00455	16.55	4	95	0.25	19.9	19.9	20	2.5	6.43	1.2	0.3	53	0.10	1.63	0.10	5106	0.84	0.40	0.4	0.75	23.3
S06-00456	17.25	4	100	0.14	17.9	17.9	5	1.8	1.34	0.5	<.2	53	0.10	1.11	0.08	5211	0.88	0.36	0.3	0.20	32.2
S06-00457	18.35	5	84	0.09	15.5	15.5	10	2.3	1.35	1.4	<.2	52	0.05	0.95	0.07	4568	0.48	0.33	0.3	0.97	24.6
S06-00458	19.05	5	92	0.07	16.6	16.6	5	2.6	5.59	1.3	<.2	44	0.20	0.97	0.07	4705	0.40	0.31	0.3	0.45	38.2
S06-00459	20.15	6	96	0.06	20.1	20.1	5	2.6	2.34	0.4	<.2	53	0.10	1.08	0.10	4594	0.39	0.35	0.2	0.08	17.4
S06-00460	21.15	4	130	0.07	14.8	14.8	5	3.7	1.09	0.7	<.2	36	0.10	0.96	0.10	3972	0.39	0.30	0.4	0.19	25.7
S06-00461	22.15	7	125	0.1	27.8	27.8	5	2.6	5.28	1.2	<.2	61	0.20	0.92	0.08	4054	0.50	0.29	0.4	3.76	24.3
S06-00463	23.19	5	95	<0.02	23.2	23.2	5	2.2	1.13	1.3	<.2	51	0.10	1.21	0.08	5322	0.47	0.25	0.4	0.26	26.3
S06-00462	23.41	4	88	0.03	22.1	22.1	5	2.4	2.12	0.3	<.2	58	0.10	1.33	0.10	5216	0.39	0.27	0.3	0.05	26.1
S06-00464	23.62	5	90	0.21	17.4	17.4	5	5.4	2.85	6.7	0.6	34	0.20	1.04	0.09	5235	0.57	0.25	0.3	6.36	28.9
S06-00465	23.95	6	98	0.03	35.0	35	5	2.6	1.49	0.5	0.6	48	0.10	1.16	0.09	5156	0.51	0.25	0.4	0.24	25.4
S06-00466	24.16	5	67	0.02	40.0	40	5	4.7	1.33	0.9	1.5	54	0.10	1.04	0.08	5111	0.49	0.24	0.3	15.9	26.9
S06-00467	24.37	5	74	<0.02	33.7	33.7	5	2.2	1.05	0.2	0.2	51	0.10	1.00	0.07	5143	0.46	0.25	0.3	1.13	27.0
S06-00468	24.63	5	85	0.035	28.4	28.4	5	2.1	1.02	0.2	<.2	36	0.20	0.87	0.07	5218	0.45	0.23	0.3	0.22	21.9
S06-00469	24.80	5	76	0.02	27.5	27.5	5	3.1	1.12	0.4	<.2	44	0.10	0.83	0.07	5487	0.40	0.22	0.3	2.98	31.3
S06-00470	25.12	5	68	0.02	28.8	28.8	5	2.4	1.10	0.4	<.2	51	0.10	0.66	0.07	5430	0.58	0.23	0.3	1.79	21.2
S06-00471	25.41	9	70	<0.02	24.5	24.5	17	3.2	1.09	0.3	<.2	51	0.10	0.48	0.06	5297	0.62	0.22	0.3	0.87	30.9
S06-00472	25.70	6	88	0.02	28.5	28.5	5	2.1	1.36	0.3	1.0	40	0.10	0.6	0.07	5302	1.12	0.22	0.3	2.80	20.9
S06-00473	25.91	6	76	0.04	53.2	53.2	5	2.0	1.13	0.2	4.4	54	0.10	0.65	0.09	5188	0.59	0.24	0.3	0.30	29.2
S06-00474	26.13	6	113	0.02	28.8	28.8	5	2.1	1.48	0.3	0.3	38	0.10	1.00	0.10	5291	0.45	0.26	0.4	18.7	14.6
S06-00475	26.51	5	82	<0.02	28.7	28.7	5	1.9	0.91	0.2	0.2	47	0.10	0.89	0.09	5281	0.16	0.23	0.4	2.02	16.9
S06-00476	26.70	5	112	0.04	30.4	30.4	5	2.0	2.41	0.3	<.2	41	0.10	0.76	0.08	5306	0.61	0.22	0.4	0.51	29.2
S06-00477	26.90	6	82	<0.02	30.9	30.9	5	2.3	0.93	0.2	<.2	49	0.10	0.82	0.07	5368	0.20	0.23	0.4	0.15	19.7
S06-00478	27.08	4	68	0.87	18.6	18.6	13	4.2	78.39	1.3	1.3	32	0.40	1.02	0.09	5147	0.22	0.21	0.4	115	104
S06-00479	27.34	3	55	0.06	21.8	21.8	11	4.5	1.24	0.4	<.2	28	0.40	0.97	0.11	5332	0.11	0.19	0.3	5.10	133
S06-00480	27.52	3	64	0.02	19.3	19.3	13	4.9	1.03	0.6	0.5	26	0.50	0.92	0.08	5254	0.11	0.19	0.3	3.65	71.8
S06-00481	27.89	4	59	0.02	19.0	19	13	2.5	1.54	0.3	<.2	30	0.40	0.81	0.08	5507	0.12	0.24	0.3	6.37	109
S06-00482	28.12	3	60	0.02	21.4	21.4	12	2.6	0.78	0.5	<.2	29	0.30	0.86	0.09	5334	0.70	0.21	0.3	1.79	68.3
S06-00483	28.37	3	58	<0.02	17.1	17.1	5	2.5	0.96	0.3	<.2	27	0.20	0.78	0.09	5691	0.32	0.23	0.3	0.43	95.6
S06-00484	28.64	5	61	<0.02	19.0	19	5	1.9	0.88	0.5	<.2	29	0.20	0.67	0.07	5606	0.72	0.22	0.3	11.4	143
S06-00485	28.94	3	46	0.03	17.2	17.2	5	1.8	0.98	0.4	<.2	27	0.30	0.7	0.08	5762	0.22	0.24	0.3	54.1	167
S06-00488	28.94	3	71	0.01	15.8	15.8	5	2.3	1.12	0.3	<.2	28	0.20	0.85	0.09	5349	1.40	0.24	0.2	9.11	156
S06-00486	29.19	2	54	0.01	18.1	18.1	5	2.7	1.15	0.4	<.2	25	0.20	0.83	0.07	5250	1.31	0.24	0.2	11.2	161
S06-00489	29.19	4	66	0.02	11.3	11.3	18	1.6	0.80	0.2	<.2	31	0.05	0.49	0.08	5671	1.06	0.23	0.2	8.81	35.0
S06-00487	29.36	5	80	0.03	12.1	12.1	5	2.7	0.99	0.4	<.2	35	0.05	0.62	0.11	5305	1.14	0.24	<.2	29.8	25.0
S06-00490	29.63	2	50	0.02	15.8	15.8	5	2.0	0.61	0.5	<.2	23	0.10	0.81	0.06	5471	0.36	0.21	<.2	3.81	75.8
S06-00491	29.82	2	55	0.01	17.5	17.5	11	2.0	0.81	0.3	<.2	30	0.20	0.87	0.07	5576	0.08	0.24	0.2	1.15	111
S06-00492	30.16	12	64	0.02	17.2	17.2	5	2.2	1.13	0.4	<.2	25	0.20	0.9	0.08	5366	0.22	0.23	0.2	10.9	46.1
S06-00502	30.42	4	61	0.01	9.5	9.5	5	2.4	1.28	1.3	<.2	24	0.30	0.86	0.08	5015	0.12	0.21	0.2	7.52	77.1
S06-00503	30.72	4	71	0.01	9.2	9.2	17	2.2	1.08	0.5	<.2	29	0.30	0.97	0.08	5258	0.12	0.24	0.3	9.57	123
S06-00504	30.90	3	63	0.01	5.2	5.2	18	2.0	0.87	0.3	<.2	28	0.30	0.9	0.08	5116	0.13	0.22	0.2	0.93	105
S06-00505	31.06	3	72	0.02	5.8	5.8	38	2.4	0.87	0.3	0.4	27	0.30	0.94	0.10	5037	0.10	0.22	<.2	0.24	80.4
S06-00506	31.40	3	81	0.06	9.6	9.6	19	3.1	1.09	0.3	0.4	27	0.20	0.88	0.11	5190	0.09	0.23	<.2	0.88	57.1
S06-00507	31.63	4	115	0.04	13.4	13.4	26	4.2	1.37	0.4	0.9	34	0.20	1.12	0.13	5684	0.12	0.24	0.2	0.52	47.0
S06-00508	31.85	3	65	0.01	17.5	17.5	10	2.4	1.03	0.2	<.2	34	0.10	0.96	0.09	5335	0.10	0.26	<.2	0.24	73.1
S06-00509	32.10	6	55	0.01	18.8	18.8	21	1.7	0.92	0.2	<.2	37	0.30	0.82	0.08	5226	0.27	0.25	<.2	0.18	131
S06-00510	32.42	3	55	0.01	22.2	22.2	15	1.4	0.80	0.4	<.2	30	0.20	0.88	0.07	5520	0.06	0.25	<.2	2.66	164
S06-00511	32.56	3	62	0.01	21.0	21	13	1.7	1.37	0.6	1.0	27	0.10	0.9	0.10	5682	0.13	0.22	<.2	1.21	53.5
S06-00512	32.90	3	55	0.01	16.0	16	5	1.4	0.75	0.2	<.2	26	0.10	0.77	0.07	5498	0.08	0.22	<.2	0.23	54.3
S06-00513	33.29	2	52	0.01	13.4	13.4	21	1.7	0.68	0.7	0.7	26	0.10	0.89	0.08	5539	0.11	0.22	<.2	6.01	91.0
S06-00514	33.46	3	69	0.01	22.3	22.3	15	1.7	0.71	0.4	<.2	27	0.20	0.96	0.09	5333	0.06	0.24	<.2	1.10	75.6

Id	Depth (m)	Al (µg/l)	B (µg/l)	Co (µg/l)	Cr (µg/l)	Cu (µg/l)	Fe (µg/l)	Li (µg/l)	Mn (µg/l)	Mo (µg/l)	Ni (µg/l)	P (µg/l)	Pb (µg/l)	Rb (µg/l)	Sb (µg/l)	Si (µg/l)	Sn (µg/l)	U (µg/l)	V (µg/l)	W (µg/l)	Zn (µg/l)
S06-00515	33.65	3	67	0.01	19.3	19.3	5	2.0	0.76	0.4	<.2	27	0.40	0.83	0.10	5348	0.06	0.25	<.2	4.28	106
S06-00516	33.86	3	62	0.02	18.5	18.5	14	1.7	0.79	0.3	<.2	26	0.20	0.81	0.08	5295	0.03	0.25	<.2	1.29	77.7
S06-00517	34.18	3	47	0.01	13.8	13.8	27	1.7	0.76	0.5	<.2	25	0.20	0.62	0.08	5475	0.07	0.24	<.2	2.56	140
S06-00518	34.59	2	54	0.02	16.6	16.6	17	2.8	0.84	0.3	0.5	27	0.20	0.72	0.09	5732	0.13	0.24	<.2	0.38	79.5
S06-00519	34.69	3	45	0.01	9.9	9.9	5	2.2	0.86	0.2	<.2	22	0.20	0.67	0.08	5362	0.23	0.23	<.2	0.22	55.9
S06-00520	34.96	2	50	0.01	11.0	11	5	2.4	0.82	0.5	<.2	22	0.20	0.86	0.12	5462	0.07	0.23	<.2	0.37	122
S06-00493	35.13	3	78	0.03	13.8	13.8	5	2.0	1.30	0.3	<.2	29	0.20	1.1	0.11	5718	0.49	0.23	0.5	0.21	75.2
S06-00494	35.39	4	76	0.03	9.1	9.1	10	2.3	1.10	0.2	<.2	29	0.20	0.91	0.11	5777	0.52	0.25	0.5	0.72	61.0
S06-00495	35.57	4	74	0.01	9.0	9	10	2.1	1.07	0.2	<.2	25	0.60	1.04	0.13	5437	0.36	0.21	0.5	1.47	155
S06-00496	35.80	3	64	0.01	21.8	21.8	5	1.9	0.91	0.3	<.2	24	0.40	0.84	0.12	5712	0.14	0.20	0.5	0.25	123
S06-00499	35.80	8	134	0.02	12.7	12.7	5	2.3	2.19	0.3	<.2	38	0.20	1.04	0.15	5858	0.56	0.22	0.4	0.22	27.4
S06-00497	36.04	4	74	0.01	28.1	28.1	16	4.2	1.27	0.3	<.2	34	0.30	0.84	0.14	5829	0.11	0.22	0.4	0.10	108
S06-00500	36.04	5	104	0.01	15.6	15.6	5	5.3	0.94	0.4	<.2	39	0.10	0.84	0.16	5550	0.50	0.21	0.3	0.15	20.6
S06-00498	36.25	3	63	0.01	28.1	28.1	10	2.1	0.95	0.2	<.2	28	1.10	0.78	0.13	5746	0.14	0.21	0.3	0.09	92.5
S06-00501	36.25	5	164	0.01	14.1	14.1	5	2.5	0.85	0.4	<.2	46	0.05	0.79	0.14	5573	0.48	0.20	0.3	0.14	18.7
S06-00521	36.60	2	43	0.01	8.8	8.8	30	2.2	0.57	0.2	<.2	26	0.30	0.63	0.11	5487	0.14	0.25	<.2	1.06	56.8
S06-00522	36.90	3	53	0.02	9.2	9.2	5	1.9	0.65	0.3	<.2	25	0.30	0.56	0.10	5446	0.10	0.28	<.2	0.72	63.3
S06-00523	37.08	2	48	0.01	12.7	12.7	5	2.2	0.63	0.2	0.5	25	0.20	0.87	0.13	5951	0.03	0.28	<.2	0.14	82.7
S06-00524	37.33	3	53	0.01	12.7	12.7	11	1.7	0.67	0.2	0.4	24	0.20	0.86	0.16	5986	0.09	0.24	<.2	0.11	126
S06-00525	37.59	3	50	0.01	11.7	11.7	5	2.0	0.75	0.2	<.2	22	0.30	0.76	0.17	6013	0.32	0.22	0.4	0.26	116
S06-00526	37.89	3	60	0.01	10.7	10.7	5	1.8	0.63	0.5	<.2	21	0.20	0.55	0.12	5883	0.08	0.20	0.4	1.22	45.7
S06-00527	38.21	3	66	0.01	10.2	10.2	5	2.1	0.77	0.2	<.2	22	0.20	0.71	0.15	6774	0.24	0.22	0.4	0.20	51.6
S06-00528	38.34	3	69	0.01	9.2	9.2	5	2.0	0.69	0.1	<.2	10	0.20	0.64	0.15	6557	0.20	0.21	0.4	0.22	53.1
S06-00529	38.71	4	50	0.01	11.0	11	5	2.0	0.72	0.3	<.2	21	0.20	0.72	0.13	6214	0.09	0.23	0.3	0.09	70.8
S06-00530	38.79	3	53	0.01	13.4	13.4	5	2.1	0.73	0.2	<.2	23	0.10	0.63	0.13	6262	0.06	0.22	0.3	0.08	123
S06-00531	39.13	3	71	0.01	10.8	10.8	5	2.2	0.82	0.2	0.2	26	0.20	0.66	0.19	6826	0.26	0.21	0.2	0.18	59.2
S06-00532	39.36	3	59	0.01	14.6	14.6	5	2.2	0.88	0.2	2.1	23	0.10	0.77	0.19	6839	0.07	0.21	0.3	0.81	87.2
S06-00533	39.55	8	54	0.01	15.1	15.1	5	1.8	0.89	0.3	<.2	21	0.20	0.53	0.17	6765	0.09	0.21	0.2	0.85	95.0
S06-00534	39.92	3	76	0.01	8.8	8.8	5	2.7	0.90	0.2	<.2	21	0.20	0.61	0.13	7907	0.07	0.21	0.2	3.88	71.5
S06-00535	40.19	3	55	0.01	13.1	13.1	5	1.9	0.79	0.6	<.2	22	1.70	0.66	0.14	7623	0.06	0.22	0.3	2.76	57.1
S06-00536	40.45	3	48	0.01	12.4	12.4	25	3.6	0.70	0.5	<.2	20	0.10	0.68	0.15	7939	0.06	0.21	0.3	3.31	34.2
S06-00537	40.60	3	52	0.01	11.3	11.3	5	3.0	0.77	0.8	0.3	10	0.10	0.68	0.14	7747	0.11	0.20	0.3	5.23	55.7
S06-00538	40.83	3	56	0.02	11.1	11.1	5	3.2	0.84	1.8	0.5	27	0.30	0.69	0.10	8026	0.10	0.21	0.2	326	58.5
S06-00539	41.09	3	54.5	0.01	6.7	6.65	5	2.8	1.03	0.8	0.7	26	0.40	0.72	0.11	8857	0.09	0.21	0.3	143	131
S06-00540	41.48	3	64	0.01	14.5	14.5	5	2.5	0.80	0.6	0.2	10	0.20	0.67	0.11	9206	0.03	0.20	0.3	12.6	55.6
S06-00544	41.73	3	55	0.01	12.0	12	5	2.7	0.93	0.8	0.3	10	0.10	0.67	0.08	8810	0.06	0.21	0.2	57.1	67.2
S06-00545	41.96	3	60	0.02	13.1	13.1	5	2.2	1.11	0.4	0.2	10	0.10	0.55	0.08	6788	0.13	0.22	<.2	8.14	46.9
S06-00546	42.15	6	54	0.01	15.5	15.5	5	2.1	0.90	0.2	0.4	10	0.10	0.58	0.09	8176	0.08	0.22	<.2	0.51	65.9
S06-00547	42.44	3	63	0.04	19.4	19.4	15	2.2	1.13	0.2	0.8	10	0.10	0.8	0.11	9784	0.09	0.24	<.2	2.67	75.2
S06-00548	42.70	4	63	0.02	16.4	16.4	12	3.5	1.06	0.2	0.6	24	0.30	0.87	0.10	10040	0.03	0.24	<.2	1.36	79.0
S06-00549	42.86	3	53	0.01	19.2	19.2	5	2.4	1.02	0.2	0.3	26	0.20	0.65	0.09	9705	0.03	0.24	<.2	0.91	118
S06-00550	43.17	24	150	0.1	19.5	19.5	50	1.8	0.98	0	<2	<20	1.60	0.67	0.00	11497	1.04	0.25	<2	4.29	126
S06-00551	43.39	14	88	0.1	17.0	17	50	2.5	0.95	0	<2	232	1.90	0.58	0.00	10540	0.90	0.23	<2	0.57	62.3
S06-00552	43.58	2	53	0.01	13.6	13.6	15	1.9	0.78	0.4	<.2	28	0.10	0.57	0.10	8865	0.09	0.24	<.2	0.49	111
S06-00553	43.86	3	59	0.01	12.6	12.6	12	1.4	0.82	0.4	<.2	31	0.10	0.45	0.07	7216	0.08	0.26	<.2	15.84	111
S06-00555	44.04	2	57	0.01	15.6	15.6	54	2.6	1.17	0.4	0.9	23	0.30	0.67	0.12	11812	0.38	0.28	<.2	10.15	46.0
S06-00554	44.42	3	60	0.01	18.8	18.8	19	2.6	0.92	0.7	0.2	24	0.10	0.62	0.11	10896	0.06	0.27	<.2	6.62	79.2
S06-00556	44.61	4	63	0.01	13.8	13.8	22	2.6	0.79	0.3	<.2	26	0.30	0.66	0.12	11966	0.10	0.29	<.2	0.81	54.6
S06-00557	44.92	3	59	0.01	10.3	10.3	5	2.2	0.68	0.3	<.2	23	0.20	0.6	0.11	11664	0.07	0.31	<.2	2.38	32.0
S06-00558	45.36	10	69	0.1	18.0	18	50	3.0	0.81	0	<2	202		0.58	0.00	11969	0.99	0.30	<2	124	35.7
S06-00559	45.51	4	52	0.01	12.5	12.5	5	2.5	0.86	0.2	<.2	24	0.30	0.78	0.13	12583	0.07	0.30	0.7	3.68	55.4
S06-00560	45.72	4	44	0.01	13.9	13.9	5	3.0	0.89	0.3	<.2	21	0.30	0.72	0.12	11639	0.03	0.30	0.7	25.1	47.4
S06-00561	45.79	4	49	0.01	13.6	13.6	5	3.4	0.98	0.2	<.2	22	0.50	0.73	0.13	12076	0.03	0.30	0.6	0.86	83.0
S06-00562	46.24	3	59	0.01	11.7	11.7	18	3.1	0.73	0.3	0.6	10	0.20	0.74	0.11	11973	0.07	0.24	0.6	11.4	33.9
S06-00563	46.32	3	47	0.01	14.3	14.3	5	2.9	0.79	0.3	0.9	10	0.20	0.86	0.12	11733	0.08	0.23	0.6	1.69	35.7
S06-00564	46.69	3	46	0.01	17.3	17.3	5	3.5	0.89	0.4	0.5	24	0.20	0.68	0.09	11820	0.09	0.23	0.5	25.2	69.5
S06-00642	46.83	4	71	0.01	4.5	4.5	36	6.2	1.16	0.4	0.4	31	0.50	1.15	0.20	15420	0.36	0.32	0.8	0.13	47.7
S06-00565	46.87	11	67	0.01	19.9	19.9	5	3.0	0.96	0.2	0.8	24	0.30	0.83	0.10	11576	0.07	0.22	0.5	1.21	87.0
S06-00566	47.13	4	81	0.02	45.0	45	13	4.4	1.43	0.5	25.5	23	0.50	0.9	0.12	12751	0.20	0.21	0.6	97.0	74.3
S06-00567	47.34	4	74	0.01	20.1	20.1	5	3.5	1.16	0.9	0.6	24	0.30	0.81	0.11	13665	0.03	0.23	0.5	4.53	63.4
S06-00568	47.74	10	78	0.01	19.7	19.7	5	3.0	1.07	0.8	2.0	25	0.20	0.79	0.10	11186	0.06	0.24	0.6	103.	67.4
S06-00569	47.93	3	60	0.01	18.9	18.9	5	2.3	1.08	0.2	0.8	24	0.20	0.7	0.09	8201	0.13	0.24	0.4	1.25	82.6
S06-00570	48.07	4	73	0.01	25.8	25.8	5	1.9	1.11	0.3	1.7	29	0.20	0.77	0.11	8615	0.07	0.25	0.6	16.8	121
S06-00571	48.37	3	72	0.01	19.3	19.3	5	3.1	1.09	0.4	2.3	26	0.40	1.19	0.20	13598	0.19	0.28	0.7	1.59	124
S06-00572	48.70	4	79	0.01	21.3	21.3	5	3.8	1.18	0.4	1.2	25	0.30	0.8	0.18	14002	0.09	0.29	0.8	0.32	117
S06-00573	48.80	4	66	0.01	17.4	17.4	27	3.0	1.09	0.3	0.8	25	0.40	0.73	0.14	13214	0.20	0.29	0.7	0.24	186

Id	Depth (m)	Al (µg/l)	B (µg/l)	Co (µg/l)	Cr (µg/l)	Cu (µg/l)	Fe (µg/l)	Li (µg/l)	Mn (µg/l)	Mo (µg/l)	Ni (µg/l)	P (µg/l)	Pb (µg/l)	Rb (µg/l)	Sb (µg/l)	Si (µg/l)	Sn (µg/l)	U (µg/l)	V (µg/l)	W (µg/l)	Zn (µg/l)
S06-00574	49.18	3	87	0.01	13.7	13.7	5	4.3	1.02	0.4	1.0	10	0.20	1.0	0.17	14154	0.09	0.33	0.9	0.24	89.2
S06-00575	49.29	4	70	0.01	25.0	25	5	4.5	1.12	0.5	2.1	25	0.30	1.11	0.19	14321	0.06	0.37	0.9	0.19	98.9
S06-00643	49.30	3	63	0.01	4.7	4.7	5	5.3	0.83	0.6	0.3	27	0.05	0.94	0.20	14696	0.06	0.31	0.7	1.98	36.5
S06-00576	49.83	5	89	0.01	12.8	12.8	5	6.3	1.51	0.7	0.4	23	0.30	1.18	0.21	15204	0.10	0.48	1.1	5.06	71.0
S06-00577	49.94	4	107	0.01	18.7	18.65	5	6.1	1.04	0.6	0.9	21	0.30	1.13	0.20	14868	0.08	0.47	1.1	3.04	66.2
S06-00578	50.11	5	99	0.01	14.1	14.1	5	7.0	0.86	0.9	0.8	25	0.40	1.07	0.25	14119	0.09	0.50	1.3	99.8	38.1
S06-00579	50.21	3	90	0.01	15.0	15	28	6.9	0.96	1	0.5	23	0.20	0.89	0.20	14401	0.31	0.55	1	27.2	50.4
S06-00644	50.60	2	55	0.01	9.6	9.6	5	5.2	0.80	0.7	0.3	37	0.05	0.88	0.14	14716	0.03	0.31	0.6	4.88	39.3
S06-00580	51.10	3	86	0.17	20.2	20.2	5	13.5	2.13	4.2	5.2	35	0.40	1.6	0.49	17242	0.16	0.79	1.2	593	62.3
S06-00581	51.43	4	116	0.08	14.9	14.9	13	11.1	1.15	3.9	2.9	30	0.20	1.37	0.68	18682	0.23	0.78	1.3	661	36.8
S06-00638	51.59	3	73	0.01	4.9	4.9	25	5.4	0.98	0.4	<.2	24	0.10	0.95	0.16	16410	0.13	0.32	0.8	0.14	46.7
S06-00582	51.60	3	111	2.38	26.9	26.9	13	10.0	2.05	30.7	17.1	28	0.60	2.43	17.20	7438	0.07	0.70	1.3	18.3	115
S06-00583	51.75	3	96	1.6	25.1	25.1	14	10.2	1.80	31.1	10.1	29	0.30	2.34	20.34	7892	0.09	0.63	1.3	10.7	124
S06-00641	51.82	14	59	0.01	3.3	3.3	5	5.8	1.21	0.4	0.5	10	0.60	0.99	0.19	15395	0.10	0.35	0.8	0.12	60.2
S06-00640	52.02	3.5	72	0.01	6.5	6.5	5	4.4	0.84	0.85	0.6	25	0.20	1.07	0.18	15325	0.18	0.33	0.7	0.35	87.0
S06-00584	52.13	4	120	0.54	19.9	19.9	12	17.8	1.51	23.8	6.3	27	0.40	2.47	16.19	8936	0.16	5.26	1.7	266	91.3
S06-00585	52.40	3	96	0.13	14.0	14	5	8.3	1.23	2.3	3.0	25	0.30	1.42	1.09	14900	0.22	0.80	1.1	412	82.9
S06-00586	52.92	3	85	0.58	12.2	12.2	13	8.8	1.46	9.5	5.9	21	0.20	2.13	5.21	5773	0.08	0.36	0.8	20.58	50.0
S06-00587	53.05	3	80	0.19	22.8	22.8	15	7.9	1.55	7.3	5.2	25	0.20	1.73	10.85	4869	0.08	0.21	0.6	0.97	85.6
S06-00588	53.18	3	71	0.3	12.6	12.6	5	7.2	1.50	9.1	2.4	10	0.30	1.58	4.88	4866	0.11	0.22	0.7	1.37	56.6
S06-00639	53.22	4	65	0.01	5.7	5.7	5	6.0	1.09	0.5	0.6	37	0.10	0.93	0.17	16441	0.12	0.33	0.8	2.84	57.7
S06-00589	53.28	3	94	0.4	15.7	15.7	16	7.7	1.50	10.3	4.3	10	0.20	1.65	5.11	5133	0.32	0.29	0.7	0.63	45.2
S06-00590	53.56	4	86	0.11	15.2	15.2	15	7.7	1.54	6.7	1.4	30	0.40	1.56	1.48	5093	0.34	0.22	0.6	2.44	63.3
S06-00594	53.83	3	105	0.18	17.7	17.7	5	9.3	1.61	10	2.4	21	0.10	1.62	3.24	6046	0.03	0.20	1.4	1.00	34.7
S06-00672	54.15	47	67	0.87	7.4	7.4	50	8.6	2.06	41.1	4.3	<20	1.10	2.22	5.43	6151	0.80	0.43	<2	0.91	267
S06-00673	54.28	26	61	0.28	1.7	1.7	50	9.7	0.25	52.9	3.9	<20		1.92	4.91	2071	0.80	0.20	<2	0.50	61.6
S06-00645	54.77	4	52	0.01	6.9	6.9	23	3.7	0.77	0.5	0.2	40	0.05	0.77	0.12	12317	0.09	0.32	0.5	0.15	51.6
S06-00595	54.79	4	83	0.32	13.7	13.7	5	9.6	1.77	12	4.3	10	0.30	1.3	3.69	6549	0.14	0.24	1.3	5.30	54.1
S06-00591	55.00	3	99	1.24	14.4	14.4	5	9.1	1.82	11.3	14.1	10	0.30	1.01	7.70	7754	0.11	0.31	0.7	1.73	84.6
S06-00592	55.25	4	96	0.27	19.5	19.5	5	7.6	2.02	11.2	3.2	21	0.30	1.25	8.44	8693	0.18	0.19	0.8	3.98	87.5
S06-00593	55.35	3	88	0.57	24.8	24.8	22	7.5	1.53	13.2	8.2	22	0.10	1.2	9.93	12834	0.06	0.38	2.3	1.99	58.8
S06-00596	55.61	3	97	0.76	22.8	22.8	21	7.2	1.83	9	11.3	25	0.20	1.1	10.90	18682	0.14	0.65	1.8	5.18	47.7
S06-00597	55.91	4	97	0.49	17.0	17	30	7.1	1.27	11.8	4.8	28	0.20	0.87	12.88	15996	0.07	2.46	2.8	0.71	77.0
S06-00598	56.15	3	90	0.01	9.5	9.5	27	6.6	1.00	1	0.3	10	0.10	0.84	0.22	16641	0.13	0.20	0.9	0.22	74.1
S06-00599	56.35	4	87	0.02	12.9	12.9	5	6.6	1.15	1.3	0.6	30	0.20	0.82	0.21	15861	0.07	0.25	0.9	0.80	73.9
S06-00600	56.55	4	118	0.04	14.7	14.7	5	7.1	1.18	1.05	<.2	27	0.40	1.68	0.28	17514	0.21	0.27	1.1	0.71	92.5
S06-00601	56.90	4	117	0.02	21.2	21.2	11	7.4	1.12	2.7	<.2	28	0.10	1.17	0.28	17957	0.06	0.26	1.2	1.32	78.9
S06-00602	57.05	4	121	0.02	24.8	24.8	5	7.2	1.32	1.5	<.2	30	0.20	1.07	0.59	18361	0.03	0.29	1.3	9.03	78.9
S06-00603	57.38	4	95	0.08	23.9	23.9	24	6.9	1.17	3.1	0.4	30	0.20	1.0	1.71	16672	0.18	0.53	1.3	1.17	83.1
S06-00604	57.55	5	108	0.02	23.1	23.1	16	5.7	1.43	1.8	1.0	34	0.30	1.12	0.23	15944	0.18	0.33	1.1	0.59	66.1
S06-00605	57.95	4	88	1.35	17.9	17.9	5	7.0	1.55	13.7	14.2	20	0.20	1.22	14.25	14645	0.18	2.33	8.2	0.35	71.4
S06-00606	58.15	3	98	0.92	19.0	19	5	7.6	1.59	13.3	8.6	20	0.10	1.09	15.21	12533	0.06	0.72	1.6	0.25	47.5
S06-00607	58.44	4	110	0.61	16.0	16	31	8.3	1.75	9.2	5.0	21	0.30	1.22	8.93	13189	0.08	0.25	1.5	0.24	88.4
S06-00608	58.55	3	106	0.28	17.9	17.9	5	8.2	1.75	7.5	2.8	24	0.10	1.14	5.61	13119	0.15	0.19	1.1	0.60	64.5
S06-00609	58.85	3	88	0.5	14.9	14.9	5	9.3	1.71	22.8	5.2	10	0.30	1.78	10.10	12477	0.08	0.36	2.3	0.97	37.5
S06-00610	59.12	4	90	3.73	14.8	14.8	30	9.4	1.81	11.9	16.8	26	0.20	1.48	11.32	14261	0.07	1.67	3.2	0.40	56.3
S06-00611	59.35	3	73	0.06	14.9	14.9	10	7.8	1.64	2	<.2	26	0.20	1.05	0.24	14872	0.07	0.36	4.4	0.65	67.2
S06-00612	59.65	2	110	0.07	16.6	16.6	13	7.8	1.63	1.3	<.2	28	0.20	0.9	0.17	18919	0.14	0.12	1	3.27	49.2
S06-00613	59.85	3	113	0.23	15.2	15.2	16	8.8	1.64	2.9	1.2	21	0.20	1.09	1.09	17114	0.06	0.20	1	0.75	56.5
S06-00674	60.25	24	66	0.1	1.8	1.8	50	8.8	0.25	19.4	<2	<20	3.70	1.39	5.22	2342	1.32	0.45	<2	0.39	42.0
S06-00675	60.45	23	61	0.1	0.5	0.5	50	8.1	0.25	25.4	<2	<20		1.35	4.13	2545	1.30	0.10	<2	0.58	18.7
S06-00615	60.98	3	80	0.14	8.3	8.3	12	10.3	1.48	8	2.4	21	0.30	1.12	2.40	10670	0.24	0.27	0.9	0.45	45.1
S06-00616	61.18	4	71	0.2	6.4	6.4	5	11.8	1.31	10	2.1		0.10	1.31	12.41	10831	0.06	0.24	0.8	0.25	25.3
S06-00617	61.44	4	74	0.36	8.4	8.4	5	12.2	1.34	3.3	3.5	22	13.70	1.32	3.11	17367	0.06	2.48	3.1	0.33	28.0
S06-00618	61.55	3	66	0.05	6.8	6.8	5	10.4	0.92	2.1	1.1	27	0.20	1.48	2.17	16039	0.06	1.84	2.4	21.6	31.3
S06-00619	61.85	4	64	0.01	6.9	6.9	40	8.1	1.17	1.2	1.0	26	0.20	1.41	1.07	16170	0.07	1.09	1.8	2.06	35.3
S06-00620	62.20	4	78	0.01	9.0	9	31	7.3	0.89	2	0.2	20	0.20	1.22	0.67	16729	0.13	0.78	1.4	1.25	45.3
S06-00621	62.45	4	78	0.01	9.8	9.8	5	7.0	0.94	2.2	<.2	23	0.20	1.16	0.58	16585	0.26	0.54	1.3	0.99	37.0
S06-00622	62.62	3	63	0.01	7.0	7	5	5.7	0.98	1.2	<.2	21	0.30	1.21	0.34	15065	0.36	0.46	1	0.70	56.9
S06-00623	62.72	3	54	0.01	9.8	9.8	26	5.2	0.98	1.3	<.2	22	0.20	1	0.23	14299	0.12	0.41	0.9	20.0	30.0
S06-00624	63.05	4	55	0.01	9.8	9.8	21	5.3	0.98	1.3	<.2	10	0.20	1.01	0.24	13503	0.12	0.42	0.9	20.1	30.2
S06-00625	63.15	3	63	0.01	7.1	7.1	13	5.4	0.90	0.6	<.2	23	0.20	1.08	0.26	14264	0.37	0.44	0.9	4.42	36.9
S06-00626	63.55	4	67	0.01	5.6	5.6	5	7.6	1.30	1	0.3	21	0.20	1.34	0.53	14770	0.08	0.64	1.3	0.43	49.1
S06-00627	63.65	3	102	0.01	7.0	7	33	8.2	1.09	1.2	1.1	10	0.20	1.46	0.67	16069	0.17	0.71	1.3	0.28	37.9
S06-00628	63.90	4	83	0.01	6.7	6.7	13	7.8	0.89	1.5	1.1	20	0.20	1.38	0.99	16565	0.07	0.84	1.7	0.25	29.9
S06-00629	64.05	3	89	0.01	5.3	5.3	5	8.2	0.97	1.5	1.3	22	0.10	1.34	1.00	15782	0.10	0.95	1.6	0.19	44.1

Id	Depth (m)	Al (µg/l)	B (µg/l)	Co (µg/l)	Cr (µg/l)	Cu (µg/l)	Fe (µg/l)	Li (µg/l)	Mn (µg/l)	Mo (µg/l)	Ni (µg/l)	P (µg/l)	Pb (µg/l)	Rb (µg/l)	Sb (µg/l)	Si (µg/l)	Sn (µg/l)	U (µg/l)	V (µg/l)	W (µg/l)	Zn (µg/l)
S06-00635	65.18	4	82	0.01	4.7	4.7	17	6.8	1.13	1.3	0.7	25	0.20	1.14	0.67	16516	0.09	0.77	0.6	0.09	42.0
S06-00631	65.44	4	52	0.01	4.0	4	39	5.8	1.03	1.1	1.1	26	0.40	1.06	0.54	14938	0.16	0.76	0.6	0.09	45.6
S06-00630	65.50	5	51	0.01	10.5	10.5	5	6.6	1.04	1	1.0	28	0.40	0.8	0.38	11262	0.11	0.68	0.4	0.29	35.5
S06-00632	65.74	4	69	0.01	8.3	8.3	48	6.9	1.46	1.2	1.3	27	0.20	1.59	0.37	17905	0.11	0.52	0.4	0.11	20.9
S06-00633	66.03	4	73	0.21	69.3	69.3	152	8.9	1.68	5.8	127.7	21	0.60	1.64	2.84	14102	0.26	6.09	2.1	0.15	41.9
S06-00634	66.06	4	65	0.01	4.8	4.8	5	5.5	1.17	0.7	0.5	20	0.20	1.25	0.24	17739	0.26	0.36	0.6	0.63	36.9
S06-00636	66.17	5	76	0.01	6.4	6.4	30	6.0	1.13	0.6	0.4	27	0.10	1.08	0.22	17040	0.09	0.32	0.4	0.09	56.3
S06-00637	66.27	5	73	0.01	7.2	7.2	33	5.8	1.25	0.6	0.6	31	0.20	0.99	0.22	17061	0.13	0.31	0.5	0.11	46.3
S06-00646	68.41	2	49	0.01	6.8	6.8	5	3.9	0.66	0.4	<.2	35	0.05	0.7	0.13	13153	0.18	0.30	0.5	0.10	49.4
S06-00647	68.75	3	49	0.01	6.5	6.5	25	3.5	0.70	0.5	0.3	32	0.05	0.79	0.14	14142	0.08	0.31	0.5	0.15	42.9
S06-00648	69.05	3	59	0.01	8.1	8.1	11	3.6	0.96	0.5	0.5	34	0.10	0.76	0.14	13152	0.10	0.30	0.5	0.52	62.5
S06-00649	69.35	3	61	0.01	11.0	11	5	3.2	0.81	0.5	0.3	36	0.05	0.78	0.13	10227	0.11	0.30	0.5	1.97	74.1
S06-00650	69.55	3	62	0.01	8.8	8.8	15	3.5	0.93	0.4	0.5	37	0.30	0.85	0.15	11810	0.35	0.32	0.5	0.58	68.9
S06-00651	69.85	3	60	0.01	5.6	5.6	32	3.2	0.74	0.3	0.5	40	0.05	0.85	0.17	12967	0.13	0.35	0.3	0.15	76.7
S06-00652	70.10	3	65	0.01	6.0	6	5	3.2	0.75	0.3	0.4	45	0.10	0.73	0.16	12614	0.14	0.35	0.3	0.16	73.3
S06-00653	70.43	3	61	0.01	7.3	7.3	5	3.2	0.73	0.4	0.2	37	0.05	0.76	0.15	12533	0.10	0.35	0.3	0.10	68.7
S06-00654	70.85	3	58	0.01	7.1	7.1	70	3.6	0.90	0.7	0.6	33	0.05	0.87	0.14	11521	0.09	0.36	0.2	89.2	57.1
S06-00655	70.95	3	69	0.01	12.5	12.5	12	3.2	0.90	0.9	0.5	50	0.05	1.07	0.15	9721	0.06	0.38	0.3	161	86.5
S06-00656	71.05	3	53	0.01	6.3	6.3	5	2.4	0.71	0.4	0.5	25	0.05	0.84	0.14	8159	0.15	0.36	<.2	16.9	58.1
S06-00657	71.40	7	43	0.04	10.2	10.2	47	3.0	1.12	0.5	0.7	51	0.05	1.06	0.16	5929	0.12	0.33	0.3	73.5	50.9
S06-00658	71.70	3	47	0.01	6.7	6.7	12	3.2	0.70	0.2	0.4	28	0.05	0.73	0.12	4868	0.12	0.29	<.2	0.60	67.8
S06-00659	71.80	3	40	0.01	6.9	6.9	5	3.0	0.78	0.2	0.6	40	0.10	0.57	0.11	4493	0.15	0.28	<.2	0.28	60.1
S06-00660	72.05	3	40	0.01	5.3	5.3	5	3.1	0.72	0.2	0.5	47	0.05	0.52	0.10	4492	0.34	0.26	<.2	0.34	36.8
S06-00661	72.15	4	46	0.01	6.1	6.1	5	2.7	0.63	0.3	<.2	28	0.10	0.88	0.13	6407	0.19	0.27	0.3	0.59	34.0
S06-00662	72.60	11	41	0.01	7.5	7.5	5	2.5	0.73	0.4	<.2	26	0.10	0.71	0.10	4810	0.11	0.22	0.3	0.45	52.3
S06-00663	72.85	4	43	0.01	6.1	6.1	5	3.4	0.66	0.2	<.2	25	0.10	0.64	0.12	4358	0.12	0.20	0.3	0.63	47.0
S06-00664	73.18	4	49	0.01	5.5	5.5	5	2.9	0.74	0.3	<.2	30	0.10	0.96	0.11	4480	0.25	0.22	0.2	0.18	43.2
S06-00665	73.33	4	47	0.01	7.6	7.6	14	2.7	0.71	0.2	0.3	31	0.30	0.76	0.09	3656	0.08	0.21	0.2	0.06	54.8
S06-00666	73.55	4	49	0.01	5.8	5.8	5	2.7	0.74	0.2	0.4	27	0.20	0.64	0.08	3295	0.16	0.21	0.2	0.57	45.1
S06-00667	73.78	2	48	0.01	7.8	7.8	12	2.9	0.73	0.3	0.2	24	0.10	0.78	0.08	3621	0.17	0.20	<.2	5.35	51.4
S06-00668	73.93	4	49	0.01	9.0	9	17	2.9	1.38	0.2	0.4	33	0.20	0.69	0.08	3344	0.14	0.21	<.2	2.56	56.4
S06-00669	74.08	3	39	0.01	7.5	7.5	5	3.1	0.86	0.2	<.2	23	0.10	0.81	0.08	4624	0.08	0.21	<.2	1.00	62.3
S06-00670	74.33	4	34	0.01	7.2	7.2	15	2.1	0.75	0.3	<.2	28	0.10	0.61	0.06	3727	0.19	0.21	0.2	68.7	54.7
S06-00671	74.68	3	41	0.01	10.0	10	5	2.3	0.97	0.2	<.2	25	0.10	0.59	0.06	3734	0.18	0.21	<.2	1.62	69.6
S06-00614	75.65	3	150	0.22	13.0	13	12	11.8	1.17	9.4	1.7	23	0.20	1.07	4.68	9190	0.29	0.31	0.9	0.43	39.3

Packer test samples and drilling bowser water- field data and major and minor elements

Id	Depth (m)	pH-lab	SEC (µS/cm)	Ba (mg/l)	Br (mg/l)	Ca (mg/l)	Cl (mg/l)	F (mg/l)	HCO3-lab (mg/l)	K (mg/l)	Mg (mg/l)	Na (mg/l)	NO_3-N (mg/l)	Si (mg/l)	SO_4 (mg/l)	Sr (mg/l)
S06-00699	29.4			0.009	0.063	97.0	16.6	0.109		0.84	1.68	7.41	6.3	6.02	13.4	0.219
S06-00707	30.9			0.009	0.068	96.1	16.8	0.103		0.87	1.71	7.44	6.34	6.19	13.2	0.220
S06-00708	33.5			0.009	0.051	97.2	16.1	0.142		0.81	1.68	7.51	6.17	6.13	13.3	0.224
S06-00706	35.1			0.009	0.055	96.3	16.6	0.118		0.79	1.68	7.45	6.26	6.16	13.1	0.222
S06-00705	37.1			0.009	0.06	96.7	16.5	0.094		0.72	1.67	7.49	6.17	6.20	12.9	0.225
S06-00704	40.2			0.009	0.056	95.4	16.4	0.101		0.73	1.67	7.47	6.12	6.41	12.7	0.223
S06-00703	46.9			0.010	0.065	98.9	16.5	0.098		0.73	1.70	7.52	6.22	6.12	13.1	0.225
S06-00702	52.4			0.009	0.059	74.8	16.5	0.115		0.77	1.76	7.74	6.28	6.41	13.2	0.226
S06-00701	59.4			0.010	0.059	85.8	16.6	0.109		0.77	1.80	7.87	6.28	6.46	13.2	0.230
S06-00700	71.4			0.013	0.061	97.1	16.6	0.104		0.75	1.74	7.39	6.26	6.04	13.2	0.227
S06-00443	bowser	8.11		0.0769	0.074	83.1	6.22	0.120	192		2.38	4.96	14.9	2.37	18.2	0.260
S06-00541	bowser	7.95	559	0.0133	0.010	110	24.4	0.09	294	1.36	2.10	11.3	4.76	4.94	11.1	0.261
S06-00542	bowser	7.95	498	0.0133	0.032	93.3	20.5	0.125	241	1.30	2.06	9.80	5.45	5.35	11.7	0.264
S06-00543	bowser	8.26	544	0.0153	0.026	108	24.4	0.104	280	1.60	2.17	11.6	5.07	5.01	11.1	0.257

Packer test samples and drilling bowser water- trace elements

Id	Depth (m)	Al (µg/l)	B (µg/l)	Co (µg/l)	Cr (µg/l)	Cu (µg/l)	Fe (µg/l)	Li (µg/l)	Mn (µg/l)	Mo (µg/l)	Ni (µg/l)	P (µg/l)	Pb (µg/l)	Rb (µg/l)	Sb (µg/l)	Si (µg/l)	Sn (µg/l)	U (µg/l)	V (µg/l)	W (µg/l)	Zn (µg/l)
S06-00699	29.4	2	12	0.01	0.25	3.4	13	0.7	7.18	0.1	<.2	28	0.54	0.54	0.03	6019	0.08	0.16	0.2	0.28	27.8
S06-00707	30.9	2	10	0.01	0.25	5.8	5	0.6	3.74	0.1	<.2	23	0.55	0.55	0.03	6194	0.03	0.15	0.2	0.27	35.4
S06-00708	33.5	21	10	0.04	0.25	2.5	32	0.7	7.8	0.1	<.2	26	0.58	0.58	0.03	6128	0.03	0.16	0.3	0.21	24.0
S06-00706	35.1	1	11	0.01	0.25	2.2	27	0.7	3.01	0.1	<.2	22	0.54	0.54	0.03	6162	0.03	0.15	0.2	0.17	17.2
S06-00705	37.1	46	64			3.8		1.2	6.87		<2		0.57	0.57		6203	0.69	0.10	<2	0.22	27.2
S06-00704	40.2	2	11	0.02	0.25	4.1	50	0.7	4.86	0.1	<.2	22	0.52	0.52	0.03	6412	0.03	0.15	0.2	0.22	22.6
S06-00703	46.9	4	16	0.01	0.25	0.8	5	1.5	3.51	0.2	<.2	94	1.29	1.29	0.10	6119	0.34	0.23	0.3	0.01	3.60
S06-00702	52.4	0.5	10	0.01	7.9	0.4	5	0.7	0.025	0.2	<.2	10	0.54	0.54	0.06	6407	0.03	0.14	0.2	0.27	0.025
S06-00701	59.4	0.5	10	0.02	8.6	0.6	25	0.7	1.07	0.4	<.2	10	0.53	0.53	0.03	6462	0.03	0.14	<.2	0.30	0.025
S06-00700	71.4	7	13	0.2	0.25	3.5	384	0.9	35.8	0.4	0.9	27	0.55	0.55	0.03	6035	0.03	0.17	0.3	0.32	49.1
S06-00443	bowser	7	89	0.07	0.8	26	5	0.8	1.79	0.2	<.2	50	0.50	0.09	0.09	2568	0.76	0.28	0.2	0.41	12.8
S06-00541	bowser	4	21	0.08	0.25	2.1	5	0.9	6.01	0.1	52.1	1683	0.87	0.07	0.07	4820	0.07	0.23	<.2	0.03	11.9
S06-00542	bowser	3	14	0.49	0.25	1.4	5	2.4	44.9	4.3	3.3	146	0.95	0.13	0.13	5121	0.03	0.26	<.2	1.88	9.90
S06-00543	bowser	5	15	0.05	0.25	4	5	1.1	2.26	0.2	0.4	1487	1.03	0.08	0.08	4574	0.1	0.24	<.2	0.44	15.0

Packer test samples CFC, SF_6 and stable isotopes

Id	Depth (m)	CFC-11	CFC-12	SF_6	d^{18}O	d^{2}H
S06-00699	29.4	3.46	16.2	1.19		
S06-00707	30.9	3.51	14.5	0.42	-6.7	-42.3
S06-00708	33.5	3.6	17	0.66	-6.28	-41.2
S06-00706	35.1	3.54	16.4	1.27	-6.76	-45.7
S06-00705	37.1	3.42	17.6	1.27	-7.11	-46.3
S06-00704	40.2	3.14	16.5	1.11	-6.33	-43
S06-00703	46.9	3.19	15.5	1.12		
S06-00702	52.4	2.98	16.6	0.43		
S06-00701	59.4	3.29	16.3	1.27		
S06-00700	71.4	1.61	13.6	0		