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Hydrological requirements of *Vertigo moulinsiana*

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Summary

1. The report describes the combined results of two projects that were commissioned to make quantitative determinations of the hydrological requirements of the land-snail *Vertigo moulinsiana* (Dupuy, 1849) on 3 English SACs.

2. The project was undertaken within small study areas at Chilton Foliat (Wiltshire), Market Weston Fen (Suffolk) and Thompson Common (Norfolk), which lie within the Kennet and Lambourn Floodplain, Waveney and Little Ouse Valley Fens and Norfolk Valley Fens SACs respectively.

3. The Chilton Foliat study area extended from a small flowing channel, and included areas of *Glyceria maxima* swamp. The Market Weston Fen area was associated with an area of tall, unmanaged *Phragmites* dominated fen community and the Thompson Common area was associated with a flooded glacial pingo remnant, which contained a pond with marginal stands of tussocky *Carex elata* swamp.

4. Following the selection of the study areas, 12 dipwells aligned along 3 transects, were installed along hydrological gradients on each study area. Water levels were recorded on a monthly or fortnightly regime between August 2000 and December 2002. There was a break in data collection during summer 2001 because of the access restrictions caused by the foot and mouth epidemic.

5. Eight further dipwells connected to water level probes and a datalogger were installed at Chilton Foliat in April 2002. These were mainly placed in areas of swamp that were not readily accessible but contained high populations of *V. moulinsiana*.

6. Snail populations were monitored using a beating method on several occasions during the project. Samples were taken on a grid across the areas in August 2002. Records of dominant plant species and a qualitative Dampness Index were also made during the snail recording. Surface topography was measured and related to ordnance datum. Soil type and soil dampness were recorded and classified. Information on regional weather patterns during the project was obtained from the Met Office.

7. Several derived hydrological parameters, including maximum, minimum and mean summer, winter and annual water levels, and estimates of annual depth of inundation and the percentage time under inundation were calculated from the dipwell data. The topography survey was used to relate water levels to ground surface level.

8. The abundance of *V. moulinsiana* at the dipwells was determined by interpolation from the 2002 grid sampling data. The hydrological requirements of the snail have been determined by examining the relationships between the hydrological parameters and snail abundance, and by reviewing the dipwell hydrographs when classified by snail abundance category.

9. The findings from Chilton Foliat and Thompson Common are reasonably clear and suggest that the snail has very similar hydrological requirements at both sites. Maximum snail densities, at locations where the hydrological conditions are considered to be at, or close to, the snail's optimum were recorded where water levels were continuously above the ground surface throughout the year, and where mean annual water levels were more than +0.25m. Annual fluctuation at these locations was between about 0m and +0.6m. Medium density snail populations were associated with conditions where water levels fluctuated within 20cms of the surface, both above and below ground level. The critical minimum summer water level threshold, where the snail occurs but only at very low abundance, was estimated to be 0.5m below surface ground level. However, it is unlikely that *V. moulinsiana* populations would be sustained under such conditions.

10. The findings from Market Weston Fen were difficult to interpret and occasional ambiguous. The tentative conclusions need to be treated with caution, and further work is recommended at this site. The range of water level fluctuation at the site was very small and low snail densities were recorded in 2002 (although high abundance was noted in 2000); these factors probably made interpretation more difficult. The snail's abundance did not correlate so clearly with water levels, although it was tentatively concluded that the snail favoured water levels that were maintained at or very close to ground level throughout the year.

11. The relationships between two qualitative measures of soil dampness (wetness class and a 5-point Dampness Index), the water level measurements, and the snail populations, were examined. Both qualitative measures correlated clearly with measured water levels and it was concluded that they could, with some care, be used as a surrogate measure of hydrological conditions, including minimum summer water levels.

12. Snail densities were found to be highest in Dampness Index classes 3, 4 or 5 on the 3 sites. A similar analysis of published data from the same sites showed that peak snail abundance was associated with different Dampness Index classes to those found in this study. This inconsistency highlights potential risks associated with the use of simple surrogate measures when seeking to define appropriate hydrological conditions for the snail.

Acknowledgements

We would like to thank Martin Drake, Gareth Morgan, Roger Key and Rob Cathcart (English Nature), and Daryl Buck and Ann Skinner (Environment Agency) for commissioning and supporting these two projects. We are also grateful to English Nature local staff, including Amanda Newsome, Patrick Robinson and Stephen Rothera, who provided advice during the site selection process, and to Rory Callan (Environment Agency) for coordinating hydrological data collection at Chilton Foliat. Ian Killeen also provided advice during site selection. Permission to work at Chilton Foliat, Market Weston and Thompson Common was kindly granted by Sir Seton Wills, and the Suffolk and Norfolk Wildlife Trusts respectively. Dennis Hart (Market Weston Fen voluntary warden) and Bev Nicholls (Norfolk Wildlife Trust) measured water levels at Market Weston and Thompson Common throughout the project and Matthew Simpson assisted with installation of dipwells and monitoring. The snail photograph on the front cover is provided under copyright by National Museum of Wales.

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1. Introduction

This report describes the combined results of two projects that were commissioned by English Nature and the Environment Agency, to define the hydrological requirements of the protected land-snail *Vertigo moulinsiana* (Dupuy, 1849) (Desmoulins whorl-snail). The first project (FIN/CON/141) commenced in April 2000 and comprised studies at 3 candidate Special Areas of Conservation (SAC), in Wiltshire, Norfolk and Suffolk.

The second project was commissioned in October 2001, and was undertaken under the *Life in UK Rivers* programme. It extended the scope of the studies at the Wiltshire site, by using a datalogger to make frequent automated records of water levels. The datalogger methodology yielded 2 significant benefits for the project. First, the high frequency of recording provides information on the diurnal changes in the water table, and second, because it enabled water level monitoring to take place in a very wet and previously inaccessible area known to support a high density of *V. moulinsiana*.

The information obtained is intended to assist English Nature and the Environment Agency when defining conservation objectives necessary for monitoring, and when undertaking reviews of consents for abstraction, as required of the Environment Agency for SACs under the Conservation (Natural Habitats, &c.) Regulations 1994. Interim findings of this project have been published in Tattersfield and McInnes (2003). Previous descriptions of the hydrological niche of *V. moulinsiana* have generally been qualitative in nature (eg. Stebbings and Killeen, 1998; Drake, 1999; Killeen, 2002; Cameron et al., 2003; Pokryszko, 2003). The objectives of the projects described here therefore include making firmer quantitative estimates of the hydrological requirements of the snail. A further objective is to define surrogate measures for suitable hydrological conditions, so that conservation staff, ideally requiring minimal training can assess whether a site is in good condition, without having to make lengthy empirical measurements.

The first project was originally intended to be completed by the end of 2001. However, because of the outbreak of foot and mouth disease in England in 2001 that prevented access to two of the sites, hydrological data could not be collected during spring and summer 2001. Accordingly the project was extended until the end of 2002.

2. Methods and project design

2.1 Study site selection

The project involved the detailed monitoring of snail populations, hydrological conditions, vegetation and other environmental variables on 3 of the candidate SACs that are designated for the species in England. One small area was chosen for detailed study within each of the selected SACs. The study areas were selected by reviewing available information on hydrology and snail populations (Killeen, 2001a, 2001b and 2001c), and by considering practical aspects that could affect the success of the project, such as access and land-use (eg. grazing and mowing management).

The SACs selected for the study are in Wiltshire, Suffolk and Norfolk (Fig. 1) and therefore reflect the different climatic regimes in central southern England and East Anglia:

- **Chilton Foliat**, Wiltshire – containing swamp (*Glyceria maxima*) and tall herb communities associated with a small flowing tributary of the River Kennet. This study area lies within the Kennet and Lambourn Floodplain SAC.

- **Market Weston Fen,** Suffolk - an East Anglian valley fen with sedge (*Cladium mariscus*), common reed (*Phragmites australis*) and other tall fen species. This fen constitutes part of the Waveney and Little Ouse Valley Fens SAC.

- **Thompson Common,** Norfolk – sedge (*Carex elata*) vegetation around the margins of a flooded waterbody formed within a fossilised glacial pingo remnant. Thompson Common is designated as a component part of the Norfolk Valley Fens SAC.

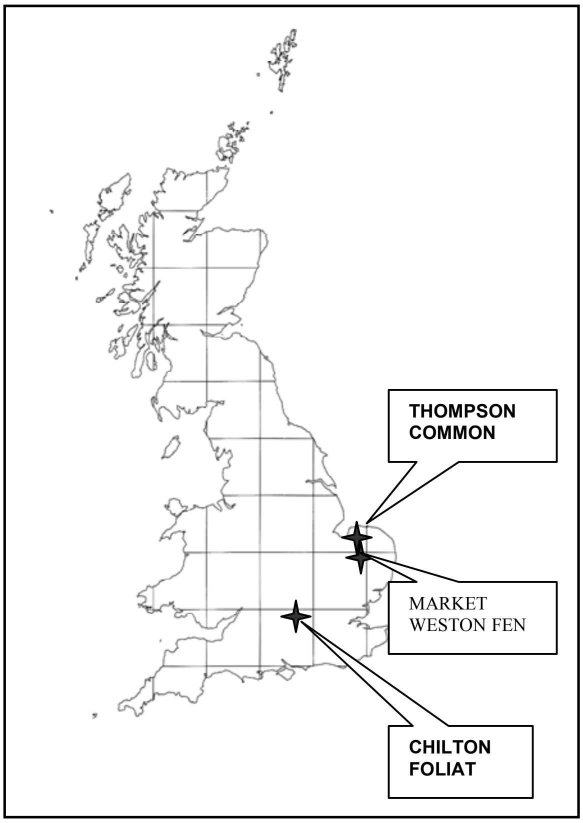

Figure 1 Locations of the cSACs

The study areas within the individual sites (Figs. 2, 4 and 6) were chosen during field visits in June 2000. A reconnaissance survey of the snail and local hydrology in suitable habitats on each of the SACs was undertaken, and the study sites eventually selected on the basis of the size and distribution of their snail populations, and the presence of local hydrological gradients.

2.2 Hydrological monitoring

2.2.1 Quantitative hydrological measurement

For the initial study (FIN/CON/141), 3 transects (A-C) each containing 4 monitoring locations (Figs. 3, 5 and 7) were marked out at each SAC, in order to record water level variation along the hydrological gradients. A dipwell was installed at each of the monitoring locations, using a 50mm Dutch Edelmann hand auger to excavate a hole to a depth of between 0.8 and 1.4m depending on the prevailing soil conditions (Fig. 8). The dipwells consisted of lengths of 32mm diameter plastic tubing, perforated with 8mm holes on 20mm centres, and lined with a porous membrane. These dipwell tubes were inserted into each hole. The holes were backfilled with pea gravel (< 10mm particle size) to 100mm below ground surface. Bentonite pellets were used to seal the top 100mm to reduce the ingress of surface water into the excavated hole. At each monitoring location a length of tubing was left extending above the ground surface. Each dipwell was covered with a cap to prevent rainfall or any other matter entering.

Water levels below top of the dipwell were recorded using a graduated electronic dipmeter. Water levels were recorded fortnightly at Chilton Foliat and Market Weston and monthly at Thompson Common. Table 1 shows the recording periods for the hydrological data reviewed in this report. Water levels were not measured at Market Weston and Chilton Foliat during the period of closure caused by the foot and mouth disease outbreak (Spring and Summer 2001). Water levels at Thompson Common were, however, measured during this period by the Norfolk Wildlife Trust warden while visiting livestock on the site.

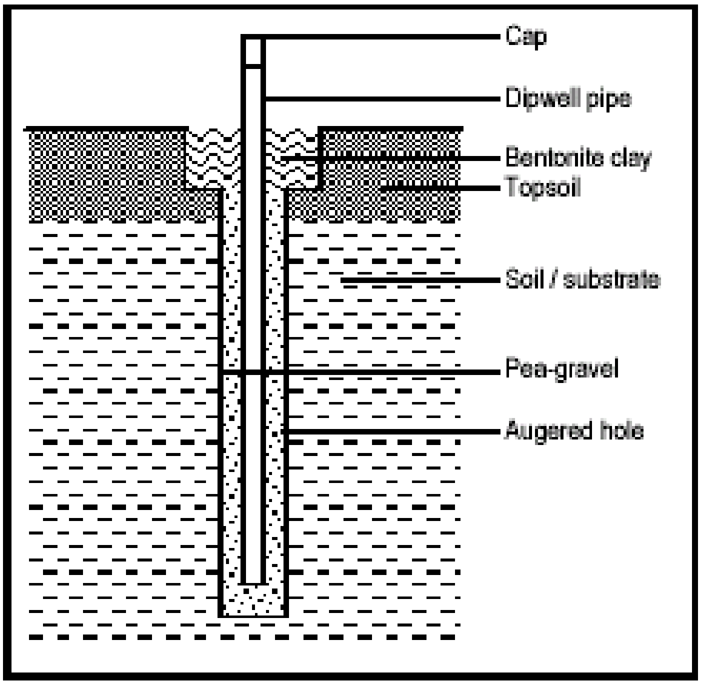

Figure 8 Dipwell installation

The automated hydrological monitoring system was installed at Chilton Foliat on 28th April 2002. This involved the use of a Skye Instruments SDL 5000 Series DataHog 2 electronic datalogger, connected to 8 pressure transducer water level recorders. The water level recorders were inserted into 8 additional dipwells that were installed as described above. These dipwells were aligned along three transects, comprising a new transect 'D' and an extension of the existing transects 'B' and 'C' (Fig. 3). The DataHog 2 was placed within a secure metal box that was fixed to a tree, to reduce the risk of vandalism.

The datalogger was set to record water levels at twenty-minute intervals. Stored information was downloaded from the datalogger to a laptop using SkyeLynx Standard Communications Software version 2.6. Three-monthly maintenance and download checks were undertaken. A communications error resulting in a loss of data between 1st July and 20th October 2002.

In total, hydrological monitoring extended over the period August 2000 to December 2002 (Table 1), although, as explained above there were some gaps in the data series caused by access restrictions and a fault associated with the datalogger.

Table 1 Hydrological data available for analysis from each of the sites

Site	Available data	Frequency recording
Chilton Foliat	23/8/2000 to 15/2/2001	Fortnightly
Manually-monitored dipwells	7/9/2001 to 22/10/2002	
Datalogger-monitored dipwells	28/4/2002 1/7/2002 20/10/2002 to 7/12/2002	20 minutes
Thompson Common	20/9/2000 to 12/11/2002	Monthly
Market Weston Fen	2/9/2000 to 23/2/2001 30/6/2001 to 15/4/2002 15/6/2002 to 16/9/2002	Fortnightly to monthly

2.2.2 Qualitative hydrological recording

The project brief included a requirement to examine simple surrogate measures to measure hydrological condition. Accordingly, soil dampness was also recorded on a qualitative five-point scale (Stebbings and Killeen, 1998) at each of the snail sampling locations. This 'Dampness Index' (Table 2) ranges from dry ground to areas inundated by water.

Table 2 Table 2 Dampness Index categories

Dampness Index	Ground Dampness Status
1	Dry
2	Damp
3	Wet – water rises under light pressure
4	Very wet – pools of standing water
5	Inundated

2.3 Soils

Soil profile descriptions were recorded during the installation of the dipwells. The recording of soil properties was conducted in order to understand the hydrological connectivity and conductivity between the soil surface, different soil horizons within the profile and groundwater. Soil cores were removed using a 40mm screw auger and each sample described to a depth of at least 100cm using the *Soil Survey Field Handbook* (Hodgson, 1997). Six properties were recorded for every 10cm of the profile: soil material, matrix colour, mottle colour, texture, organic matter and soil moisture. All these properties were determined in the field. Matrix colour and mottle colour were recorded by reference to a Munsell Soil Colour Chart. Colours determined were recorded as colour descriptions. Texture and mineral material were determined using a finger assessment method for mineral soils outlined in Rowell (1994). Organic matter was recorded as fibrous peat, amorphous peat, semi-fibrous peat, humus, humose, roots, undecomposed organic matter or decomposed organic material.

Samples of the top 100mm of the soil profile were collected in the field for calculating soil moisture. The soil samples were placed on a pre-weighed, open, porous plate. The combined weight of the plate plus soil was weighed before being placed in an oven at 80°C for 3 days, or until a steady weight was achieved indicating that all moisture had been removed. The plate and dried sampled were reweighed and the moisture loss calculated.

2.4 Weather and climate information

Site specific climatic data were not available and therefore regional climatic information for the study period has been acquired from the Meteorological Office (Fig. 9). These data allow the wider catchment hydrological conditions to be set in context against historical records, and consequently may be used to explain potential anomalies in the hydrological data collected over the monitoring period.

Information from the Meteorological Office region 'England South East and Central South' has been used to describe the prevailing climatic conditions at Chilton Foliat. Records from the Meteorological Office region 'East Anglia' have been used to describe the rainfall at both Market Weston and Thompson Common.

2.5 Site topography

Detailed topographic maps were made of the 3 study sites. At each site the topographic survey extended beyond the dipwell transects to include surrounding ground levels. The extent of the survey areas were: 50 x 30m at Chilton Foliat, 30 x 20m at Thompson Common and 25 x 20m at Market Weston Fen.

At each site a grid was established using a graduated steel tape and marker posts. Spot heights were recorded at minimum of 2.5m centres using a Leica NA720 Automatic Level. Frequently, where detailed topographic variation occurred spot heights were recorded on less than 1.0m centres. The site surveys were leveled in to Ordnance Datum using known benchmarks or reference points such as the top of existing EA groundwater monitoring standpipes. The adjacent ground level and the top of tubing were recorded for each dipwell. This allowed water levels to be converted to elevations above Ordnance Datum.

The spot height field data were used to generate detailed topographic maps for the three sites by applying an inverse distance weighting method using ArcView 3.2 GIS software.

2.6 Vertigo moulinsiana monitoring

Vertigo moulinsiana populations were monitored quantitatively on the study areas using the methods described by Stebbings and Killeen (1998). This approach involves shaking a stand of tall vegetation, approximately 0.5 x 1m in area, over a plastic sheet and counting the snails detached. The numbers of adult and juvenile *V. moulinsiana*, and other snail and slug species, were recorded.

This sampling method inevitably causes disturbance to the structure of the vegetation, and, in view of the small extent of the study areas, it was considered undesirable to repeat the monitoring too frequently, in case it affected the local distribution of the snail. In order to examine whether the snail's local distribution changed during the project, samples taken at varying degrees of intensity in June 2000, September 2000, October 2001 (Chilton Foliat only) and August 2002. Analyses of these data (Kendalls Concordance Test: all $P<0.001$) indicate that there was a high degree of concordance on all the sites over the 3 years, and therefore the combined data have been used. The most intensive snail sampling was undertaken in August 2002 when samples were taken on a 2.5 or 5m grid that extended across each of the study sites (Figs. 3, 5 and 7).

In order to examine whether *V. moulinsiana* were present lower in the vegetation and in the decaying leaf litter, two litter samples were removed in September 2000 from selected points known to contain a high snail density on each of the 3 cSACs. These samples were dried and sieved but no *V. moulinisana* were recorded so no further litter samples were taken in subsequent sampling. Other malacologists (Cameron *et al*. 2003) have observed that the snail can be found in the litter layer in the winter, but that it climbs vegetation in the summer. As a result of this behaviour, late summer is the optimum time of year to use the 'beating' method.

However, it should be noted that the method is sensitive to local conditions because of its reliance on the climbing behaviour of the snail that can be affected by climatic and seasonal conditions such as rainfall and wind. The method thus yields information on the snail's <u>relative</u> distribution and abundance, which means that direct comparison between different sampling sessions is not always meaningful. In order to try and avoid such problems, the detailed snail recording on each site was undertaken over the course of one day and under reasonably constant weather conditions.

Other methods of *V. moulinsiana* sampling were tried, including an attempt to count the number of snails on each stem of vegetation, but none were found to be practicable or provide advantages over the 'beating' method.

2.7 Microclimate variables

An attempt was made in September 2000 and October 2001 to record relative humidity, air temperature and incident light on each of the study areas at the same time as the snail sampling. However, these 'one-off' results show very little variation, and even less in relation to the dipwell locations. Therefore, they cannot be used to help account for the snail's local distribution. Furthermore, variation in local weather conditions, and changes due to the time of day, clearly had a major effect on the results, which rendered the results difficult to interpret meaningfully. As a consequence, these results are not presented or discussed further in this report.

The microclimate measurements were taken at ground level, at 50cms height within the vegetation, and also outside the vegetation canopy. A hand-held Hanna Instruments (HI93640) probe was used to record relative humidity and temperature, and a Leningrad 4 photographic exposure meter (with mounted invercone) used for light.

Based on this experience, it seems likely that an automated recording method, which could take readings throughout the day, might yield more readily interpreted information that might be related to the snail's distribution.

2.8 Vegetation and study site description

Sketch maps were compiled showing the main vegetation types on each of the study areas. Vegetation heights, and the dominant and abundant plant species, were recorded at the snail sampling locations. Additionally, 1 x 1m quadrats were placed near the dipwells and their constituent vascular plant species (with DOMIN values) recorded. This information was used to help classify the vegetation according to the NVC.

2.9 Methods of Analysis

The analysis focuses on the relationship between the snail's distribution and water levels and the qualitative Dampness Index, but also examines the snail's relationships with plant species and the other environmental variables. Regression analysis has been used to examine the relationship between several derived hydrological parameters obtained from the water level monitoring in the dipwells and the abundance of the snail at the dip-well locations. The Dampness Index is also related to the quantitative hydrological measurements.

2.9.1 Snail distribution and abundance

The grid-based snail data (adults and juveniles combined) collected in 2002, and results from the September 2000 samples, were interpolated using Arcview 3.2 GIS (ESRI), to produce 'surfaces' representing the snail's populations on the study areas. Three forms of an inverse distance-weighting algorithm (idw) were applied, involving inverse (1/d), inverse-square

($1/d^2$) or $1/d^4$ rules. The $1/d^4$ model was found to most closely represent the field data and this surface has therefore been used to make estimates of *V. moulinsiana* abundance at each of the dipwell locations. These estimates have then been used to relate the snail's distribution to the hydrometric measurements

2.9.2 Hydrological parameters

The topographic survey of the site has been used to calculate water levels relative to local ground level. Thus, periods of surface inundation are represented by positive water levels, whereas negative values represent sub-surface water tables. The values of water levels relative to ordnance datum provides information about local hydrological processes.

The following hydrological variables have been calculated for each dip-well location over the data-recording period.

- Annual, summer and winter mean water level.
- Annual, summer and winter maximum water level.
- Annual, summer and winter minimum water level.
- Annual, summer and winter range of water level.
- Annual, summer and winter mean depth of inundation.
- Annual, summer and winter percentage of time ground surface inundated.

In hydrological terms, winter is classified as the period October to March (inclusive); the remainder of year is termed summer.

3. Soils, soil moisture and water chemistry

Attempts have been made to classify the soils in terms of their overall properties and their wetness class. Assessment of the soils allows general hydro-geomorphological comparisons among the sites to be made which can assist in understanding the hydrological functioning of the sites.

3.1 Soils

The soils at all the sites exhibit similarities expected within wetland soils generally (Table 3). Groundwater gleys predominate, with humic groundwater gleys and peats common in the locations that experience longer periods of waterlogging. The drier soils are characteristically brown soils, often grading into groundwater gleys.

i. Chilton Foliat

At Chilton Foliat the soils furthest from the channel (Fig. 3) are characteristically transitional between brown soils and groundwater gleys. The soils become more humic and waterlogged towards the channel. Clays, with sand or grading into sandy clays, predominate overlying fluvial sands and gravels set within a clay matrix. The lowest lying areas are characterised by humic groundwater gleys with a well-developed surface organic horizon extending to a depth of at least 40cm below surface.

ii. Market Weston Fen

The Market Weston soils are the most uniform of the three sites, being predominantly amorphous to fibrous peats to a depth in excess of 100cm below surface. On the slightly elevated areas in the vicinity of dipwells A1, B1 and C1 the soils grade into humic groundwater gleys characterised by amorphous to fibrous peat over light grey calcareous clay.

iii.Thompson Common

The soils recorded at Thompson Common demonstrate a similar gradient to the soils observed at Chilton Foliat. Humic groundwater gleys dominate the lowest areas adjacent to the open water of the pingo remnant grading through groundwater gleys into brown soils with increasing elevation and distance from the open water. The groundwater gleys are characterised by amorphous humified peat developed on light grey clay with reworked chalk fragments. The brown soils are relatively freely drained demonstrating no signs of mottling or the development of gley features.

Table 3 Summary soil descriptions from the study sites (* classification based on Avery (1987))

Dipwell	Depth (cm)	Horizon description	Classification*
Chilton Foliat			
A4 B4 C4	0 - 10	Dark brown, silty clay with occasional sand	Transitional between Brown soil and Groundwater gley
	10 - 50	Light brown to grey brown, silty clay with abundant sand and lithic clasts up to 40mm diameter	
	50 – 60	Brown white, clay with chalk fragments	
	60 - 100	Light brown to brown grey, sandy clay, becoming sand and gravel	
A3 B3 C3 D3	0 - 25	Dark brown grey, silty clay abundant lithic clasts up to 40mm diameter	Groundwater gley
	25 - 45	Light grey, clay abundant lithic clasts up to 40mm diameter	
	45 - 70	White, occasionally brown white, clay, abundant chalk fragments	
	70 - 80	Dark brown to black, clay, occasionally silty to sandy	
	80 - 100	Light grey to brown grey, clay with abundant sand, becoming sand and gravel	
A1 A2 BA B0 B1 B2 CA C0 C1 C2 D0 D1 D2	0 - 40	Dark brown to black, clay with occasional sand	Humic groundwater gley
	40 - 50	Medium brown to dark grey brown, sandy gravel with clay matrix	
	50 - 100	Light grey brown to grey, sandy gravel with clay matrix	
Market Weston			
A1 B1 C1	0 - 60	Dark brown to black, amorphous humified to fibrous peat	Humic groundwater gley
	60 - 100	Light grey, calcareous, clay	
A2 A3 A4 B2 B3 B4 C2 C3 C4	0 - 100	Dark brown to black, amorphous humified to fibrous peat	Peat soil
Thompson Common			
A1 C1	0 - 10	Medium brown, humose, clayey sand	Brown soil
	10 - 30	Medium brown to brown, sand to sandy clay	
	30 - 100	Light brown to light grey, sand, silty sand to sandy clay	
A2 B1 C2	0 - 20	Dark brown to black, amorphous to fibrous peat	Groundwater gley
	20 - 35	Light brown to light grey silty to sandy clay	
	35 - 100	White to occasionally light grey clay and reworked chalk fragments	
B2	0 - 35	Dark brown to black, amorphous humified to fibrous peat	Humic groundwater gley
	35 - 100	White to occasionally light grey clay and reworked chalk fragments	
A3 A4 B3 B4 C3 C4	0 - 45	Dark brown to black, amorphous humified peat	Humic groundwater gley
	45 - 55	Light grey to light grey brown silty clay	
	55 - 65	Dark brown to orange clay to silty clay	
	65 - 100	White to occasionally light grey clay and reworked chalk fragments	

3.2 Soil moisture

Unsurprisingly, soil moisture within the topsoil (top 100mm) is strongly correlated with water levels, with the soils possessing the highest moisture levels correlating with the highest water levels (Fig. 10). The correlation is strongest at Chilton Foliat (r^2=0.7737) and Thompson Common (r^2=0.8318). At Market Weston a much weaker correlation (r^2=0.0053) exists, demonstrating the minimal variation in both variables.

Based on the hydrological monitoring and the soil profile descriptions it is possible to assign each dipwell location a soil wetness class (Hodgson, 1997) (Table 4). Dipwells A4, B4, and C4 at Chilton Foliat and A1 and C1 at Thompson Common are relatively dry and can be assigned to wetness class III. The soils at all the other locations possess gley features within 40cm of the ground surface. The majority of the remaining dipwell locations can be assigned to wetness class IV or VI. The only exceptions are dipwell A3 at Market Weston and dipwell B2 at Thompson Common which are assigned to wetness class V due to the presence of a humose or peaty topsoil greater than 20cm thick.

Table 4 Dipwell locations assigned to soil wetness classes (from Hodgson, 1997)

	Dipwell			
Wetness Class	**Chilton Foliat**	**Market Weston**	**Thompson Common**	**General Properties of the Soil Profile**
I				The profile normally lacks gley features within 70cm or an impermeable horizon within 80cm depth. Many strongly gleyed, permeable soils, with efficient drainage systems also occur in this class.
II				The profile normally lacks gley features within 40cm or an impermeable horizon within 60cm depth.
III	A4 B4 C4		A1 C1	The profile normally lacks gley features or an impermeable horizon within 40cm depth.
IV	A3 B3 C3 D3	A1 B1 C1	A2 B1 C2	The profile normally has gley features and an impermeable horizon within 40cm depth, but lacks a humose or peaty topsoil greater than 20cm thick.
V		A3	B2	The soil normally has predominant gley features within 40cm depth and is usually wet within 70cm depth. Commonly the topsoil is humose or peaty and the natural vegetation has numerous hydrophilous species.
VI	A1, A2 BA, B0, B1, B2 CA, C0, C1, C2 D0, D1, D2	A2, A4 B2, B3, B4 C2, C3, C4	A3, A4 B3, B4 C3, C4	The profile normally has a peaty topsoil, a predominantly gleyed mineral subsoil and is usually wet within 40cm depth. The natural vegetation consists of hydrophilous species.

3.3 Water chemistry

One off pH readings, using a Hanna Instruments probe, were recorded at the three sites in order to provide a very cursory assessment of the base status of the water (Table 5). The mean pH values range between 6.68 and 6.88 for the three sites indicating neutral to base-rich conditions during the monitoring period. The maximum range of values was observed at Thompson Common, with the lowest range recorded at Chilton Foliat. No clear gradients were observed at any of the sites and accordingly the data have not been used for further analysis.

Table 5 pH of water from dipwells, 8 to 10 October 2001

	Chilton Foliat	Thompson Common	Market Weston
A1	7.03	6.51	6.87
A2	6.80	6.97	7.01
A3	6.72	6.34	6.56
A4	6.80	6.52	6.74
B1	6.80	6.71	6.48
B2	6.94	6.57	6.81
B3	6.71	6.60	6.85
B4	6.88	6.69	7.02
C1	6.98	6.93	6.60
C2	6.94	6.86	6.73
C3	6.99	7.14	6.64
C4	7.01	6.30	6.62
mean	6.88	6.68	6.74
Max	7.03	7.14	7.02
Min	6.71	6.30	6.48
range	0.32	0.84	0.54

4. Chilton Foliat

This chapter presents the results from the Chilton Foliat study area on the Kennet and Lambourn Floodplain SAC. It is divided into subsections on a) vegetation and plant communities, b) the climatic conditions during the project, c) hydrology, and d) the populations of *V. moulinsiana* on the site. Figure 11 shows a simplified vegetation map of the Chilton Foliat study area, and the site's surface topography is shown on Fig. 12.

a. **Vegetation**

The dipwell transects A-C at Chilton Foliat (Fig. 3) run along a hydrological gradient that extends northwards from a permanently flowing channel. The vegetation (Fig. 11) at the channel margins (dip-wells A1, B1 and C1) is dominated by *Glyceria maxima* and is readily classified as *Glyceria maxima* swamp community (National Vegetation Classification (NVC) community S5). Immediately south of these transects, the flowing channel is dominated by a bed of *Rorippa nasturtium-aquaticum*. The additional transect D, and the southwards extensions of transects B and C (dipwells B0, BA and C0, CA, Fig. 3), that were installed for the datalogger monitoring, extend onto the south side of the flowing channel, which also contains an extensive area of *Glyceria maxima* swamp. There is an area of mature woodland outside the study area to the south, that partly casts shade on the swamp communities to the south of the watercourse.

The ground rises (Fig. 12) to the north of the channel (dip-wells A3/4, B3/4 and C3/4) where the tall-herb vegetation has a more mixed composition. This vegetation community contains terrestrial species including locally frequent *Urtica dioica*, *Petasites hybridus, Phalaris arundinacea* and *Galium aparine.* The area also shows signs of recent surface disturbance, possibly caused by scrub clearance management undertaken over the past few years. Its plant community is not readily classified using the NVC, but it appears to have affinities with the *Phragmites australis-Filipendula ulmaria* tall-herb fen (NVC S26) or/and the *Epilobium hirsutum* community (OV26). However, it lacks some of the constants of both of these community types. A line of mature trees and shrubs runs outside and to immediately to the north of the study area.

b. **Weather/climate during the project**

At Chilton Foliat the period between the onset of monitoring in August 2000 and April 2001 was characterised by unusually 'wet' conditions, with rainfall between 28 and 165% above the long-term average (Fig. 9). Following this 'wet' period, relatively 'dry' conditions prevailed for the early part of summer 2001 with May and June recording –44 and –58% of the long-term average rainfall respectively. Late summer 2001, extending into the autumn, was characterised by relatively 'wet' conditions (rainfall between 8 and 78% of the long-term average). The winter and early spring of 2001 to 2002 was uncharacteristically 'dry', with the notable exception of a 'wet' February 2002.

The period May through to September 2002 was marked generally by alternating relatively wet and dry months, with May and July being 'wet' and the other months being 'dry'. The onset of winter 2002, from September to October through to November, was marked by a rapid increase in rainfall and the prevalence of relatively 'wet' conditions.

c. **Hydrological context**

The study site at Chilton Foliat occupies the riparian and floodplain areas adjacent to a small tributary stream of the River Kennet. The tributary stream joins the River Kennet approximately 450m downstream of the study site.

The water levels across the site are controlled primarily by water levels in the River Kennet and the catchment hydrogeological controls. The geology of the Kennet in this part of the catchment is dominated by the cretaceous Chalk. The Chalk aquifer acts as a large water storage unit, supplying 95% of the water in the Kennet as groundwater (Environment Agency, 2000). Therefore the stream-flow hydrograph is characteristically smooth, depicting a slow response to rainfall events and droughts alike. The Kennet hydrological regime is typical of a Chalk stream as it receives a stable base flow component from the groundwater all year round, despite the reduction in rainfall in the summer months (Whitehead *et al*, 2002). The rainfall and percolation patterns driving the Kennet hydrological regime cause spring peaks and late autumn troughs in water levels. Low flows in summer and early autumn will clearly have a major impact on instream ecological quality. A study by Limbrick *et al.* (2000) has shown that the impacts of climate change on the low flow regime could be significant for the River Kennet and its associated wetland habitats.

Head gradients across site vary from transect to transect (Fig. 13). At Transect A, the furthest upstream of the four transects, flows are predominantly from the floodplain to the channel during both winter and summer. However, at the three other transects flows are from the channel towards the elevated floodplain to the north. The precise mechanism for these gradients is not clear from the data collected and would need to be investigated further through detailed piezometric monitoring. A possible mechanism could be the local ponding and backing up of water from the western end of the site, resulting from the constriction in the flow caused by the footpath bridge. This would also explain the relatively elevated water levels across the transect C in comparison with the upstream transects B and D.

Figure 14 shows the variation in water levels in the manually recorded dipwells during the course of the project. Figure 15 shows equivalent results for the shorter time period in 2002, obtained from the datalogger. Data from both manual and automated water level recording are shown on Fig. 16. The values of the derived hydrological variables are given in Appendix I. Figure 17 shows the variation in Dampness Index across the Chilton Foliat study area.

The seasonal flow characteristics of the River Kennet are mirrored in the water levels recorded within the study site stream and the adjacent areas (Fig. 18). Water levels remained high through the winter of 2000 to 2001 reflecting the relatively ‘wet’ period. With the onset of monitoring post the lifting of the foot and mouth restrictions, water levels over the late summer and into autumn 2001 demonstrated a gradual increase following a ‘wet’ July to October period. Instead of a steady increase in water levels, as observed over the winter 2000 to 2001, the uncharacteristically ‘dry’ November and December in 2001 manifested itself in a decrease in water levels across the study site.

The relatively ‘wet’ January and February 2002 resulted in the characteristic spring peak in water levels, which over the period from March to September 2002 result in an autumn trough. Fluctuations in water levels over this period reflect the influence of catchment rainfall, such as experienced over May 2002 which recorded in excess of 50% above the long-term average rainfall for the area.

The rapid increase in rainfall in October through to December 2002 is just recorded in the dipwell data (Fig. 14), with water levels increasing by in excess of 30cm at the three monitoring locations.

Figure 17 shows the variation in the qualitative Dampness Index at Chilton Foliat. The fringes of the channel and most of the extensive *Glyceria* swamp to the south fall into DI3, but there is a wetter area that is classified as DI4 in the vicinity of dipwells D0 and B0.

4.1 Evaluation of the use of the datalogger

The datalogger allowed a more thorough examination of the fluctuation of water levels to be recorded at Chilton Foliat. Figure 16 provides a comparison between the datalogger and the manually recorded data for the period between April and June 2002. For the wetter areas (C1 and D1) the overall trend is similar. However for the sites with increasing dryness (especially C3 and D3), and therefore potentially towards the threshold of suitable conditions for *V. moulinsiana*, subtle variation in water levels is not always defined through manual recording. The change in water levels over periods of one or two days of approximately 20cm observed in D3 was not identified in C3. It is possible that manual recording could either over or under estimate the wetness of the site, depending on the timing of the recording. Consequently, assumptions on the suitability of the site for *V. moulinsiana*, especially in their more peripheral habitat, could be inaccurate.

Unfortunately, given the existing data sets, the mechanism for these short term water level fluctuation is not clearly understood. Further information on site specific rainfall and evapotranspiration would be required to define better the processes responsible.

Any field based data collection will be invasive to a degree and can alter the habitat being monitored. Following initial installation, the utilisation of a datalogger and the associated automatic sensors ensured that any subsequent damaged to the habitat and associated fauna was minimised. Consequently the hydrological and ecological dynamics associated with the datalogger sensor locations were less disturbed and are more representative of undisturbed *Vertigo moulinsiana* habitat.

An important element of using a datalogger was the reduced health and safety risk associated with recording data in poorly accessible or more potentially dangerous areas associated with soft substrates and subject to flooding. By limiting the frequency of access, risk to human health was minimised and appropriately managed.

d. ***Vertigo moulinsiana*** **populations**

The distribution of *V. moulinsiana* interpreted from the 2002 grid sampling is shown on Fig. 19. A summary of the *V. moulinsiana* data for 2000 and 2002 is given in Table 6, and the full snail results from 2002 provided in Appendix II. *Vertigo moulinsiana* abundance ranged from zero to 57 and 115, in samples taken during the main recording sessions in September 2000 (27 samples all north of the channel) and August 2002 (94 samples on both sides of the channel) respectively.

Vertigo moulinsiana is absent from most of the tall herb communities in the north part of the study area (approximately north of the dipwell 3 line), but its abundance rises rapidly in the vicinity of the watercourse. However, the species is most abundant in the extensive area of *Glyceria* swamp on the south side of the channel, especially between transects A and B, but also in the vicinity of dipwell C0; these parts of site contain the largest continuous stands of *Glyceria* and are mostly assigned to Dampness Index 3. The area between transects B and C on the south of the channel supports a lower density of *V. moulinsiana* and has damper soils that were assigned to Dampness Index 4)(Fig. 20). The snail is also less abundant along the southern fringe of the study area, probably because it is partial shade from the adjacent tall trees immediately outside the area.

Vertigo moulinsiana is most abundant (2002 data) from samples dominated by *Rorippa nasturtium aquaticum, Glyceria maxima* or *Carex riparia/acutifomis* (Fig. 20). Very few specimens were recorded from samples where other tall herb species dominated.

In respect of the qualitative measure of soil wetness, *V. moulinsiana* is most strongly associated with samples assigned to Dampness Index 3 (Fig. 21).

Table 6 Chilton Foliat: Numbers of *Vertigo moulinsiana* at the dipwell positions (September 2000 August 2002)

Chilton Foliat									
Transect	**Well**	**Position**	***Vertigo moulinsiana* 2000**			**Dipwell**	**2000 Mean**	**2002**	**Abundance category**
			Adult	Juvenile	Total				
A	1	A1	8	0	8				
A	1	A1+0.5	13	0	13	**A1**	8.7	30	H
A	1	A1+0.5	5	0	5				
A	2	A2+0.5	0	0	0	**A2**	0.5	17	M
A	2	A2+0.5	1	0	1				
A	3	A3	0	0	0	**A3**	0	1	L
A	3	A3	0	0	0				
A	4	A4	0	0	0	**A4**	0	0	A
A	4	A4-1	0	0	0				
B	1	B1-1	15	10	25				
B	1	B1-1	12	2	14	**B1**	14.5	13	H
B	1	B1	12	1	13				
B	1	B1	5	1	6				
B	2	B2	1	0	1	**B2**	0.5	2	L
B	2	B2	0	0	0				
B	3	B3+0.5	0	0	0	**B3**	0	2	l
B	3	B3+0.5	0	0	0				
B	4	B4-1.5	0	0	0	**B4**	0	0	A
B	4	B4-2	0	0	0				
C	1	C1+0.5	40	17	57	**C1**	42.5	12	H
C	1	C1+0.5	18	10	28				
C	2	C2	13	3	16	**C2**	14.5	6	M
C	2	C2	9	4	13				
C	3	C3	0	0	0	**C3**	0	0	A
C	3	C3	0	0	0				
C	4	C4-0.5	0	0	0	**C4**	0	0	A
C	4	C4-1	0	0	0				
						B0		48	H
						BA		3	L
						C0		35	H
						CA		0	A
						DO		11	M
						D1		33	H
						D2		7	L
						D3		0	A

1) 2000 sampling: Position refers to the offset from the closest dipwell (m, with negative distances closer to watercourse (eg C4-1 is 1m closer to watercourse than dipwell C4)

2) 2002 data are obtained from the 1/d^4 interpolation which is based on the 2002 grid sampling.

Abundance categories: H – high; M – medium; L – low; A - absent

5. Market Weston Fen

The results from Market Weston Fen are presented in this section. It is divided into subsections on a) vegetation and plant communities, b) the climatic conditions during the project, c) hydrology, and d) the populations of *V. moulinsiana* on the site. Figure 11 shows a simplified vegetation map and the site's surface topography is shown on Fig. 22.

a. Vegetation

The transects (Fig. 5) extend across an area of tall fen vegetation near the east edge of the Suffolk Wildlife Trust (SWT) reserve (Fig. 4). The study area was selected because, unlike much of the fen vegetation on the reserve, it has not been cut for many years. A cursory review of *V. moulinsiana* distribution across the Fen during site selection indicated that cut areas appeared to support lower snail densities. The study area has a hydrological gradient extending more-or-less south-west to north-east, from damp grassland communities along the southern fringe of the site, towards a ditch along the north edge of the site that also marks the edge of the nature reserve. However, the study area also contains small-scale, locally undulating topography, which apparently contributes to more complex hydrological patterns. Overall topographic variation on the Market Weston Fen study area is very low, with elevations ranging by only about 33cms, from 20.67m to 21.00m AOD (Fig. 22).

The main part of the study area comprises tall (>150cms) *Phragmites* with stands of *Cladium* and *Carex paniculata* (Fig. 11). These communities can be ascribed to the NVC *Phragmites australis-Eupatorium cannabinum* tall-herb fen community (S25), probably the *Carex paniculata* sub-community (S25b). The western edge of the study area contains a shorter (c. 80cm) community dominated by *Juncus subnodulosus* with a sparse and open cover of *Phragmites*. In the NVC it can be classified as *Juncus subnodulosus-Cirsium palustre* fen meadow community (M22).

b. Weather/climate during the project

The rainfall conditions recorded across East Anglia were broadly the same as for England South East and Central South (Fig. 9). Notable exceptions were the magnitude of variation from the long-term average during the winter of 2000 to 2001, with deviation from the average generally less than experienced in the South East and Central South of England. Conversely, over the summer of 2001 the rainfall recorded in East Anglia demonstrated a larger deviation from the long-term average than in the South East and Central South of England.

c. Hydrological context

Unlike the Chilton Foliat study site, Market Weston Fen has been subject to numerous hydrological investigations (Gilvear *et al*., 1989, Williams *et al*., 1995, Environment Agency, 1999a and 1999b) and is extensively monitored through a network of dipwells and piezometers.

Market Weston Fen lies in a shallow valley with most of the fen on the south side of a small tributary stream of the Little Ouse. The study area lies to the south east of the causeway, which transects the fen, towards the boundary of the site (Fig. 4).

The regional geology is till overlying upper chalk. ‘Putty chalk’, a low permeability cryoturbated layer at the surface of the chalk, forms a thin but distinct and hydrogeologically important layer within the fen area but its presence appears to be discontinuous (Gilvear *et al*., 1994). Where present, the ‘Putty chalk’ will reduce flow interactions between the wetland and the underlying groundwater. Sand and gravel deposits underlie the till, and peat occurs locally on the fen, and is present within the study area. Therefore the site represents a wetland overlying an unconfined aquifer with a number of springs and flushes.

Fluctuations in the water levels from the chalk aquifer vary across the area from 0.5 to 3.0m for the period 1972 to 1998, but from within the site annual fluctuation is usually less than 1m (Environment Agency, 1999b). Analysis of piezometric data reveals upward head gradients along the southern edge of the fen and peat piezometric values almost always at or above ground level (Gilvear *et al*., 1994). Further analysis of on-site piezometric data from the locations closest to the study site reveal long-term variations in piezometric surface of less than 0.15m (Environment Agency, 1999b).

The water levels recorded over the monitoring period from September 2000 to September 2002 (Fig. 23) exhibit a maximum fluctuation of 0.11m, a value consistent with earlier studies. The low magnitude of water level variation is reflected in weak hydraulic gradient across the three transects from dipwell 1 to dipwell 4 (Fig. 13). However, it must be noted that dipwells record water levels in the peat under atmospheric rather than piezometric pressure, therefore direct comparison is not fully appropriate. What can be demonstrated is that the water level fluctuation at the study site was minimal over the monitoring period and correlations with local rainfall weak, suggesting a greater reliance on regional groundwater dynamics than surface water or precipitation inputs.

The qualitative Dampness Index ranges from 1 to 4 on the study area, with the dampest areas being found in the north east corner, and along the south east edge (Fig. 24). Based on the Dampness Index, the main gradient of dampness extends from the relatively dry south west corner to the wetter samples along the south east side of the site.

d. ***Vertigo moulinsiana*** **populations**

Figure 25 shows the distribution of *V. moulinsiana* on the study area based on the 2002 grid sampling. Table 7 summarises the *V. moulinsiana* results for 2000 and 2002 and the full 2002 snail data are provided in Appendix II.

Very different numbers of *V. moulinsiana* were recorded in 2000 and 2002. Overall, the mean number of *V. moulinsiana* per sample was 24.7 (range: 0-79) in September 2000, but only 1.8 (range: 0-16) in August 2002. The reason for the low density in 2002 is not clear, especially since high numbers were found in the same month at both Thompson Common and Chilton Foliat. Inspection during the sampling confirmed that the snail was not present (and being overlooked) in significant numbers in the leaf litter on the ground.

The low counts in 2002 means that the grid-based interpolation (Fig. 25) is likely to be less accurate than it might have been. However, despite this, the snail’s local distribution is very similar in 2000 and 2002, with the interpolation surface generated from the 2000 data (not shown) bearing a close resemblance to Fig. 25. The highest *moulinsiana* densities were in the north-east corner of plot, especially in vicinity of dipwells C4, C3, C2 and B3 (2002 only) and B2 (2000 only). The snail was absent, or present at low density along transect row 1 and on transect A.

The snail's distribution clearly correlates with the patterns of soil wetness on the site, as measured by the Dampness Index (Fig. 24). The 2002 samples ranged from Dampness Index 1 (one sample only) to 4 (Fig. 21). If the single Dampness Index 1 sample is excluded, then *V. moulinsiana* was recorded most abundantly in samples assigned to Index 3 or 4; it was significantly less abundant in Dampness Index 2 samples.

Vertigo moulinsiana was most abundant in samples dominated by *Carex paniculata* and *Phragmites* (Fig. 20).

Table 7 Market Weston Fen: Numbers of *Vertigo moulinsiana* at the dipwell positions (September 2000 August 2002)

Market Weston Fen									
Transect	**Well**	**Position**	***Vertigo moulinsiana* 2000**			**Dipwell**	**2000 Total**	**2002**	**Abundance category**
			Adult	Juvenile	Total				
A	1	0.5	4	0	4	**A1**	7	0	L
A	1	1.5	3	0	3				
A	2	0.5	8	2	10	**A2**	16	2	M
A	2	0.5	5	1	6				
A	3	0.5	20	6	26	**A3**	48	1	M
A	3	0.5	17	5	22				
A	4	0.5	7	9	16	**A4**	27	0	M
A	4	0.5	2	9	11				
B	1	0.5	6	0	6	**B1**	10	0	L
B	1	0.5	4	0	4				
B	2	0.5	41	27	68	**B1**	10	0	L
B	2	0.5	10	18	28				
B	3	-0.5	2	1	3	**B3**	16	6	M
B	3	-0.5	2	0	2				
B	4	-0.5	2	0	2	**B4**	16	0	M
B	4	-0.5	12	2	14				
C	1	1.5	0	0	0	**C1**	2	0	L
C	1	2.5	1	1	2				
C	2	0.5	39	23	62	**C2**	110	2	H
C	2	0.5	24	24	48				
C	3	0.5	66	13	79	**C3**	128	5	H
C	3	0.5	36	13	49				
C	4	0.5	43	12	55	**C4**	116	7	H
C	4	0.5	50	11	61				

1) 2000 sampling: Position refers to the offset from the closest dipwell (m, with negative distances to the south west)
2) 2002 data are obtained from the 1/d^4 interpolation which is based on the 2002 grid sampling.

Abundance categories: H – high; M – medium; L - low

6. Thompson Common

The results from Thompson Common are presented in this section. It is divided into subsections on a) vegetation and plant communities, b) the climatic conditions during the project, c) hydrology, and d) the populations of *V. moulinsiana* on the site. Figure 11 shows a simplified vegetation map and the site's surface topography is shown on Fig. 26.

a. **Vegetation**

The pingo remnant that forms the study site is referred to as Pingo no. 64b by the Norfolk Wildlife Trust. The vegetation is strongly zoned in concentric belts around the open water of the pingo remnant (Fig. 11). The dip-well transects extend radially from a broad belt (c. 10-12m wide) of tussocky *Carex elata* swamp (NVC S1), which fringes the open water. Further away from the open water there is a belt dominated by *Juncus subnodulosus*, with patchy stands of *Juncus acutiflorus,* which can be assigned to the NVC's *Juncus subnodulosus-Cirsium palustre* fen-meadow community M22a. The land then rises (Fig. 26) to drier areas of the transects that support mesotrophic grassland with abundant *Holcus lanatus*, *Arrhenatherum elatius, Festuca rubra*, *Avenula pubescens* and *Anthoxanthum odoratum*.

b. **Weather/climate during the project**

Thompson Common is located 18km from Market Weston Fen and weather conditions over the period of the project (based on regional meteorological office data) are assumed to be equivalent on these two sites (see para 5.4 and Fig. 9).

c. **Hydrological context**

Thompson Common is situated in a south-westward trending valley of a tributary of the River Wissey. The surface of the site is gently undulating, comprising a number of depressions known as pingos, or more accurately as fossilised pingo remnants. The site has been subject to monitoring in recent years on behalf of the Environment Agency (Environment Agency, 1999c and 1999d).

The site is underlain by the chalk aquifer. Groundwater conditions vary across the site due to the variable nature of the overlying drift deposits. Semi-confined to near unconfined conditions occur in the vicinity of the study area. Analysis of chalk water levels from the closest borehole to the study site suggests that the Drift water level is in direct hydraulic continuity however any correlations between groundwater levels and surface water levels in the pingos need to be viewed with caution (Environment Agency, 1999d).

Analysis of historical water level monitoring reveals the same annual fluctuations as recorded between September 2000 and September 2002 (Fig. 27). Peak water levels occur in late winter, usually in March. Water levels reduce over spring and summer to an annual low in late summer early autumn, often in September. Annual water level fluctuation in some pingos can be in excess of 1.0m. Observed maximum fluctuation over the monitoring period varied between 0.3 and 0.5m, with seasonal variation in water levels being positively correlated with rainfall data.

The hydraulic gradients for transects B and C demonstrate that flow is from the higher adjacent land towards the pingo (Fig. 13). However transect A is anomalous due to relatively low water levels recorded in dipwell A1, indicating that flow is away from the pingo. A gradient also exists from transect C, through transect B, towards transect A. This might indicate that the groundwater movement is predominantly towards east and south-east perpendicular to transects B and C, reflecting a stronger influence of groundwater movements than surface water run-off inputs.

In August 2002, Dampness Index ranged from 1-5, with the samples taken from *Carex elata* tussocks on the fringes of the open water being inundated. The pattern of Dampness Index (Fig. 28) on the study area indicates a gradual pattern, which follows the relatively uniform topography of this pingo depression.

d. ***Vertigo moulinsiana* populations**

Figures 20 and 29 show that *V. moulinsiana* (2002 data) is strongly associated with the *Carex elata* swamp at the fringes of the pingo's waterbody, rather than the higher areas of grassland, or the *Juncus subnodulosus* community. Table 8 summarises the 2000 and 2002 *V. moulinsiana* results and the full 2002 snail data are provided in Appendix II. The distribution of *V. moulinsiana* is very similar in 2000, suggesting that there has not been a significant shift during the course of the project.

In 2002, *Vertigo moulinsiana* was most abundant in samples assigned to Dampness Index 5 (Fig. 21), and there was a gradual decline in abundance across the range Dampness Index 1-4. Only 4 snails were recorded in the 21 samples assigned to Dampness Index 1.

Table 8 Thompson Common: Numbers of *Vertigo moulinsiana* at the dipwell positions (September 2000 August 2002)

Thomson Common									
Transect	**Well**	**Position**	***Vertigo moulinsiana* 2000**			**Dipwell**	**2000 Total**	**2002**	**Abundance category**
			Adult	Juvenile	Total				
A	1	0.5	0	0	0	**A1**	0	0	A
A	1	1	0	0	0				
A	2	2.3	0	0	0	**A2**	0	0	A
A	2	2.6	0	0	0				
A	3	4.3	1	1	2	**A3**	2	5	L
A	3	4.3	0	0	0				
A	4	7.5	15	8	23	**A4**	34	33	H
A	4	7.5	9	2	11				
B	1	-0.5	0	0	0	**B1**	0	1	A
B	1	0.8	0	0	0				
B	2	1.5	0	0	0	**B2**	0	3	L
B	2	1.5	0	0	0				
B	3	3	0	1	1	**B3**	3	8	M
B	3	3	2	0	2				
B	4	6.8	4	1	5	**B4**	19	9	M
B	4	6.8	8	6	14				
C	1	0.7	0	0	0	**C1**	0	0	A
C	1	0.8	0	0	0				
C	2	2	1	0	1	**C2**	1	1	L
C	2	2	0	0	0				
C	3	4	3	0	3	**C3**	6	15	M
C	3	4	2	1	3				
C	4	8.8	12	5	17	**C4**	34	12	H
C	4	8.8	12	5	17				

Note:
1) 2000 campling: Position refers to the distance (m) from dipwell 1 in the transect
2) 2002 data are obtained from the 1/d^4 interpolation which is based on the 2002 grid sampling.

Abundance categories: H – high; M – medium; L – low; A - absent

7. Hydrological requirements of *Vertigo moulinsiana*

Vertigo moulinsiana abundance varies very strongly over short distances on all the study areas, and the general patterns follow obvious hydrological gradients. At Chilton Foliat, *V. moulinsiana* abundance rises rapidly in the riparian fringe, which extends for a distance of less than 4 metres on the north side of the channel. A similar pattern is observed at Thompson Common in relation to the flooded pingo. At Market Weston Fen, the hydrological gradients and their relationship with the snail appear to be more complex, partly because of the low range of topography, but also as a result of the low snail counts made in 2002. However, even here, the interpolated surface (Fig. 25) clearly demonstrates that populations are higher in the damper north-east corner of study area.

7.1 Quantitatative hydrological measures

There is a close, linear relationship between water level and the abundance of *V. moulinsiana* (log scale) at Thompson Common and Chilton Foliat (Figs. 30 and 32). The range of annual fluctuation in mean water level, from about –0.4m to +0.4m, is very similar on both these sites. Clearly, given the uniformity of the hydrological controls, the dipwell data for summer and winter maximum, minimum and mean water levels will be highly correlated, so all the graphs show similar patterns. At Chilton Foliat, there is an indication that *V. moulinsiana* abundance may reach a maximum under the high water levels in the *Glyceria* swamp on the south side of the channel; this may tentatively suggest that optimum water level conditions may have been identified for the snail at Chilton Foliat, although additional data, from more deeply inundated sites, and over a longer time period, would be required to confirm this.

In contrast, water levels show very little seasonal fluctuation at Market Weston Fen, and the relationship between *V. moulinsiana* and water level is weak and probably non-linear (Fig. 31). Polynomial regressions for annual mean and summer maximum levels with *V. moulinsiana* abundance are significant ($P<0.05$), and may indicate that there is an optimum hydrological regime for the snail on this site. However, the weak correlations indicate that relationships with water levels do not adequately account for the snail's distribution at Market Weston Fen.

At Chilton Foliat and Thompson Common, *V. moulinsiana* was significantly correlated with mean annual percentage inundation, but no relationship was found with the annual range of water level on any of the sites, in either summer of winter. At Thompson Common, the highest *V. moulinsiana* counts were associated with dipwells that were inundated for at least about 40% of the year.

Figures 30-32 contain information about the snail's hydrological requirements, but it must be interpreted with caution since several of the dipwells were situated in 'dry' locations where there were no snails, and the inclusion of these tends to 'flatten' the regression line. An alternative approach is to identify water levels on Fig. 30-32 below which the snail does not occur. This method of interpretation yields minimum summer and winter threshold water levels (Table 9). *Vertigo moulinsiana* does not occur where the water level is lower than these thresholds, and it only occurs at very low levels under these hydrological conditions. They can thus be considered to be critical water levels for the snail. The summer and winter thresholds at Thompson Common and Chilton Foliat are identical, and they are –0.5m and –0.4m respectively. The equivalent mimima at Market Weston Fen are –0.1m and –0.07m.

Table 9 Critical minimum water level thresholds for *V. moulinsiana*

	Chilton Foliat		**Thompson Common**			**Market Weston Fen**	
m	Summer	Winter	Summer	Winter	m	Summer	Winter
0.2					**0.04**		
0.1					**0.02**		
0.0	**GROUND SURFACE**				**0.00**	**GROUND SURFACE**	
-0.1			**Maximum**	**Maximum**	**-0.02**	**Maximum**	
-0.2					**-0.04**		**Maximum**
-0.3		Maximum			**-0.06**		Minimum
-0.4	**Maximum**	Minimum		Minimum	**-0.08**		
-0.5	Minimum		**Minimum**		**-0.10**	Minimum	

The critical thresholds identified above represent hydrological conditions where the snail can occur at very low levels of abundance. Managing a site to maintain these critical minimum water levels would be unlikely to retain healthy snail populations. Information about the hydrological conditions where the snail is abundant, and where its population might be considered closer to a 'favourable condition', has been obtained by categorising populations at each dipwell into high, medium, low and absent categories. These categories have been assigned subjectively, by reviewing the 2000 and 2002 data (Tables 6, 7 and 8).

Classification of the hydrographs according to these categories (Figs. 33-36), shows, as expected, that snail abundance generally increases with increasing water levels. The 4 snail abundance categories are associated with very similar hydrological regimes at Chilton Foliat and Thompson Common, whereas different patterns are evident at Market Weston Fen. At Chilton Foliat and Thompson Common, in the high snail abundance category, the water level never or very rarely falls below the ground surface over the duration of the project; overall, it fluctuates around a mean level of about 0.2-0.3m. The medium abundance category is associated with a hydrological regime in which the water level fluctuates around ground level, but rarely exceeds 0.2m either above or below the ground surface, whereas water levels associated with low populations are mainly restricted to below ground level, and they typically fluctuate between –0.4m and ground level (0m). At Chilton Foliat, the snail is absent where the water level remains below (or very rarely exceeds) 0.4m below the ground surface. In contrast, at Thompson Common, the hydrology of the absent snail class fluctuates more widely and tracks the low abundance class, although its water levels are consistently lower. At Thompson Common, water level does not rise above ground level during the study period at any of the dipwells where *V. moulinsiana* was absent.

The Chilton Foliat datalogger information provides a shorter time series of information, but it generally supports these conclusions although there are some anomalies. The snail is absent from dipwell CA, which is one of the two 'wettest' dipwell sites recorded. Dipwell CA may be sited in hydrological conditions that are too wet for the snail, although a high snail population is present at dipwell D1, where the hydrological regime is very similar to that of CA. Shading from the adjacent trees may provide another explanation why CA is unsuitable for the snail.

Patterns at Market Weston Fen (Fig. 35) are less readily interpreted. However, the most abundant snail populations are associated with sites where the water level fluctuates around ground surface. Two of the medium populations also follow this hydrological regime, although the other 2 medium populations are associated with water levels that remain above or below the ground (+0.2m and –0.2m). The snail is absent where the water table rarely exceeds –0.05m, except for C1 and to a lesser extent B1 during June-October 2002 when water levels rise to near the ground surface.

7.2 Qualitative hydrological measures

The availability of quantitative hydrological data at most *V. moulinsiana* sites is likely to be low. Consequently, an assessment has been made of the potential application of qualitative hydrological measures (or 'surrogates'). The two measures investigated are soil wetness class (*sensu* Hodgson, 1997) and Dampness Index (*sensu* Stebbings and Killeen, 1998).

7.2.1 Soil wetness class

Unsurprisingly, soil wetness class correlates positively with mean water level relative to ground surface (r^2=0.7027). Each wetness class is characterised by a range in mean water levels. The water level range for each wetness class is described in Table 10 and based on this the high *V. moulinsiana* populations would be associated with Wetness Class IV, at least at Chilton Foliat and Thompson Common. It is possible that a proficient soil surveyor could use soil wetness class, in conjunction with other surrogate indicators to assist in assessing site condition for *V. moulinsiana*.

Table 10 Mean water levels associated with soil wetness classes described from the study sites

Wetness class	Mean water level ranges relative to ground surface recorded at the study sites (m)
III	-0.69 to -0.39
IV	-0.46 to -0.06
V	-0.18 to -0.04
VI	-0.14 to +0.39

7.2.2 Dampness index

Analysis has been undertaken to try and relate the qualitative Dampness Index (Table 2) to the quantitative hydrological conditions recorded in the dipwells. Dampness Index measurements made towards the end of August 2002 provide a qualitative estimate of late summer ground dampness conditions. The water levels recorded on the date nearest to the day when Dampness Index was recorded have been compared with the summer minimum level, to evaluate whether the Dampness Index is representative in terms of defining the driest ground conditions associated with late summer draw-down. The results indicate that there is a strong positive correlation (r^2=0.974) between the overall summer minimum water level (recorded over the monitoring period) and the late August 2002 water level, and this suggests that the Dampness Index recorded in August 2002 might be useful as a surrogate for summer minimum water levels.

Figure 37 shows the relationships between the August 2002 Dampness Index, August 2002 water levels and the overall minimum summer water levels. The information is summarised in Table 11. The relatively low hydrological gradient recorded at Market Weston is demonstrated by the limited variation in the water level associated each dampness class. The range of summer water levels associated with each dampness index class is greatest at Chilton Foliat. The values recorded at Thompson Common broadly lie towards the wetter range of the Chilton Foliat data.

There is a strong positive linear relationship between summer minimum water level and Dampness Index at both Chilton Foliat (r^2=0.550) and Thompson Common (r^2=0.881). The gradient of the linear relationship is the same at the two sites (Chilton Foliat: 0.299; Thompson Common: 0.293) which demonstrates that for these 2 types of site, the relationship between dampness index and minimum summer water level is equivalent. Again this substantiates the use of Dampness Index as a potential surrogate measure of summer minimum water level.

Table 11 Range of summer minimum water levels associated with dampness indices recorded at the study sites

	Summer minimum water level relative to ground surface (m)					
Dampness index	**Chilton Foliat**	**Market Weston**	**Thompson Common**	**Maximum**	**Minimum**	**Average**
1	-0.79 to -0.52	n/a	-0.98	-0.52	-0.98	-0.76
2	-0.56 to 0.24	-0.16 to -0.06	-0.66 to -0.26	0.24	-0.66	-0.24
3	-0.11 to 0.34	-0.06 to -0.05	-0.25	0.34	-0.25	-0.03
4	0.05 to 0.26	-0.01 to 0.01	0.07 to 0.11	0.26	-0.01	0.08
5	n/a	n/a	n/a	n/a	n/a	n/a

7.2.3 Relationship between dampness index and *Vertigo moulinsiana* populations

In late August 2002, *V. moulinsiana* is most abundant in samples assigned to Dampness Index 3 (Table 2) at Chilton Foliat, and 4 and 5 at Market Weston Fen and Thompson Common respectively (Fig. 21). An equivalent analysis of Killeen's (2001a, 2001b and 2201c) data for the same 3 sites (collected in August/September 2001) indicate a slightly different pattern, with optimum Dampness Index categories of 3 or 4, 3 and 4 for Chilton Foliat, Market Weston Fen and Thompson Common respectively. Clearly, these differences may reflect seasonal or year-to-year variation in soil dampness, or possibly variation between recorders. However, the discrepancies also illustrate that the Dampness Index needs to be used with caution when interpreting the suitability of hydrological conditions for the snail, or for basing management decisions.

The critical summer minimum water level threshold for *V. moulinsiana* at Thompson Common and Chilton Foliat has been identified as –0.5m (see para. 7.5 and Table 9) which would (see Fig. 37) be equivalent to a minimum Dampness Index of 2. However, as discussed above, managing a site to maintain a Dampness Index of 2 in the summer would not be adequate to sustain a population of *V. moulinsiana.* A similar analysis of the Market Weston Fen data is not possible because of the very low range in water level.

7.3 Conclusions

The findings from Thompson Common and Chilton Foliat are remarkably consistent and clear, and suggest that the hydrological requirements of the snail are essentially the same at these two sites. The project has thus established the hydrological requirements of *V. moulinsiana* with a reasonably high degree of confidence at these sites.

The findings from Thompson Common and Chilton Foliat can be used to identify critical minimum water levels, and also the hydrological regime associated with high snail populations. These conclusions are summarised in Table 12, and can form the basis for the management of hydrological regimes for the snail on these candidate SACs.

In contrast, interpretation of the Market Weston Fen results is difficult, and, in some cases, the results from this site are ambiguous. This is probably partly a consequence of the very small range in water level exhibited at Market Weston Fen, and the low snail density recorded in 2002. These factors mean that it is difficult to resolve the requirements of the species, and, as a result, conclusions drawn from the Market Weston Fen study should be treated cautiously, and require further validation. The Market Weston Fen findings may suggest that the hydrological requirements of the snail are very different at this fen site compared with Chilton Foliat and Thompson Common, and that the snail occurs in a much narrower range of hydrological conditions where water fluctuates by only a few centimetres around the ground surface.

The hydro-geomorphology and soils of the Chilton Foliat and Thompson Common are similar. Both sites are dominated by vertical fluctuations in water associated with inundation from an adjacent water body and characterised by groundwater gley soils. Whereas the Market Weston site is characterised by seasonal waterlogging resulting in ephemeral standing water over peat dominated soils. The difference in hydro-geomorphic controls results in the different hydrological regimes recorded. Consequently the weaker conclusions drawn at Market Weston may also result from overall hydro-geomorphic functioning of the site.

The close relationships found between the snail's abundance and water level at Thompson Common and Chilton Foliat suggest that site hydrology is the major factor determining the local distribution of the snail. However, it would seem likely that the influence of ground water levels on the snail maybe mediated via air humidity, since the snail spends much of the year climbing high in the canopy of the vegetation well away from the ground. This relationship would merit further investigation, and could have practical conservation relevance, since humidity regimes are likely to be influenced vegetation structure, which are clearly affected by management.

Additionally many other aspects germane to the interpretation of the occurrence of *V. moulinsisana*, such as water discharge rates, water chemistry, especially pH, soil chemistry, predation and inter species competition could also warrant further study.

Table 12 Hydrological requirements of *Vertigo moulinsiana* at Chilton Foliat and Thompson Common

Status of *V. moulinsiana*	Mean annual water level	Annual range of fluctuation in water level	Critical minimum water level		Relationship with ground surface
			Summer	**Winter**	
Presence of *V. moulinsiana*			-0.5m	-0.4m	
High population	Greater than +0.25m	0m to +0.6m			Water level never/very rarely falls below ground.
Medium population	0m	0.2m to +0.2m			Water level fluctuates between –0.2m and +0.2m during the year.
Low population	Less than 0m	-0.4m to 0m			Surface inundation rare.

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Figures

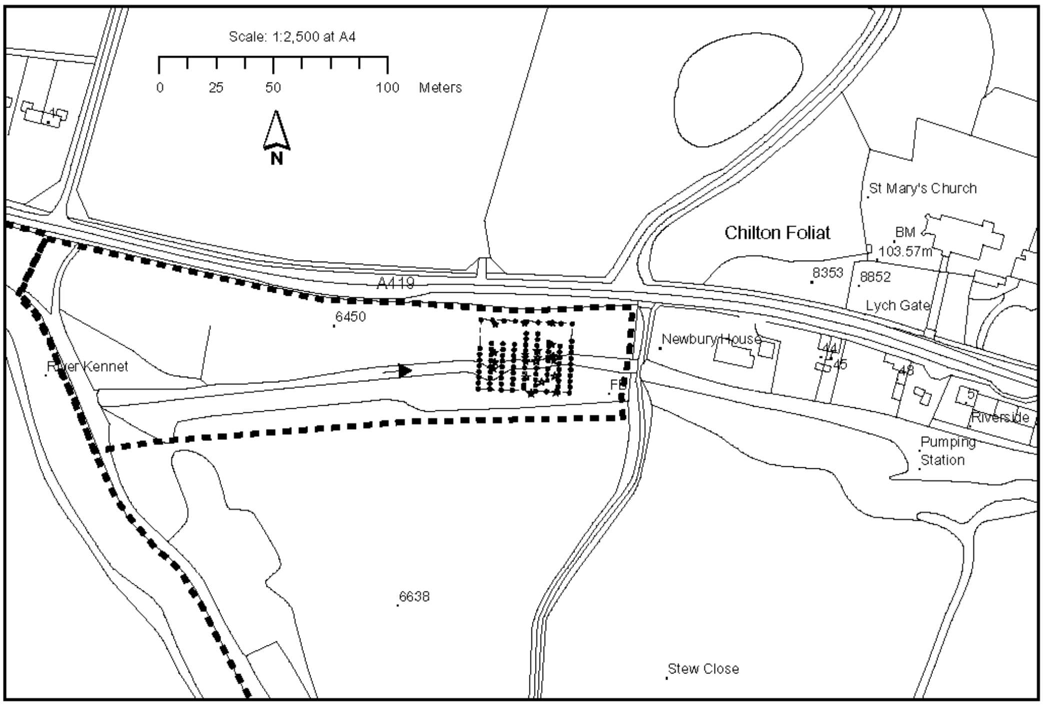

Figure 2 Location of the Chilton Foliat study area within the Chilton Foliat cSAC

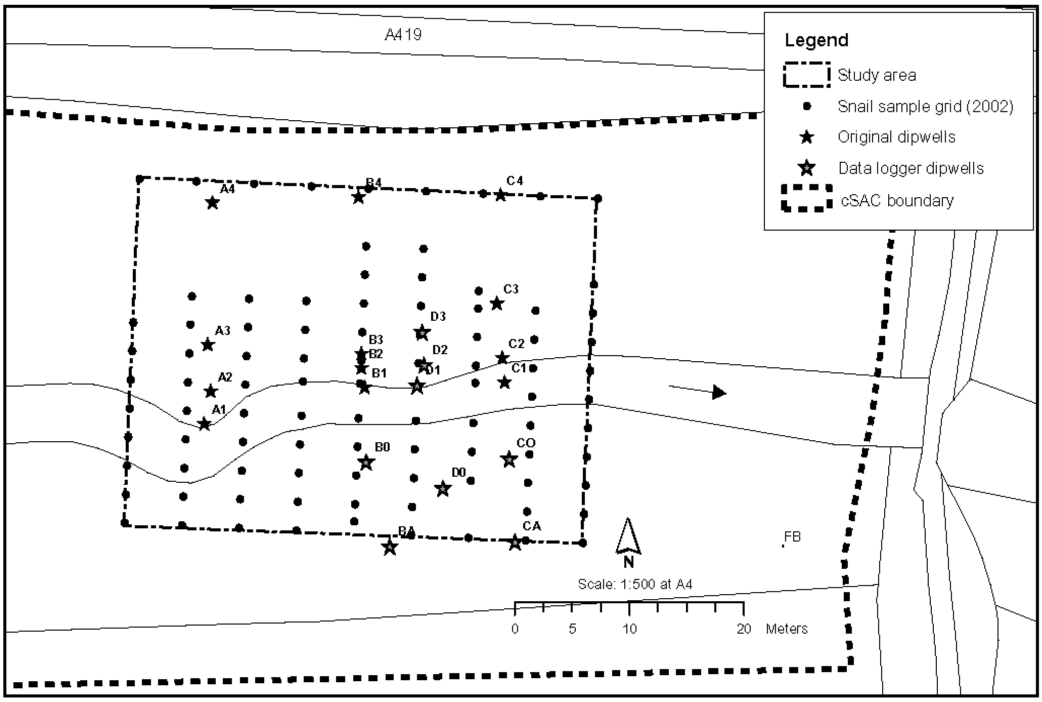

Figure 3 The Chilton Foliat study area with dipwell locations and snail sampling grid

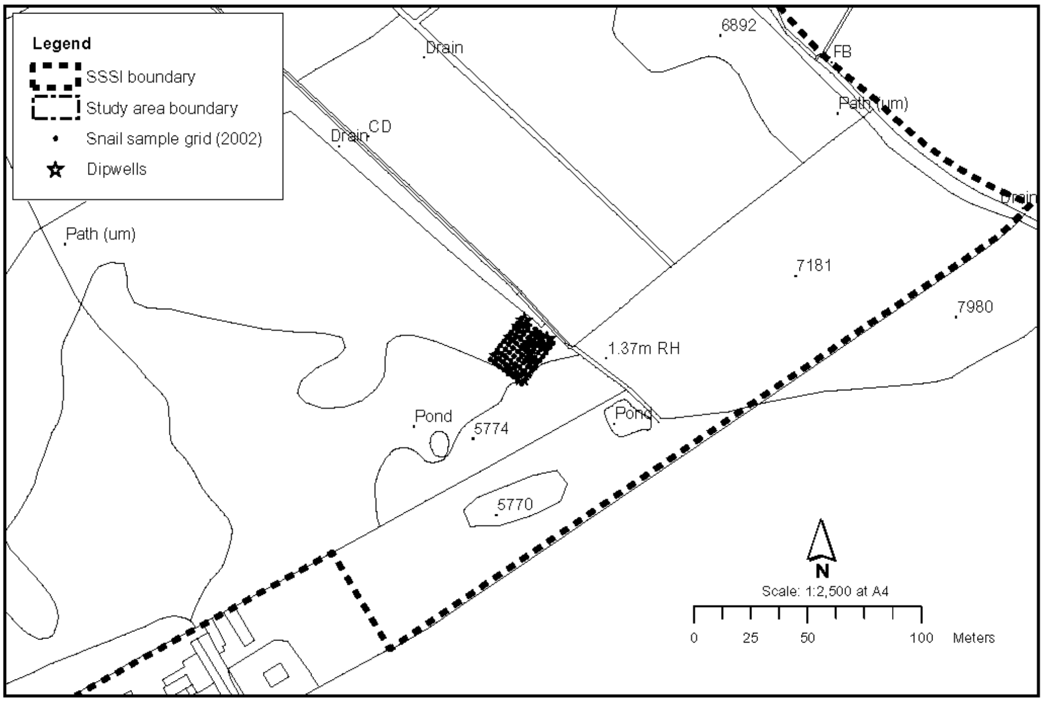

Figure 4 Location of the Market Weston Fen study area

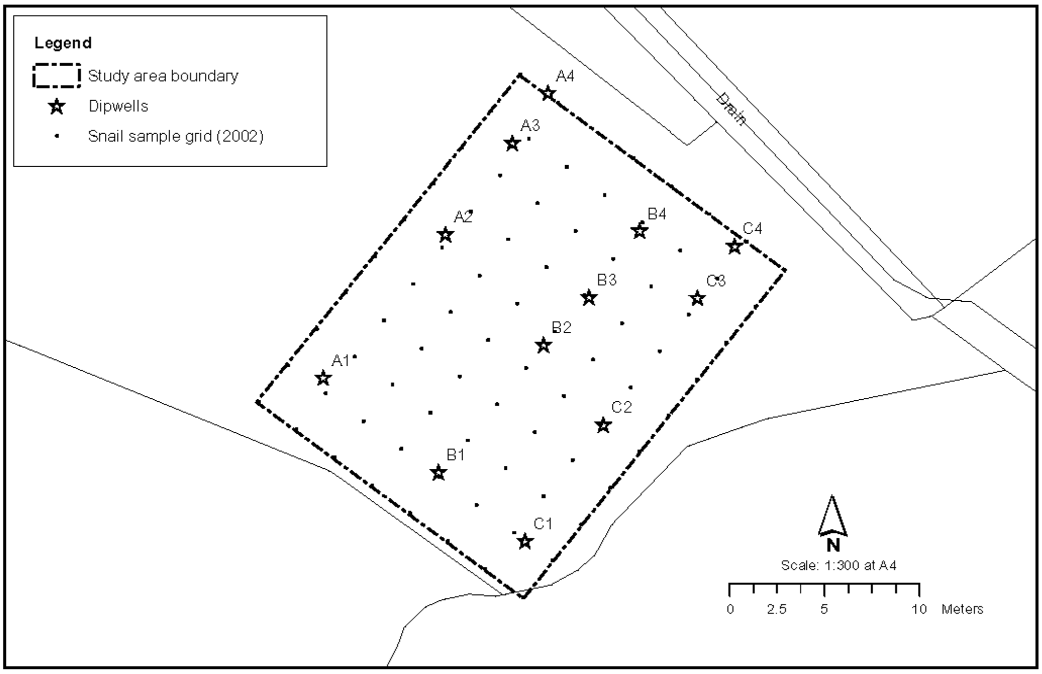

Figure 5 The Market Weston Fen study area with dipwell locations and snail sampling grid

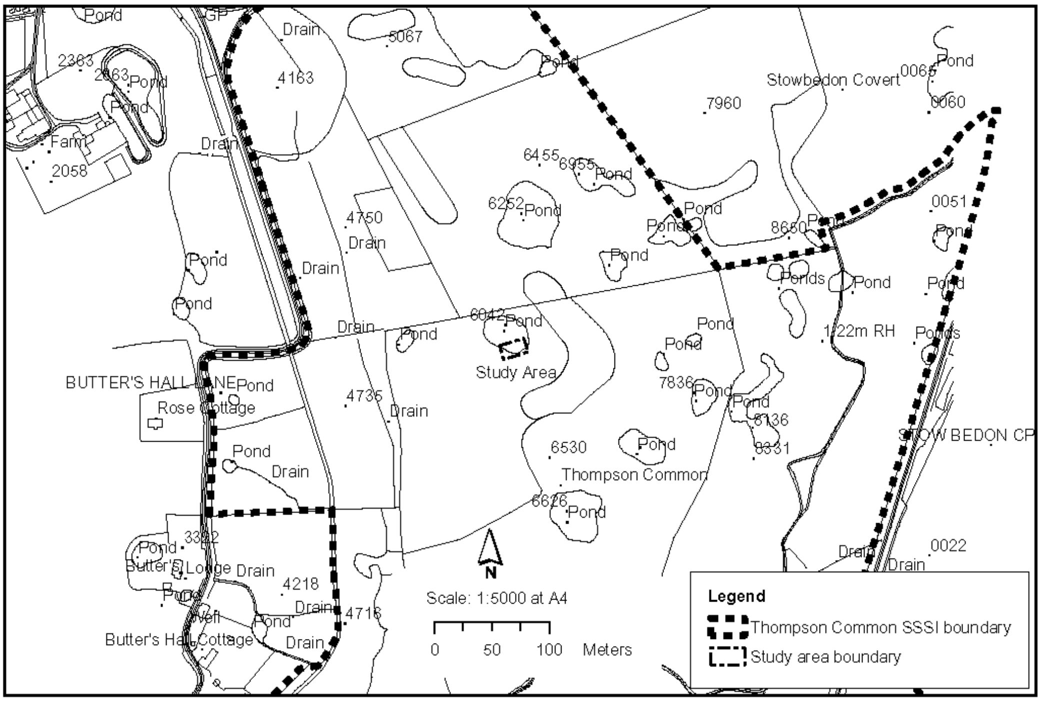

Figure 6 Location of the Thompson Common study area within Thompson Common SSSI

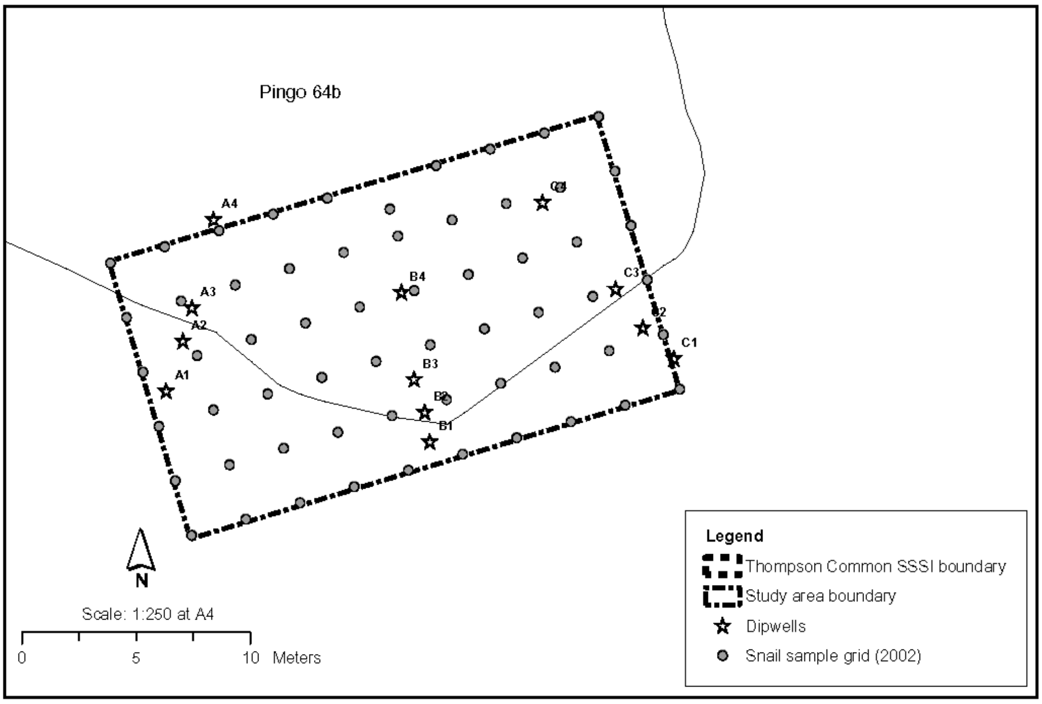

Figure 7 The Thompson Common study area with dipwell locations and snail sampling grid

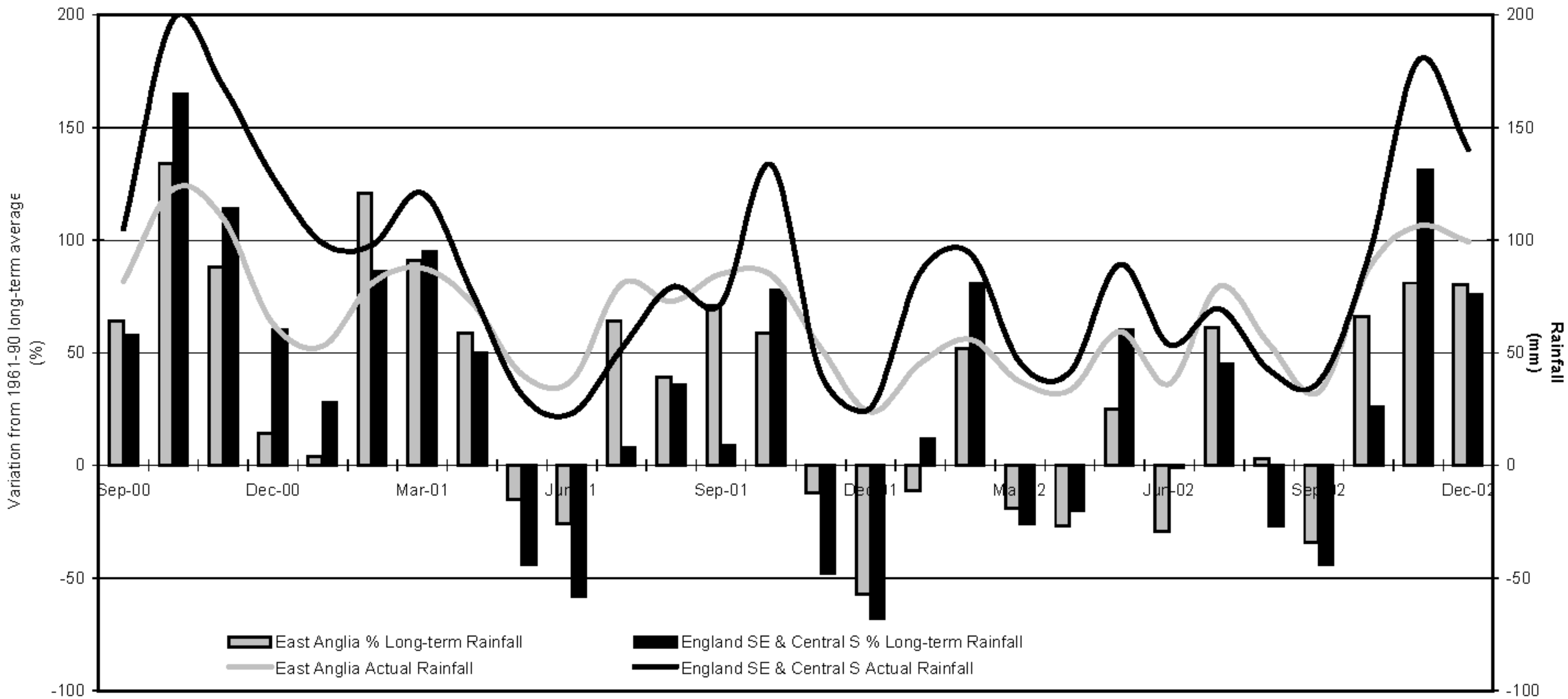

Figure 9 Regional rainfall: September 2000 – December 2002
(Source: http://www.met-office.gov.uk/climate/uk/)

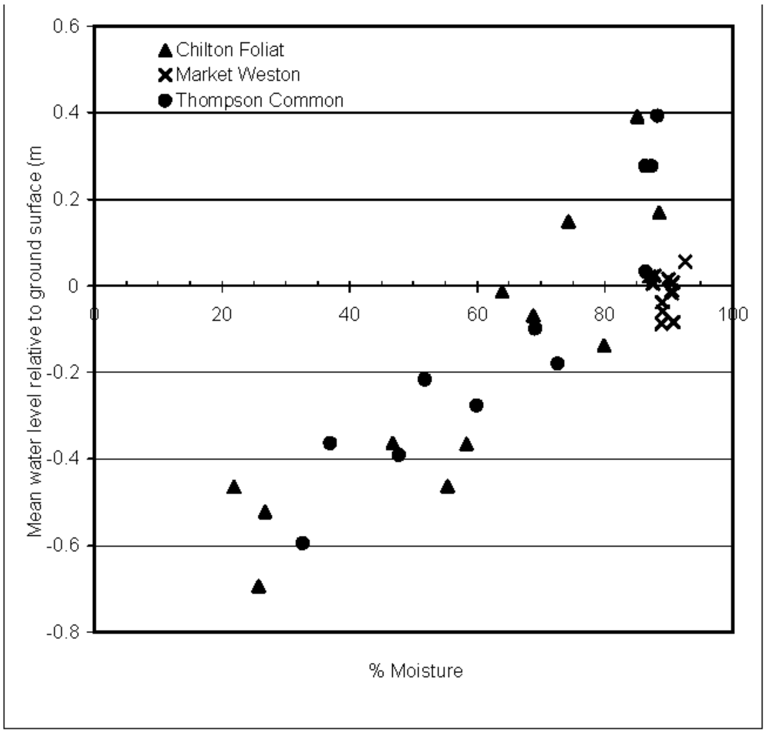

Figure 10 Relationship between mean water level and % soil moisture

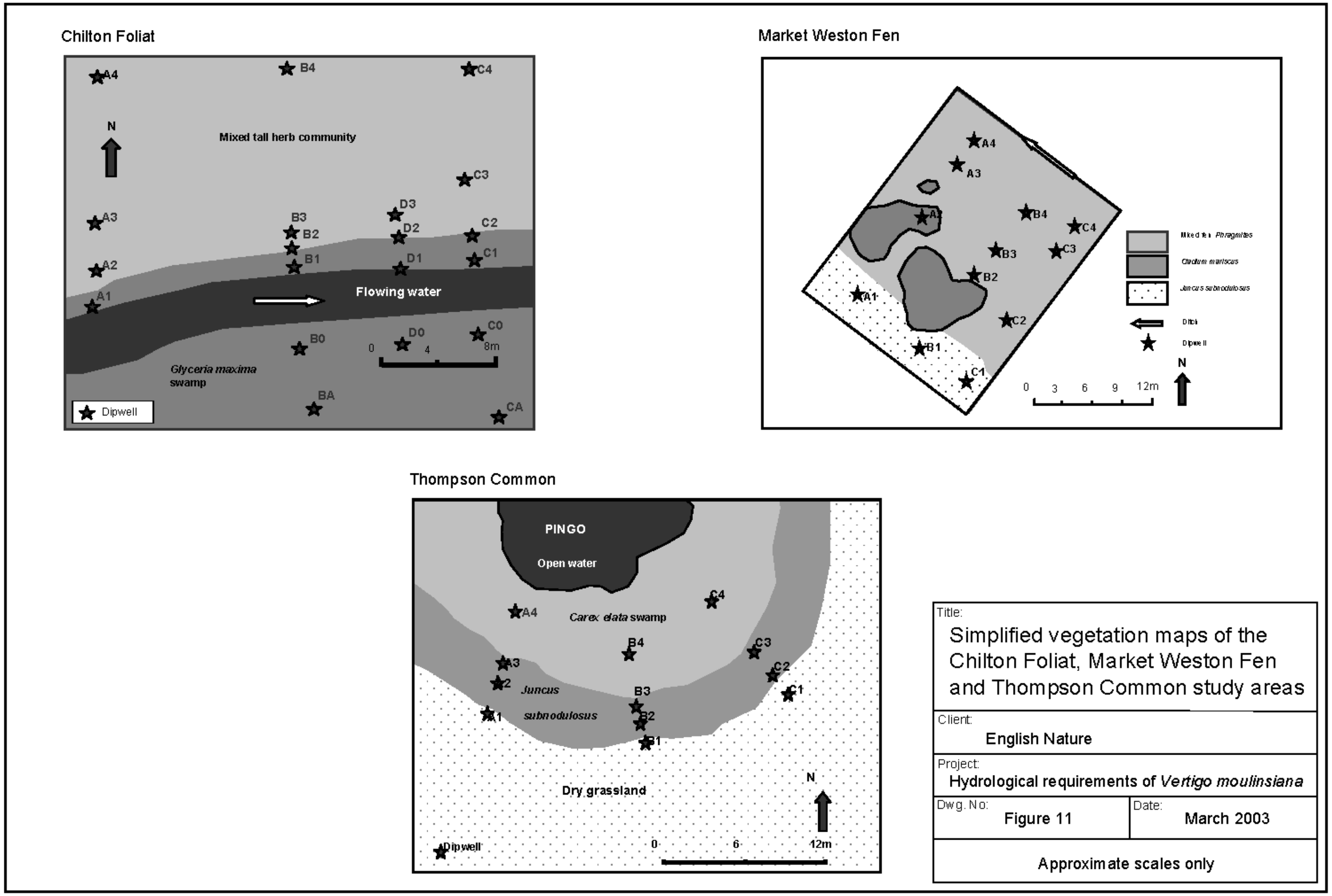

Figure 11 Simplified vegetation maps of the Chilton Foliat, Market Weston Fen and Thompson Common study areas

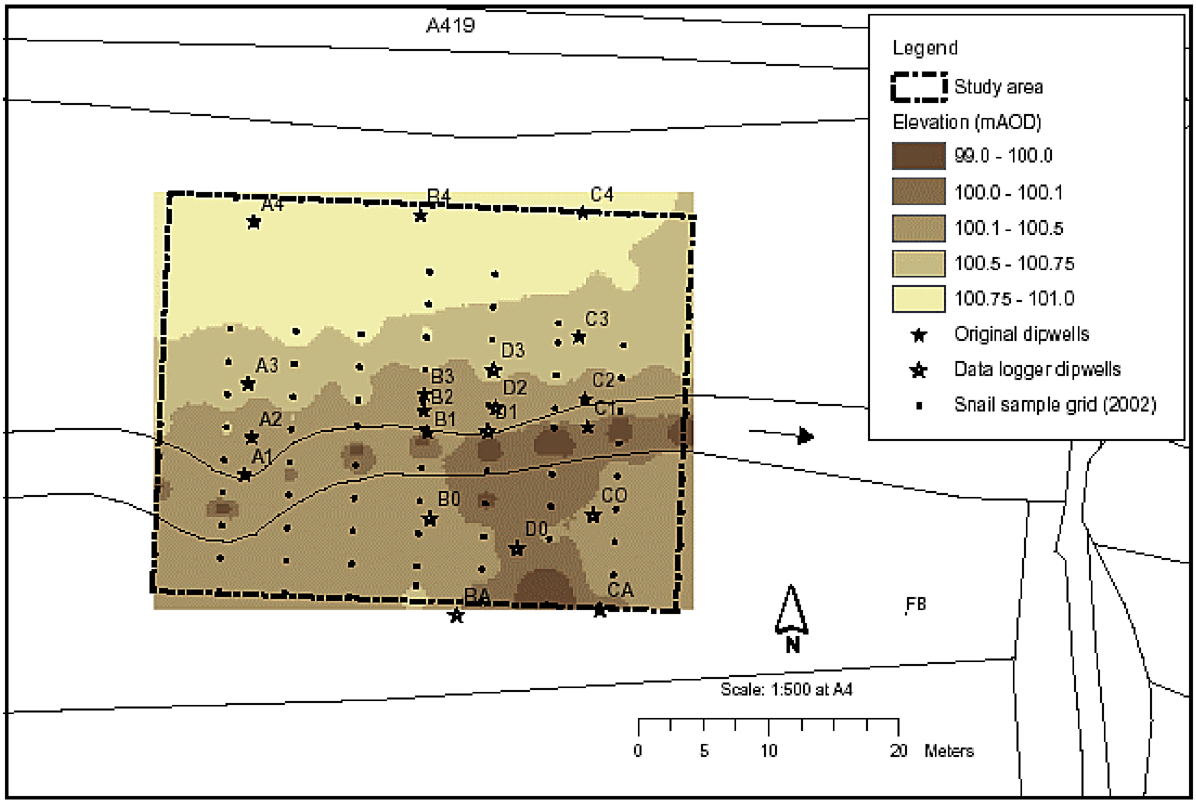

Figure 12 Surface topography of the Chilton Foliat study area

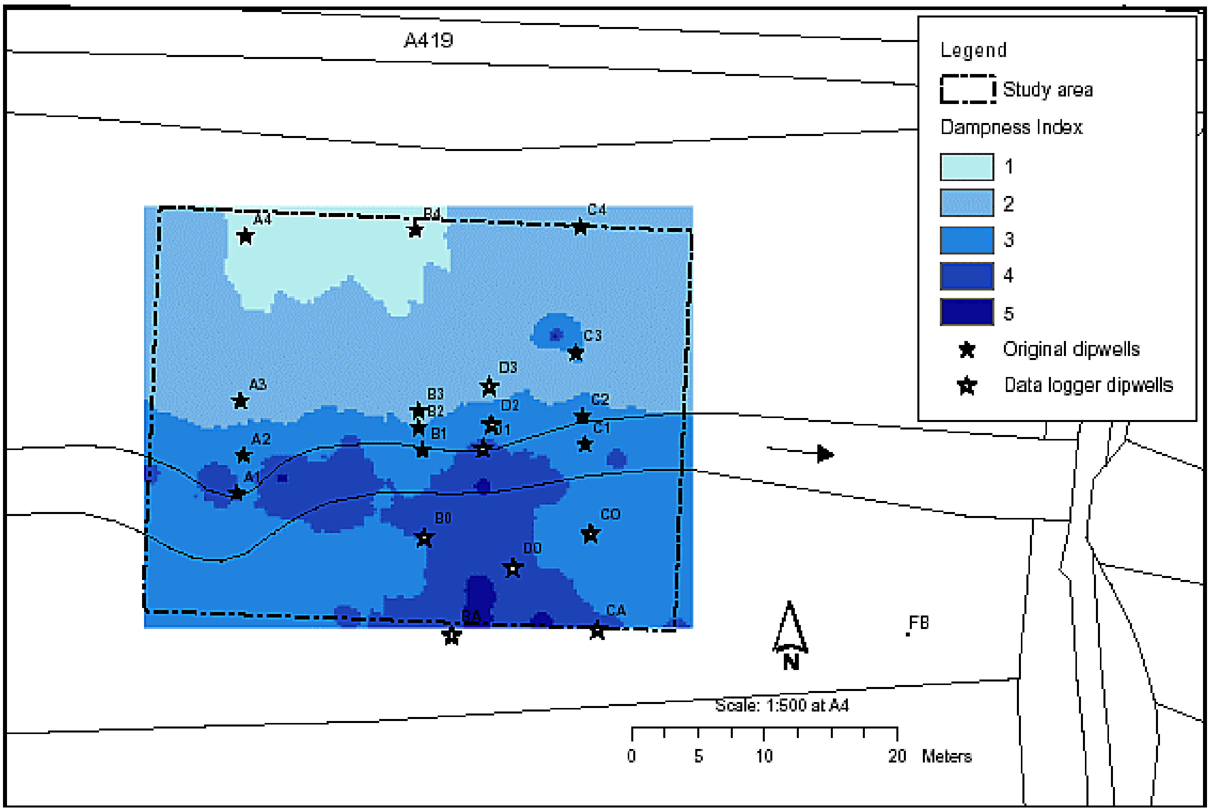

Figure 17 Variation in dampness index across the Chilton Foliat study area

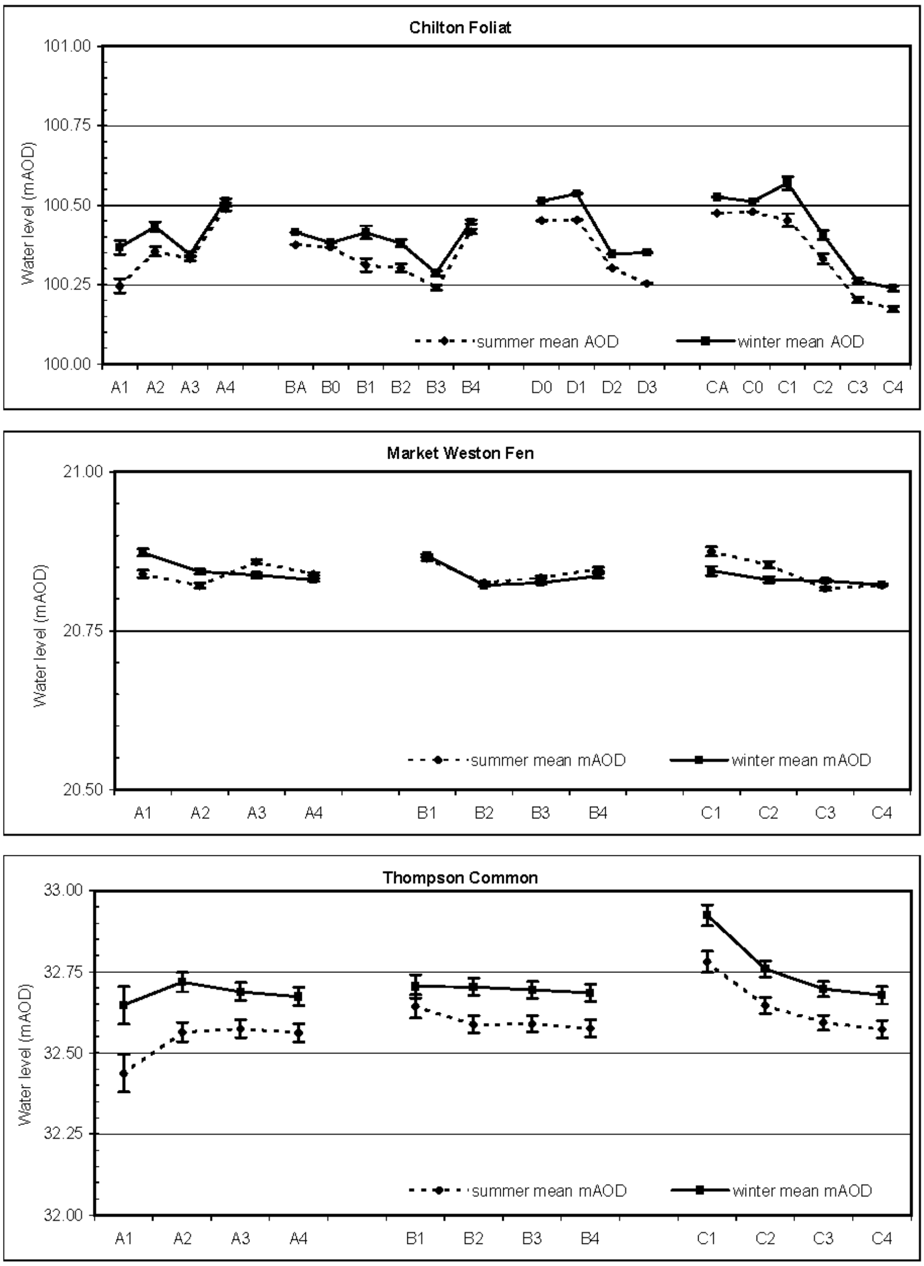

Figure 13 Hydraulic gradients for Chilton Foliat, Market Weston Fen and Thompson Common

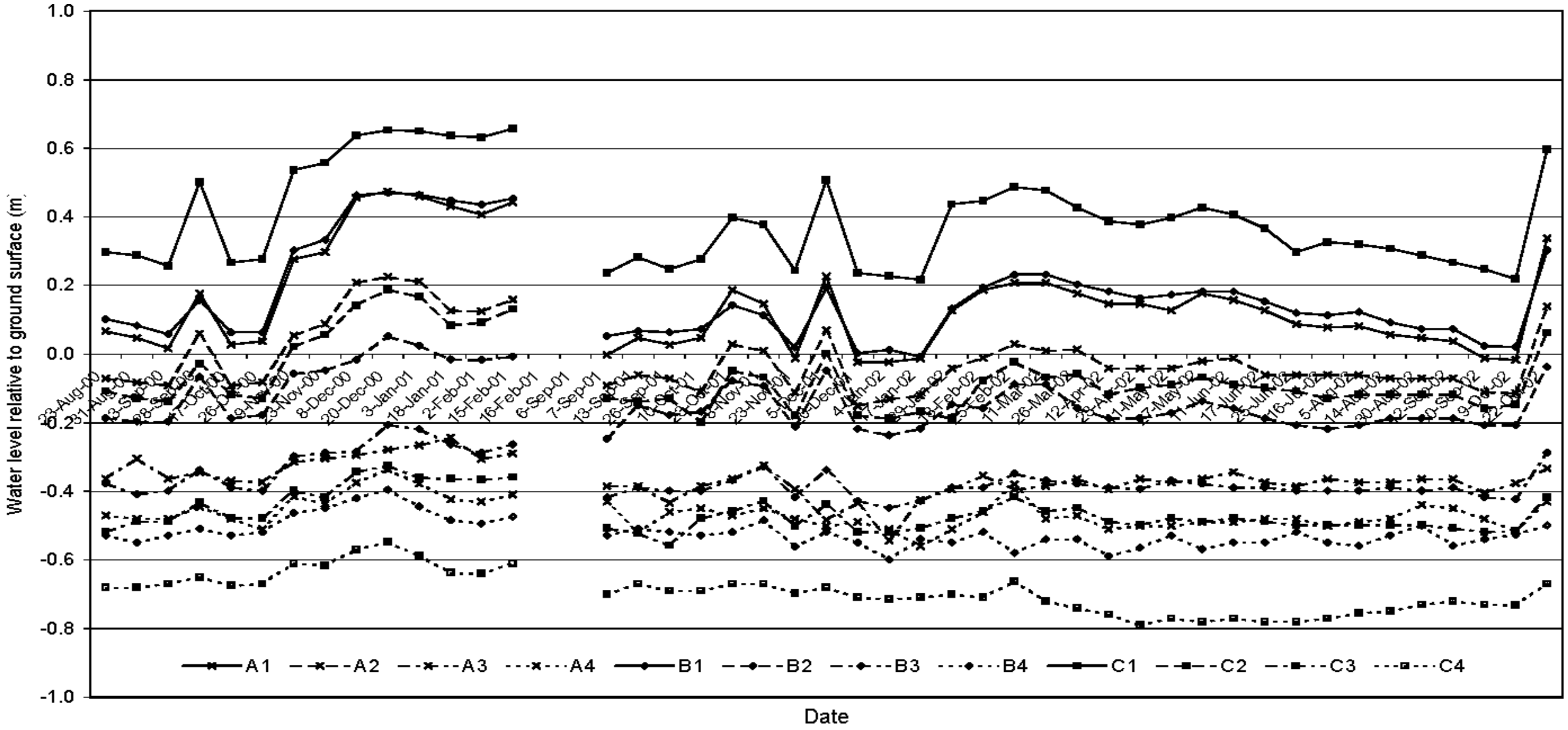

Figure 14 Chilton Foliat: Hydrograph from manual dipwells August 2000-October 2002

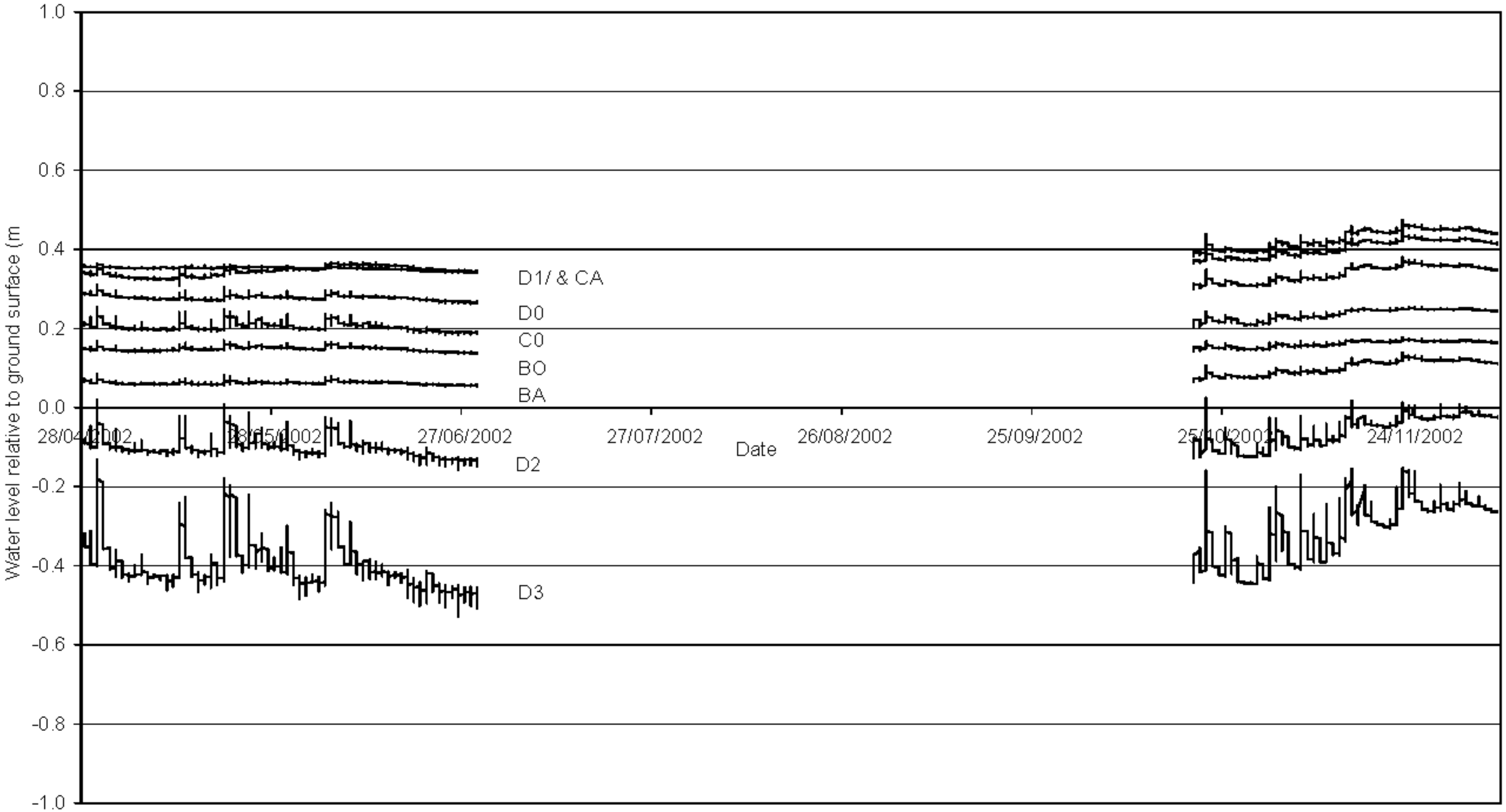

Figure 15 Chilton Foliat: Datalogger data April 2002-June 2002 and October 2002-December 2002

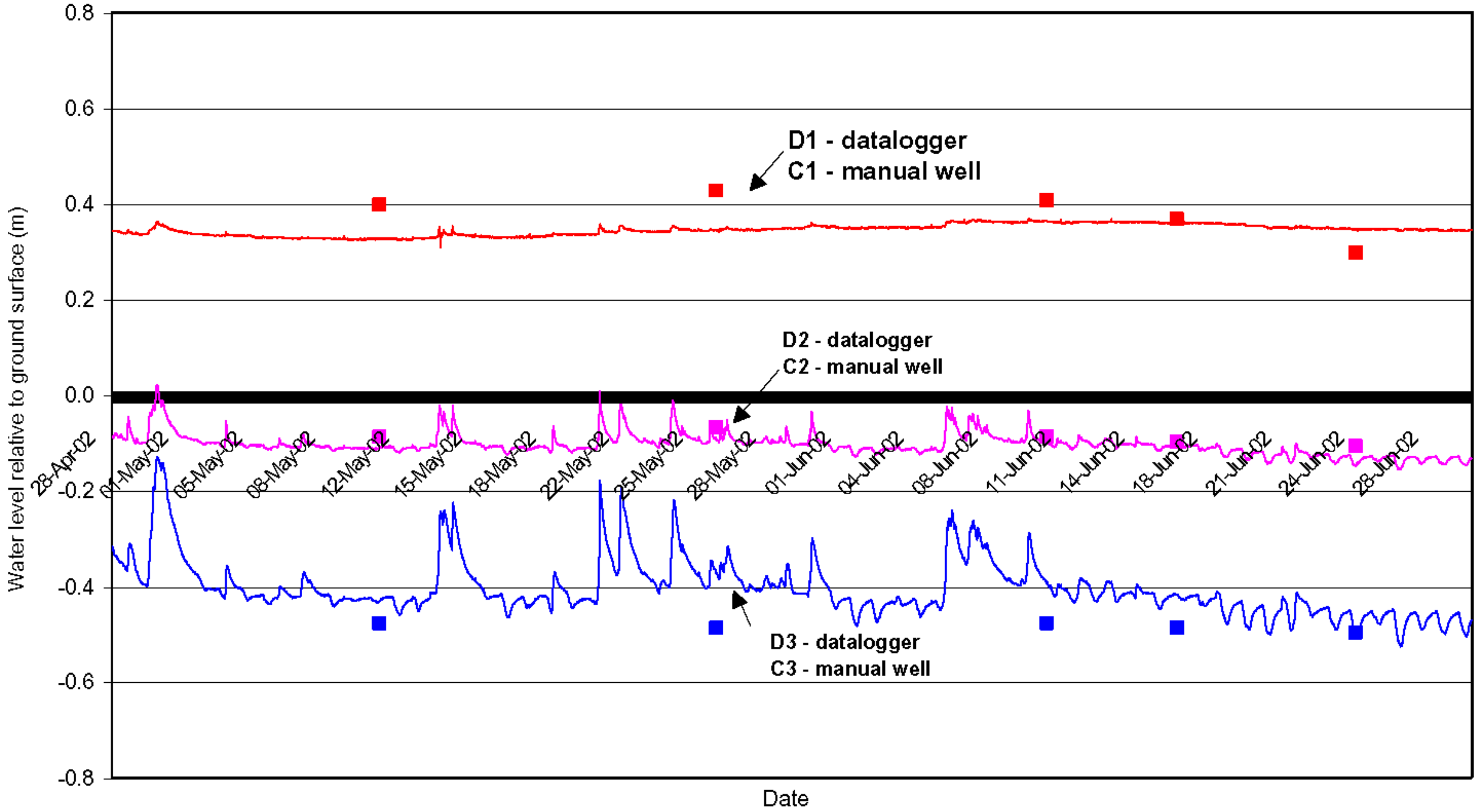

Figure 16 Chilton Foliat: Comparison of water level results from the datalogger and manual dipwells

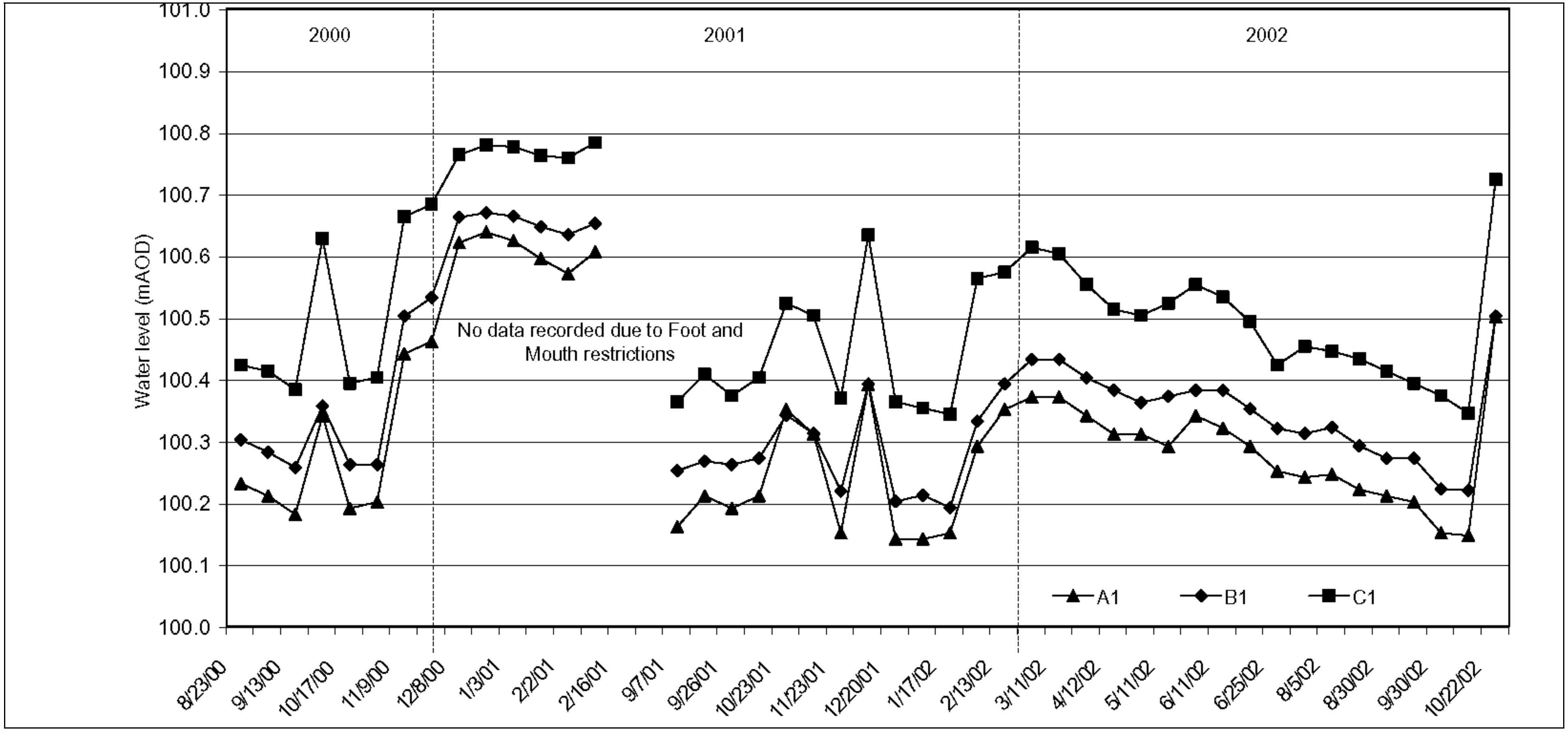

Figure 18 Chilton Foliat: Water levels recorded in dipwells adjacent to stream channel August 2000 – October 2002

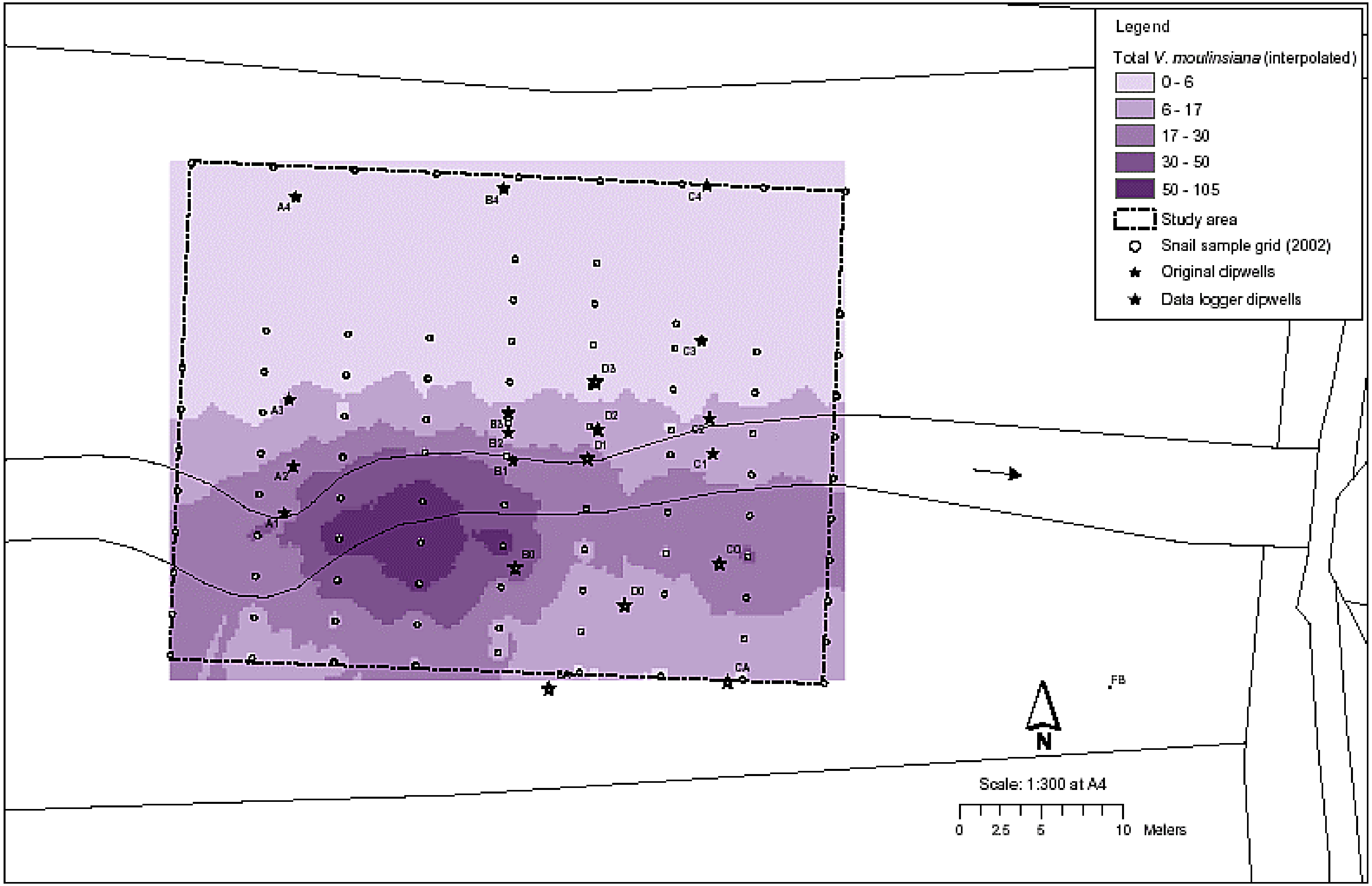

Figure 19 Distribution of *Vertigo moulinsiana* (interpolated) across the Chilton Foliat study area

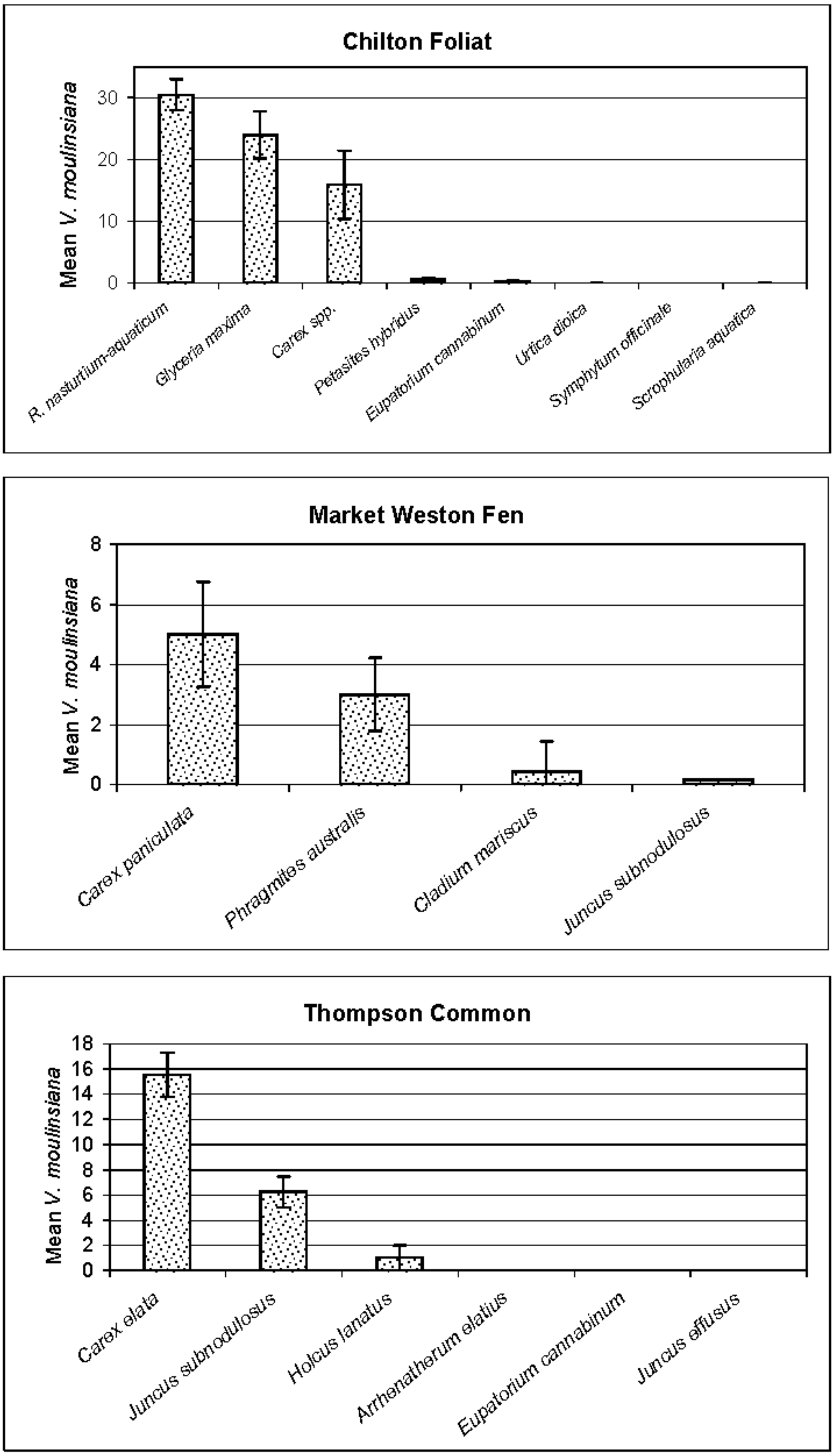

Figure 20 Mean number of *V. moulinsiana* (+/- SE) in samples dominated by different plant species (2002 data)

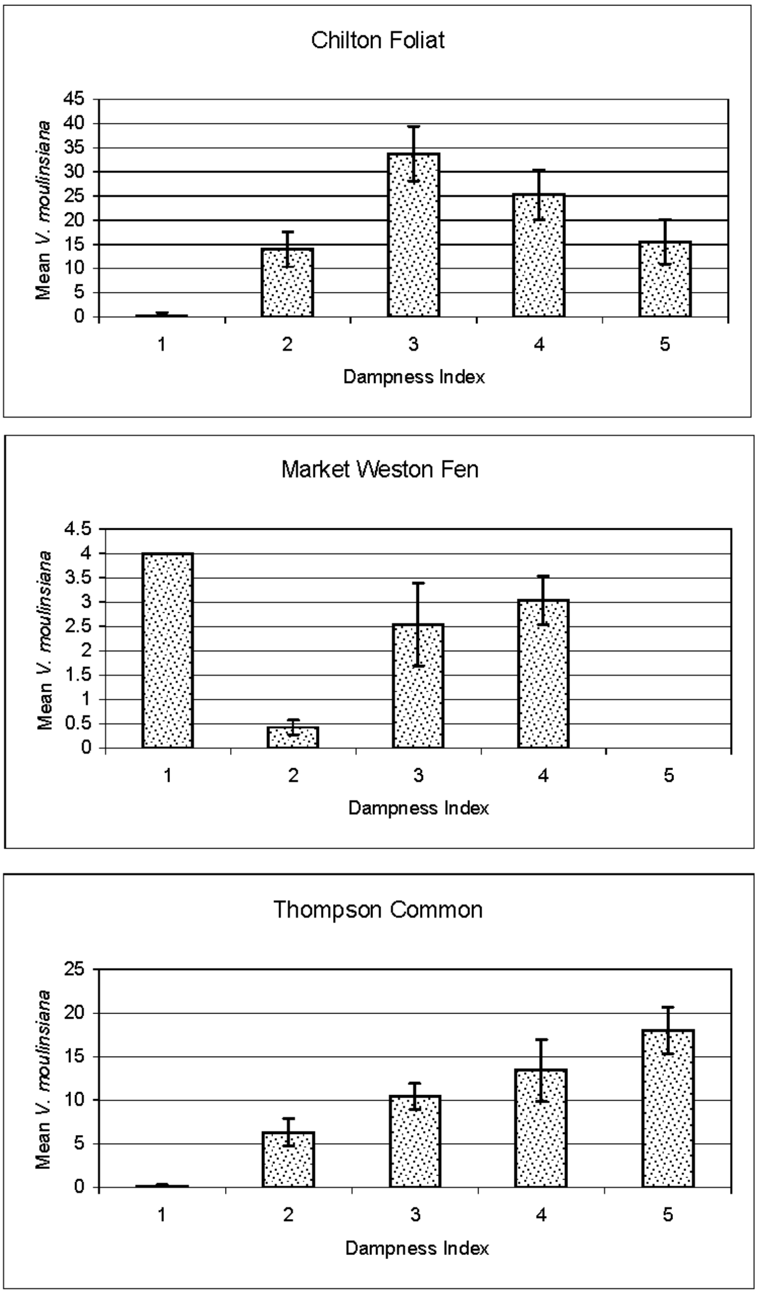

Figure 21 Mean number of *V. moulinsiana* (+/-SE) in dampness index categories (2002 data)

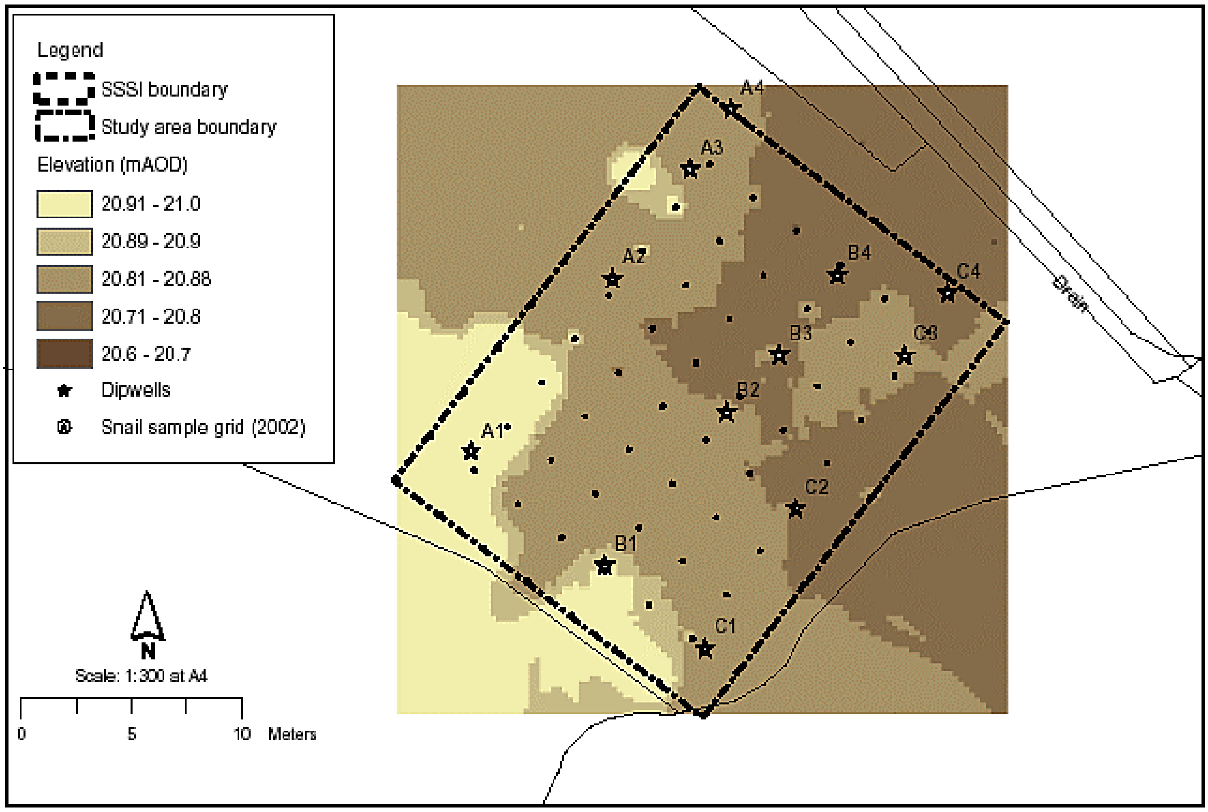

Figure 22 Surface topography of the Market Weston Fen study area

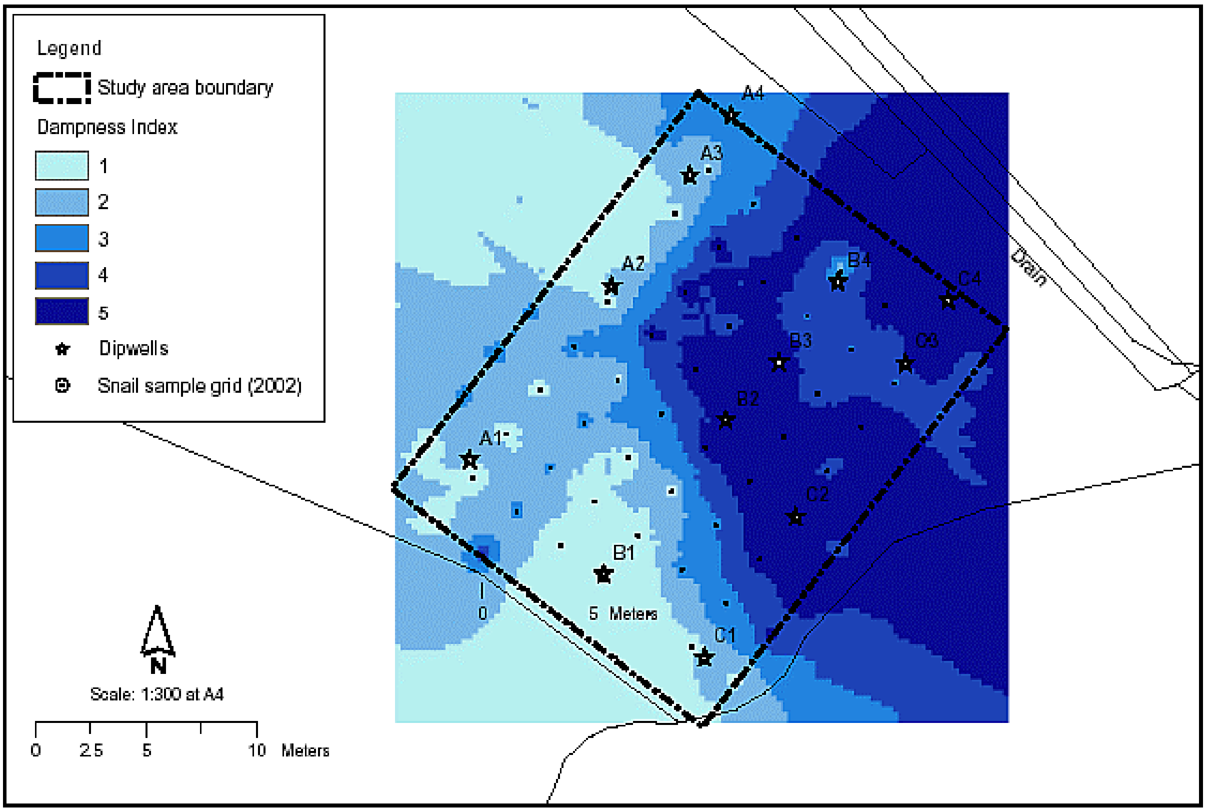

Figure 24 Variation in Dampness Index across the Market Weston Fen study area

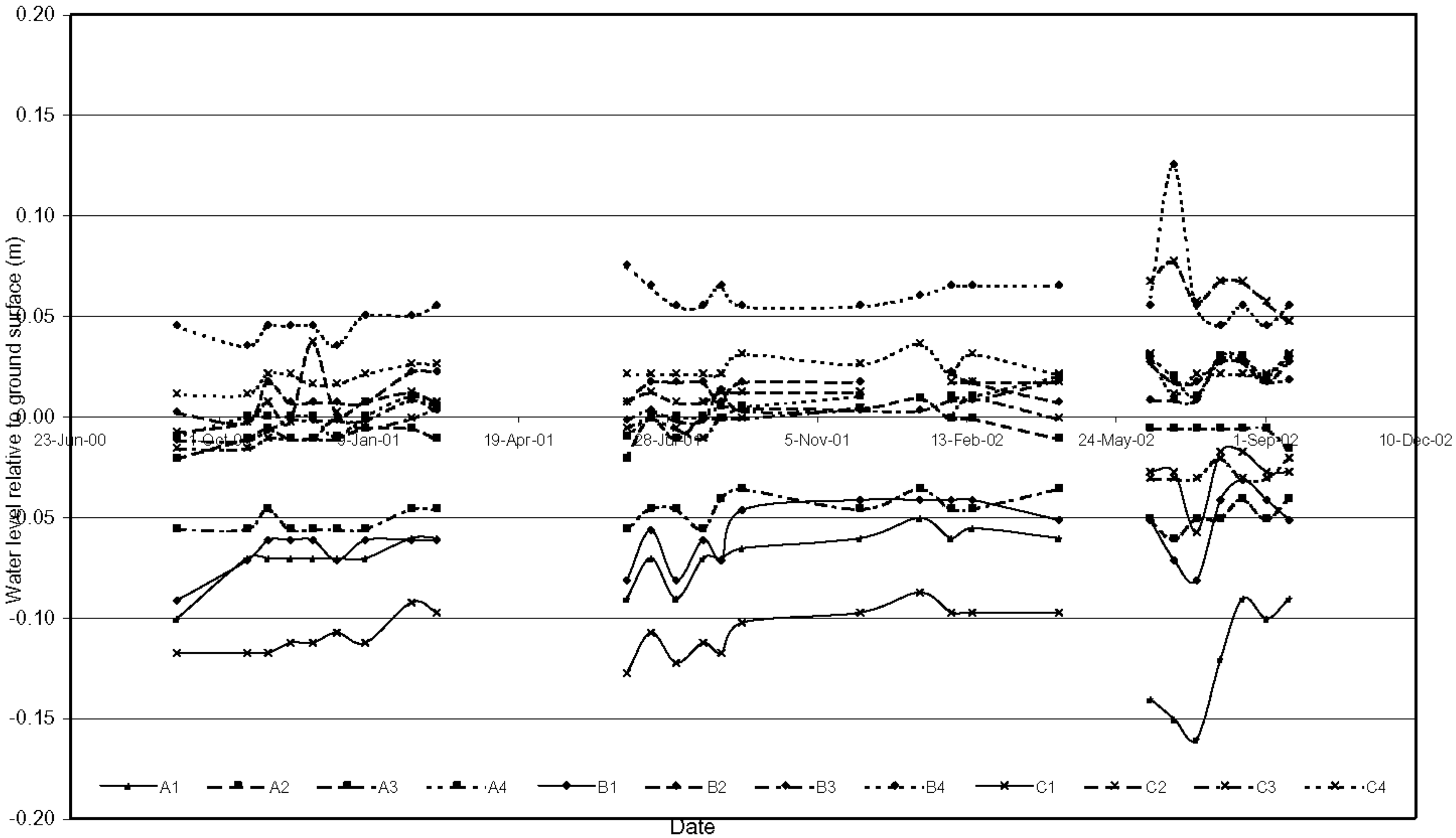

Figure 23 Market Weston Fen: Hydrograph from dipwells – September 2000-September 2002

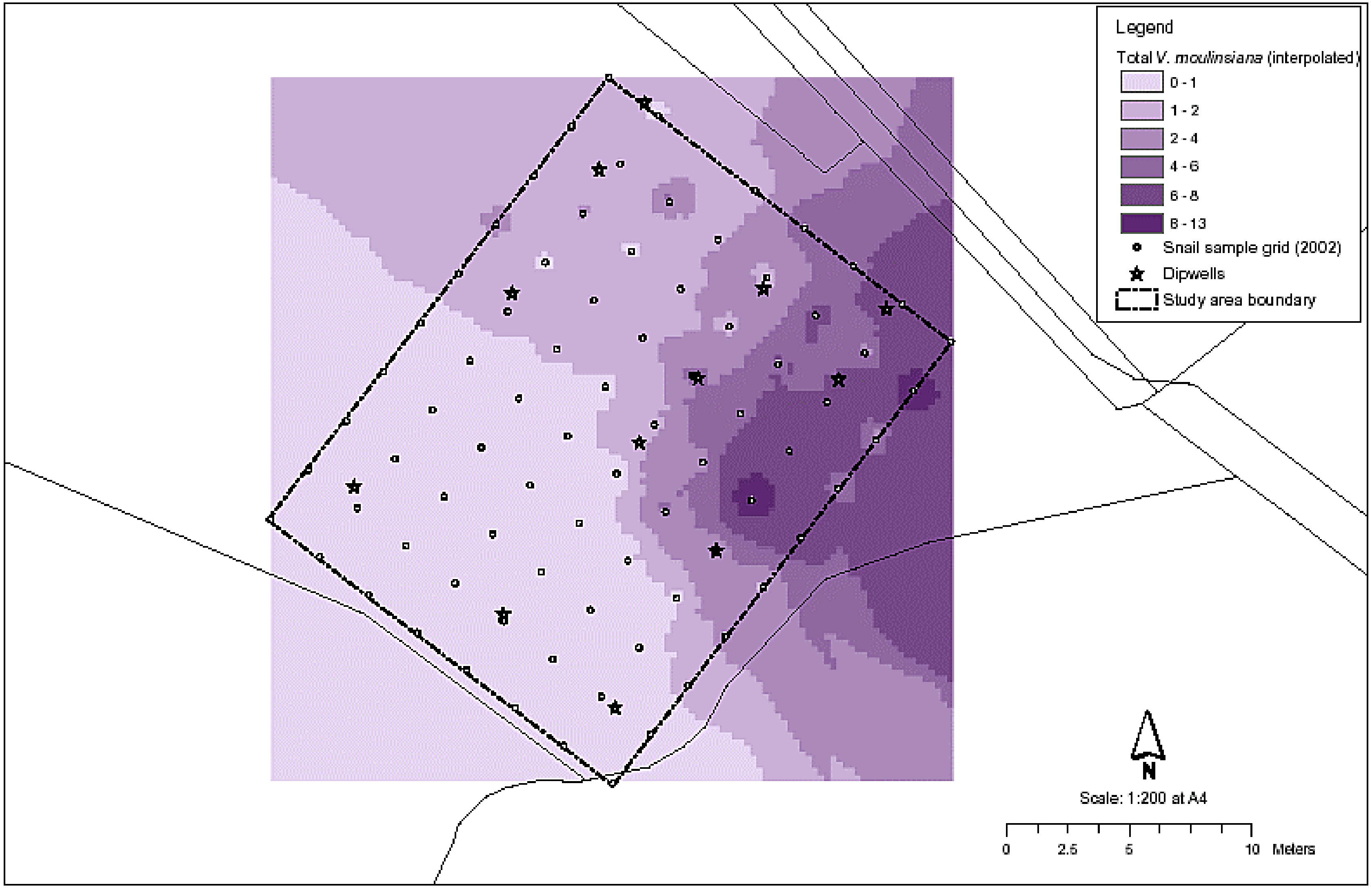

Figure 25 Distribution of V. moulinsiana (interpolated) across the Market Weston Fen study area

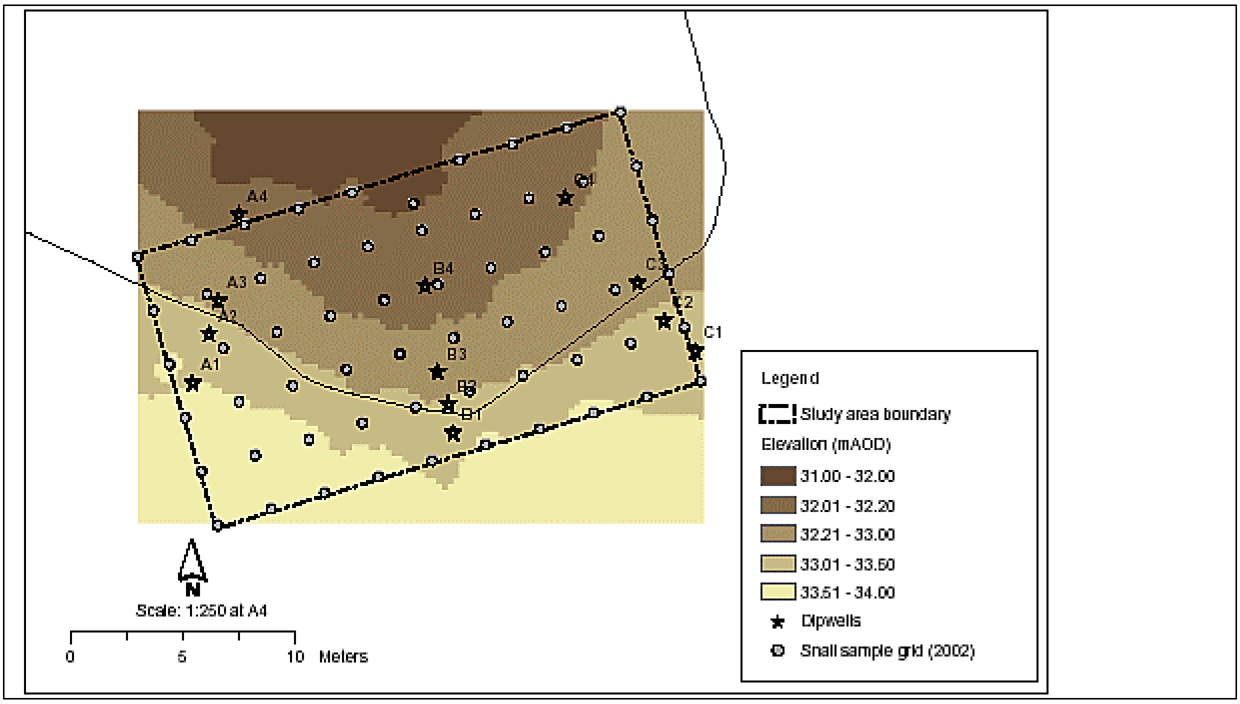

Figure 26 Surface topography of the Thompson Common study area

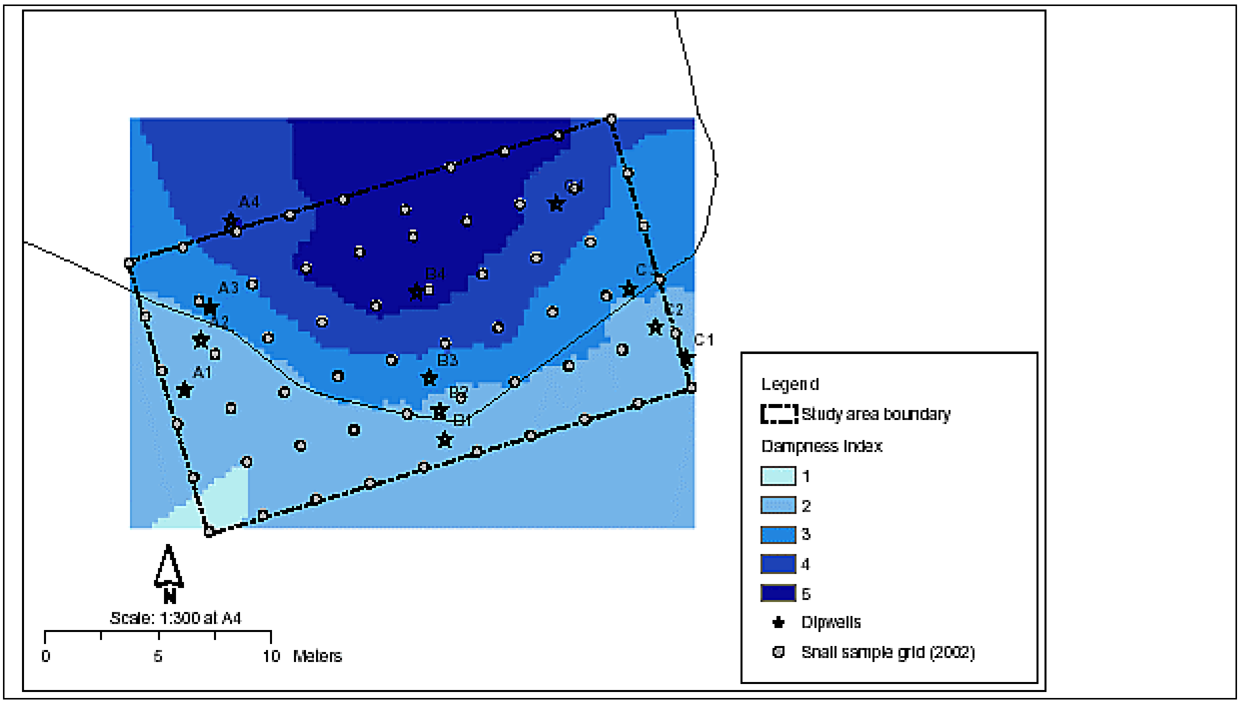

Figure 28 Variation in Dampness Index across the Thompson Common study area

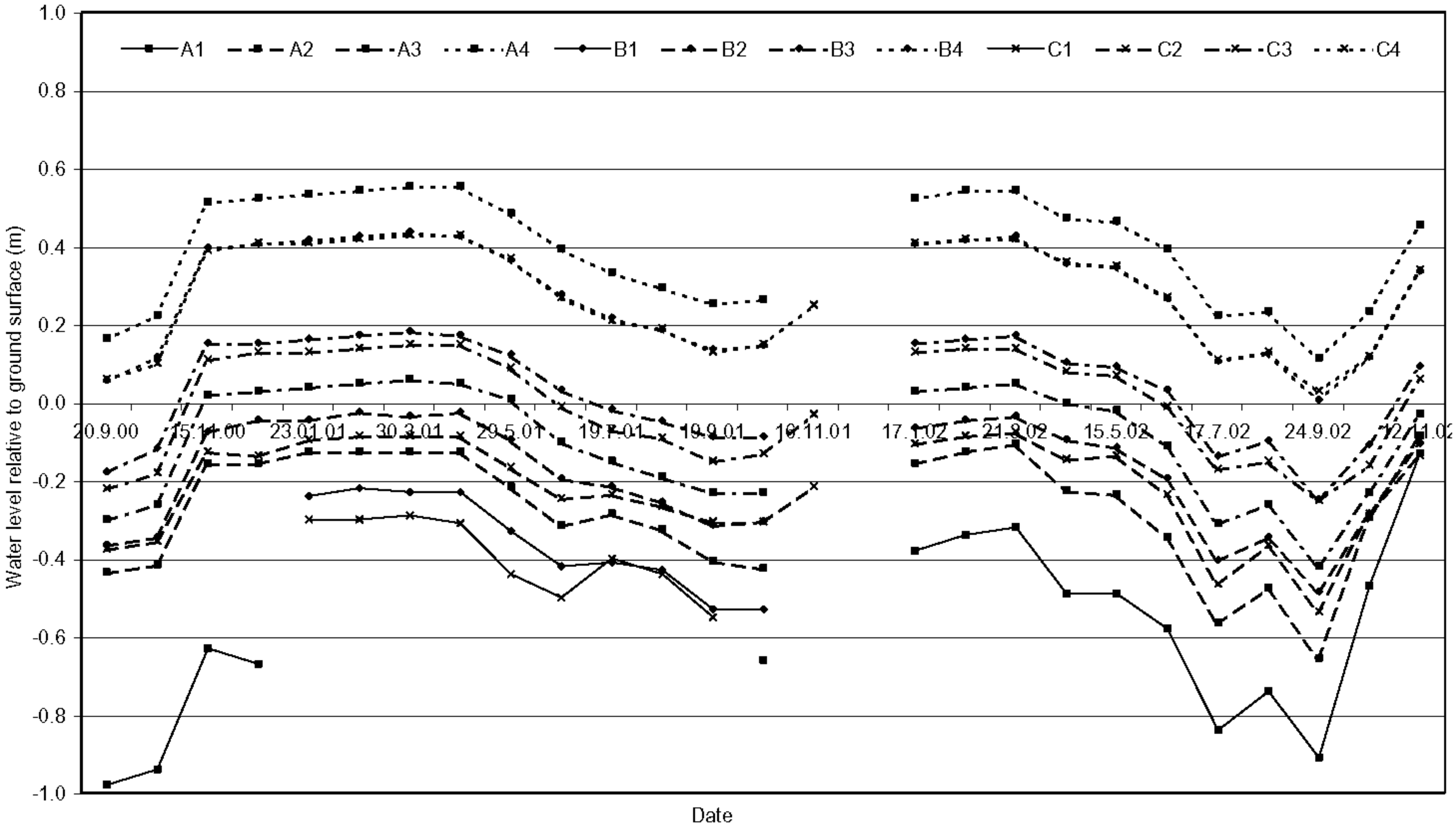

Figure 27 Thompson Common: Hydrograph from dipwells – September 2000-November 2002

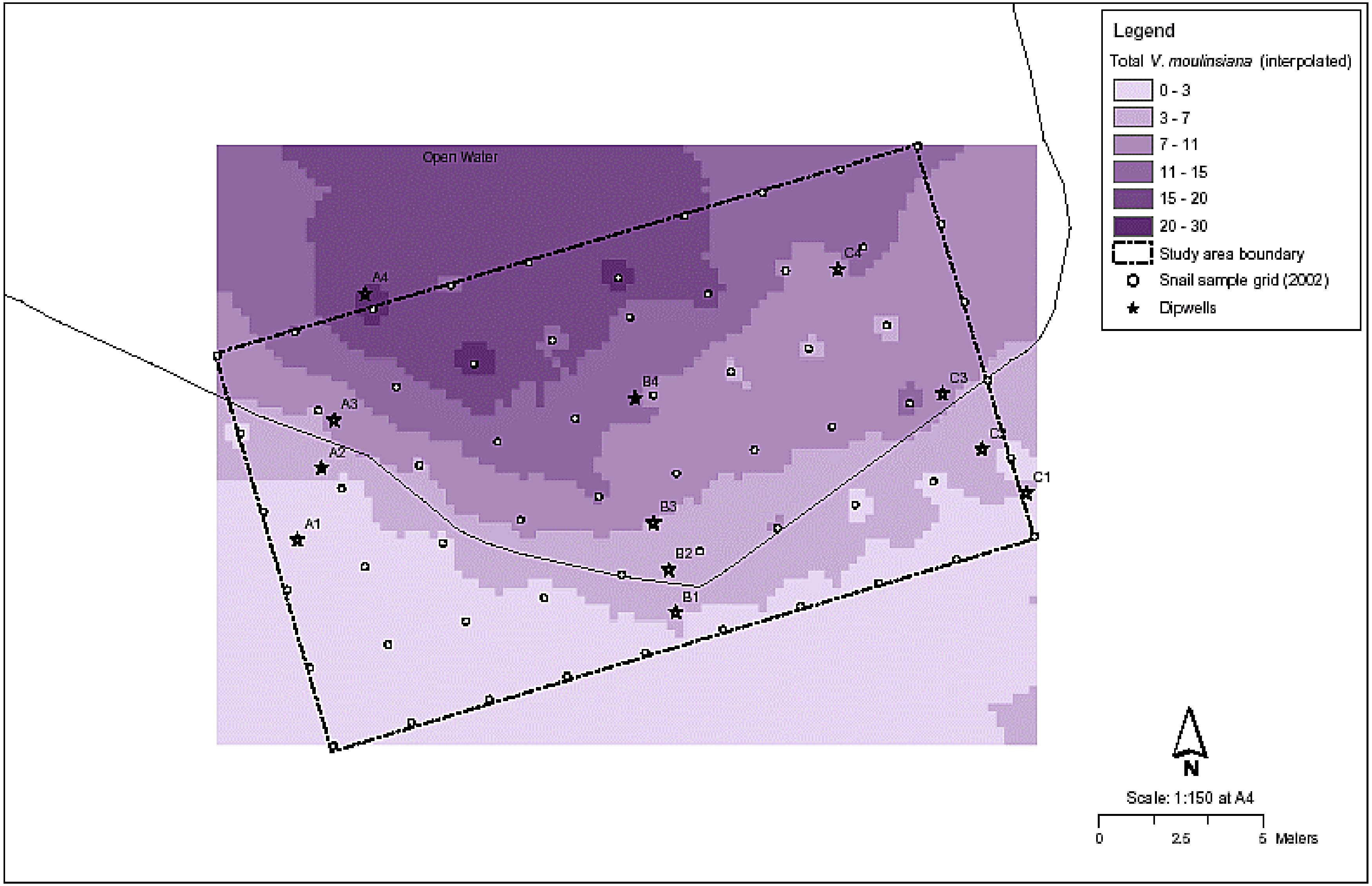

Figure 29 Distribution of *Vertigo moulinsiana* (interpolated) across the Thompson Common study area

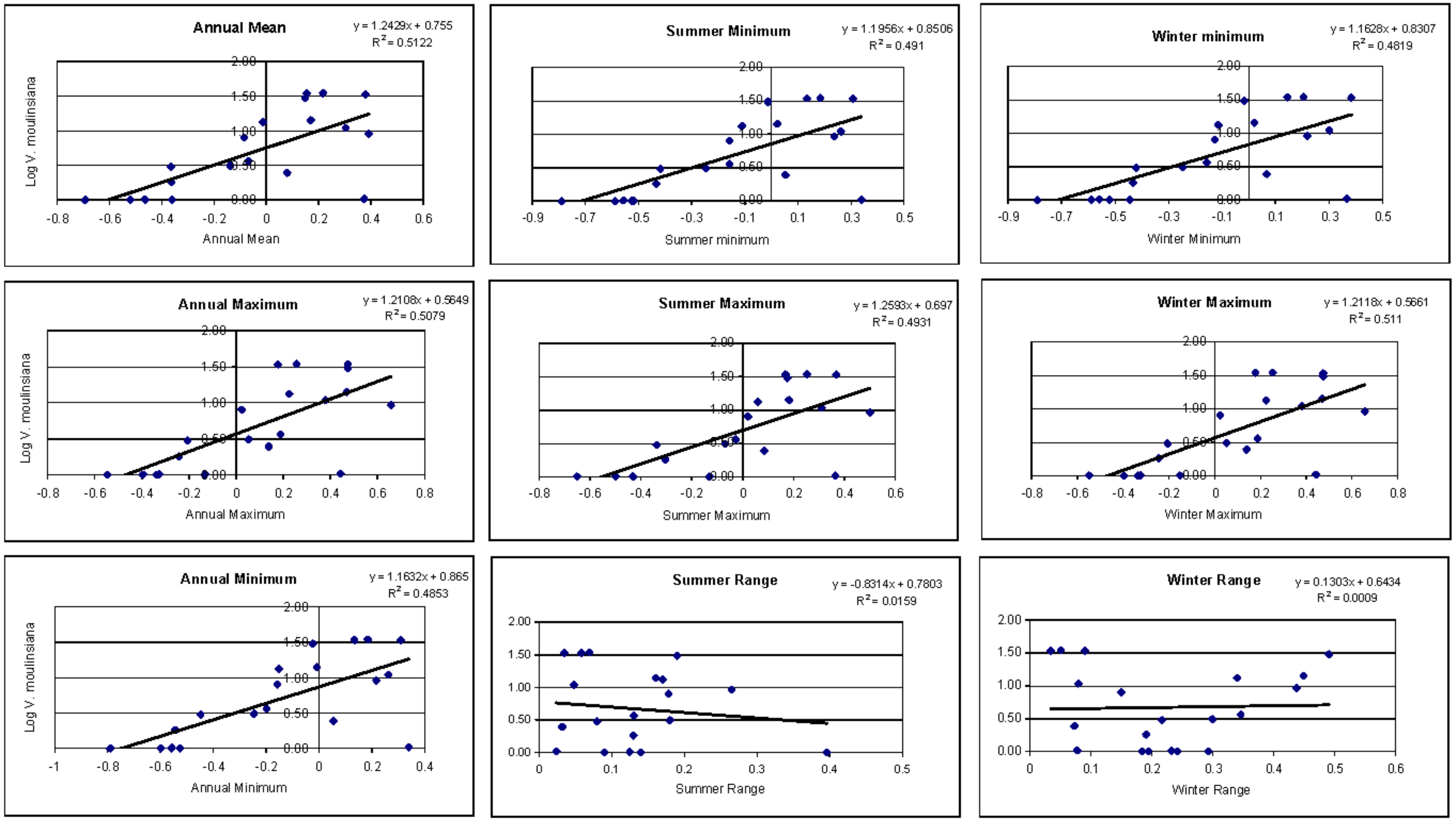

Figure 30 Chilton Foliat: relationships between *V. moulinsiana* and hydrological parameter

Note: *V. moulinsiana* numbers interpolated from Fig. 19.

Figure 30 Chilton Foliat: relationship between *V. moulinsiana* and hydrological parameter
Note: *V. moulinsiana* numbers interpolated from Figure 19

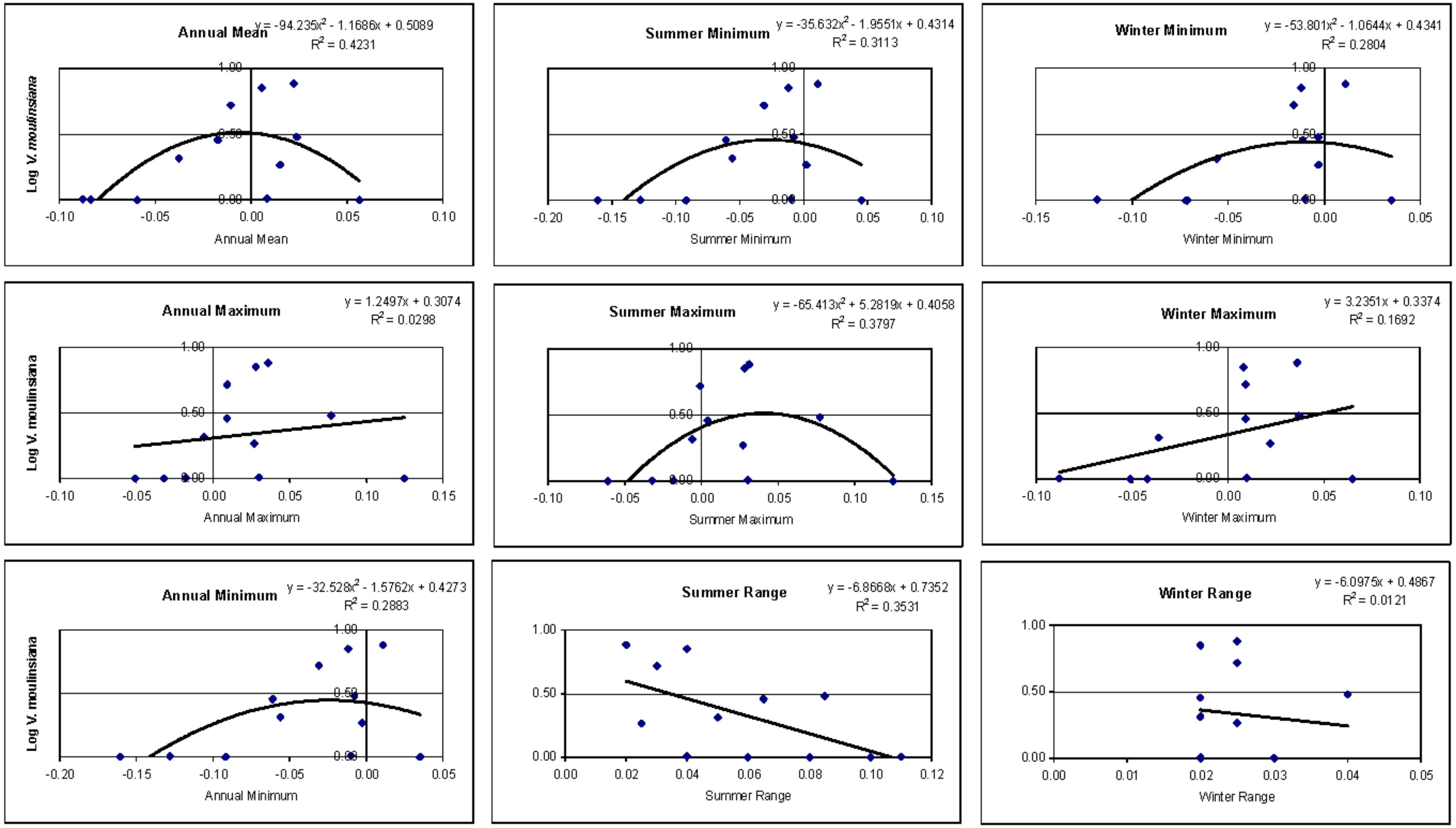

Figure 31 Market Weston Fen: relationship between *V. moulinsiana* and hydrological parameter

Note: *V. moulinsiana* numbers interpolated from Figure 25

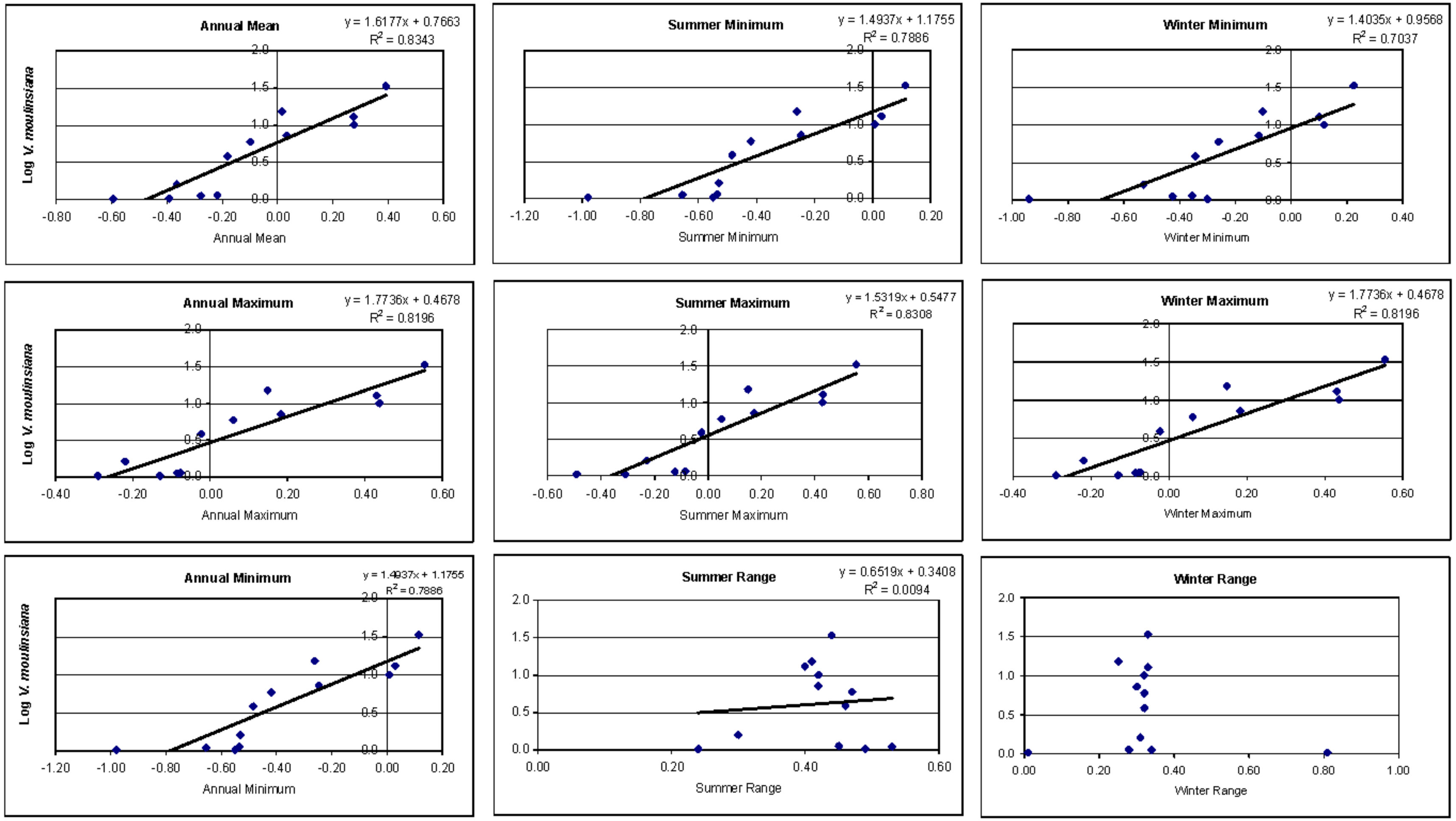

Figure 32 Thompson Common: relationships between *V. moulinsiana* and hydrological parameter

Note: *V. moulinsiana* numbers interpolated from Figure 29

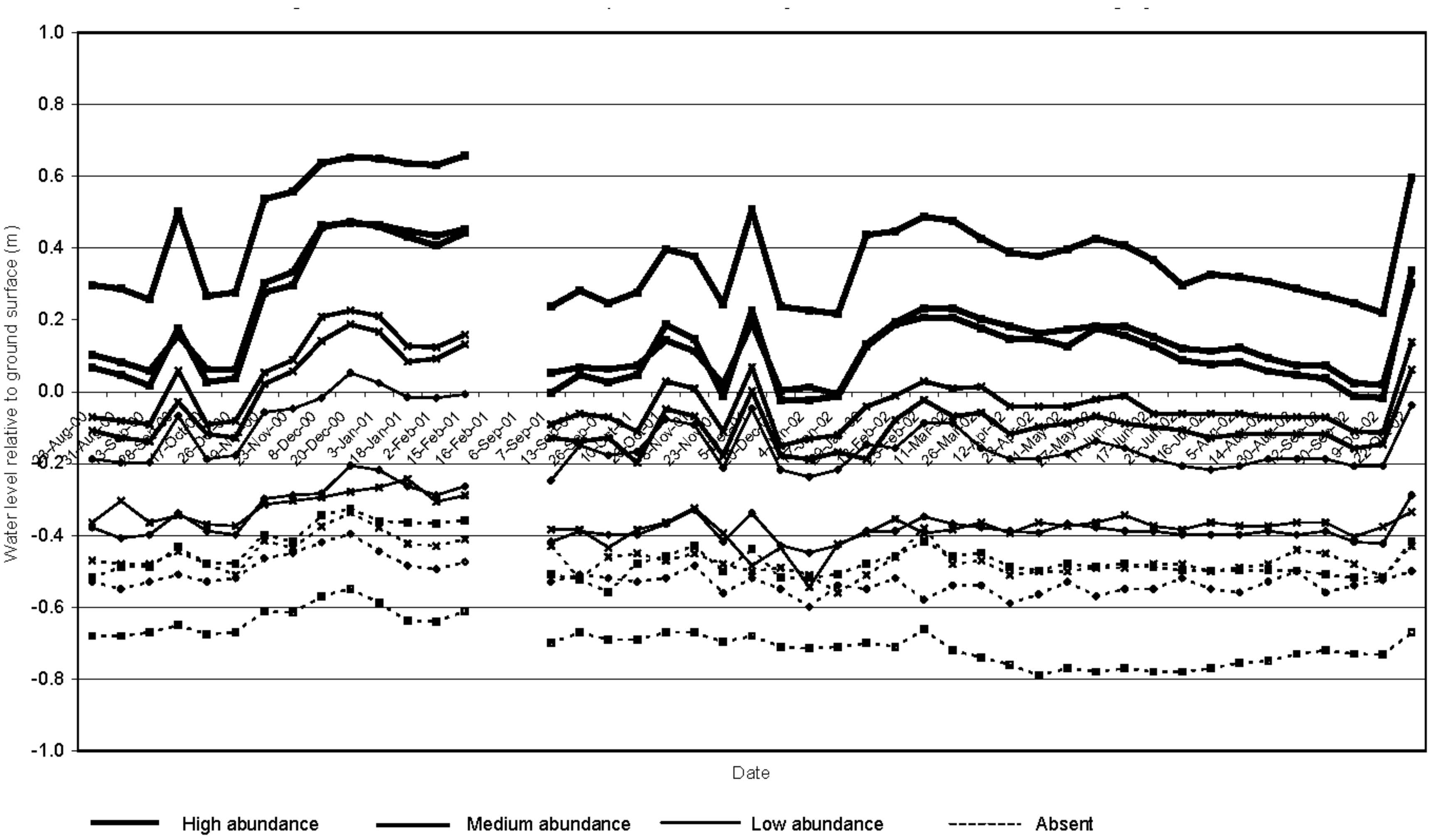

Figure 33 Chilton Foliat: manual dipwells classified by *V. moulinsiana* abundance category

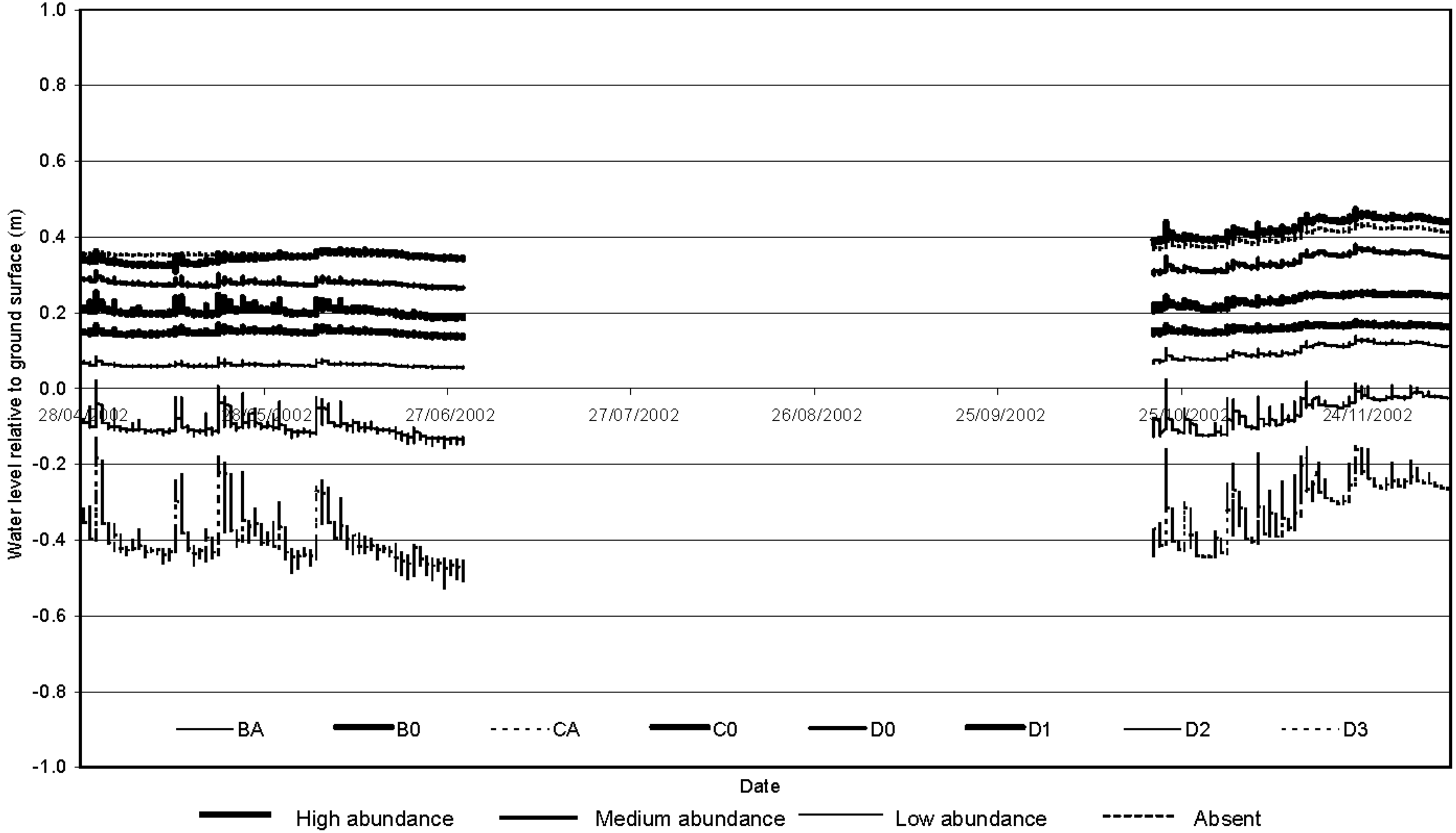

Figure 34 Chilton Foliat: Datalogger data – hydrographs classified by snail abundance category

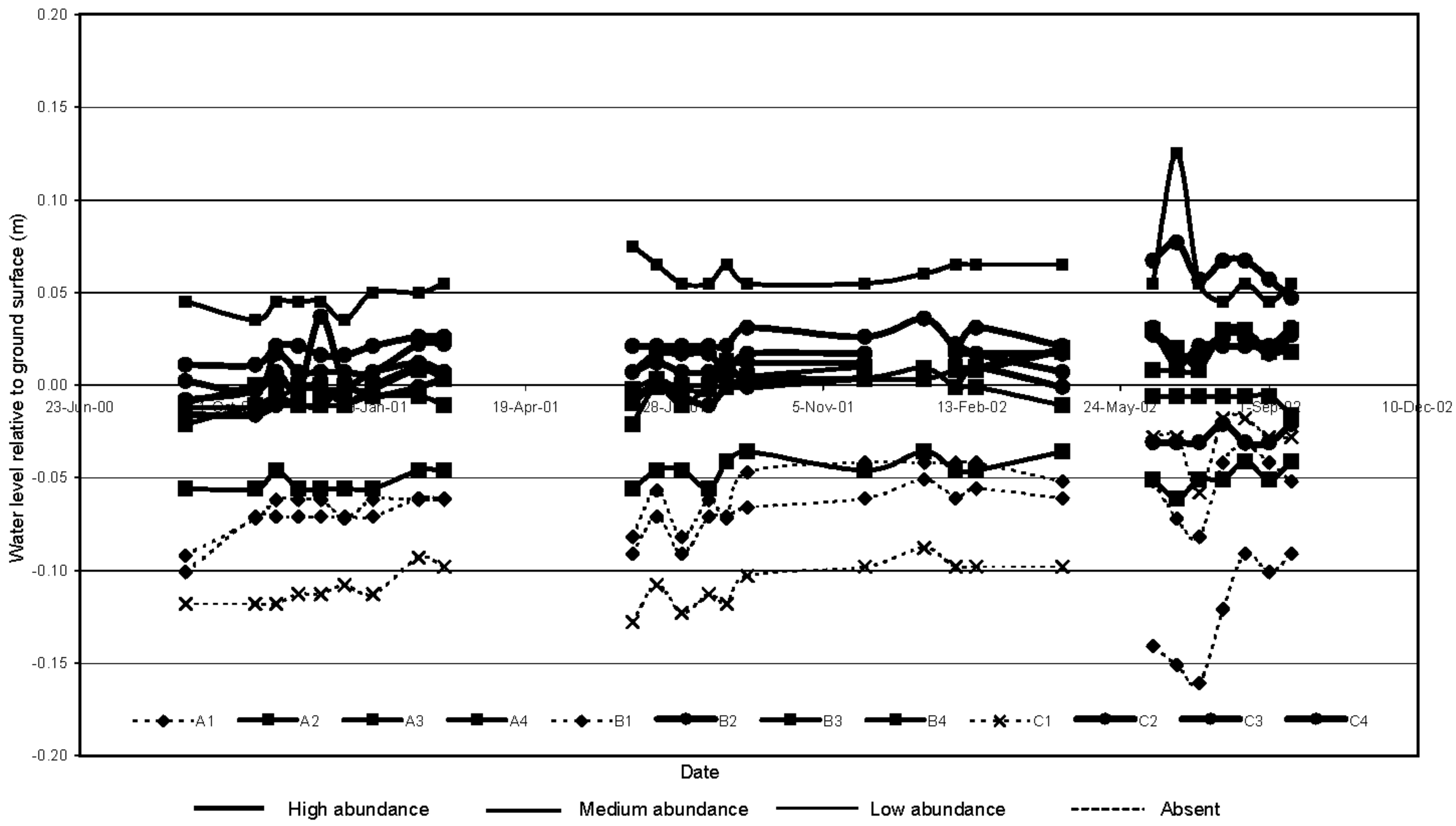

Figure 35 Market Weston Fen: Hydrograph classified by *V. moulinsiana* abundance category

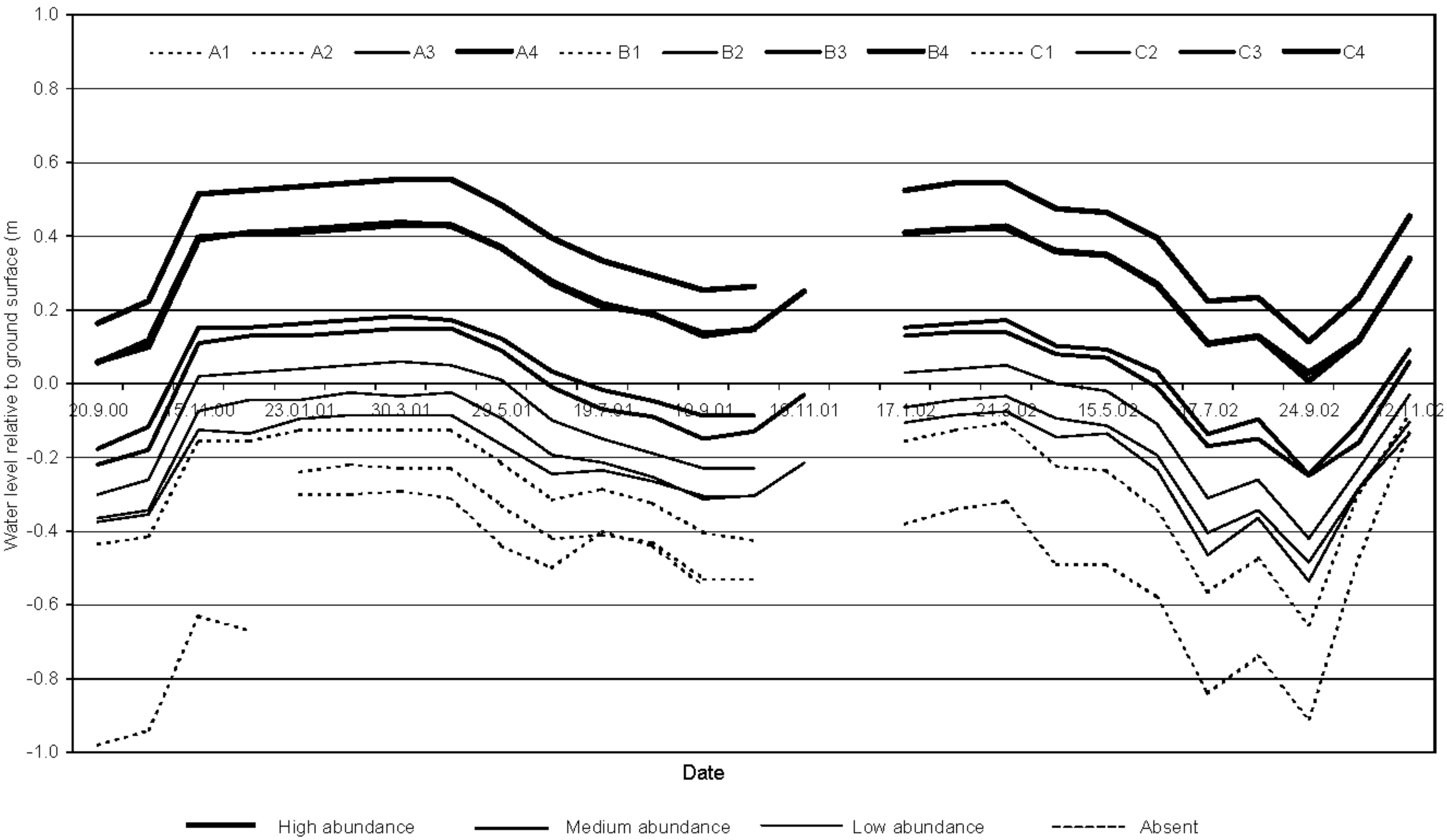

Figure 36 Thompson Common Hydrograph by *V. moulinsiana* abundance category

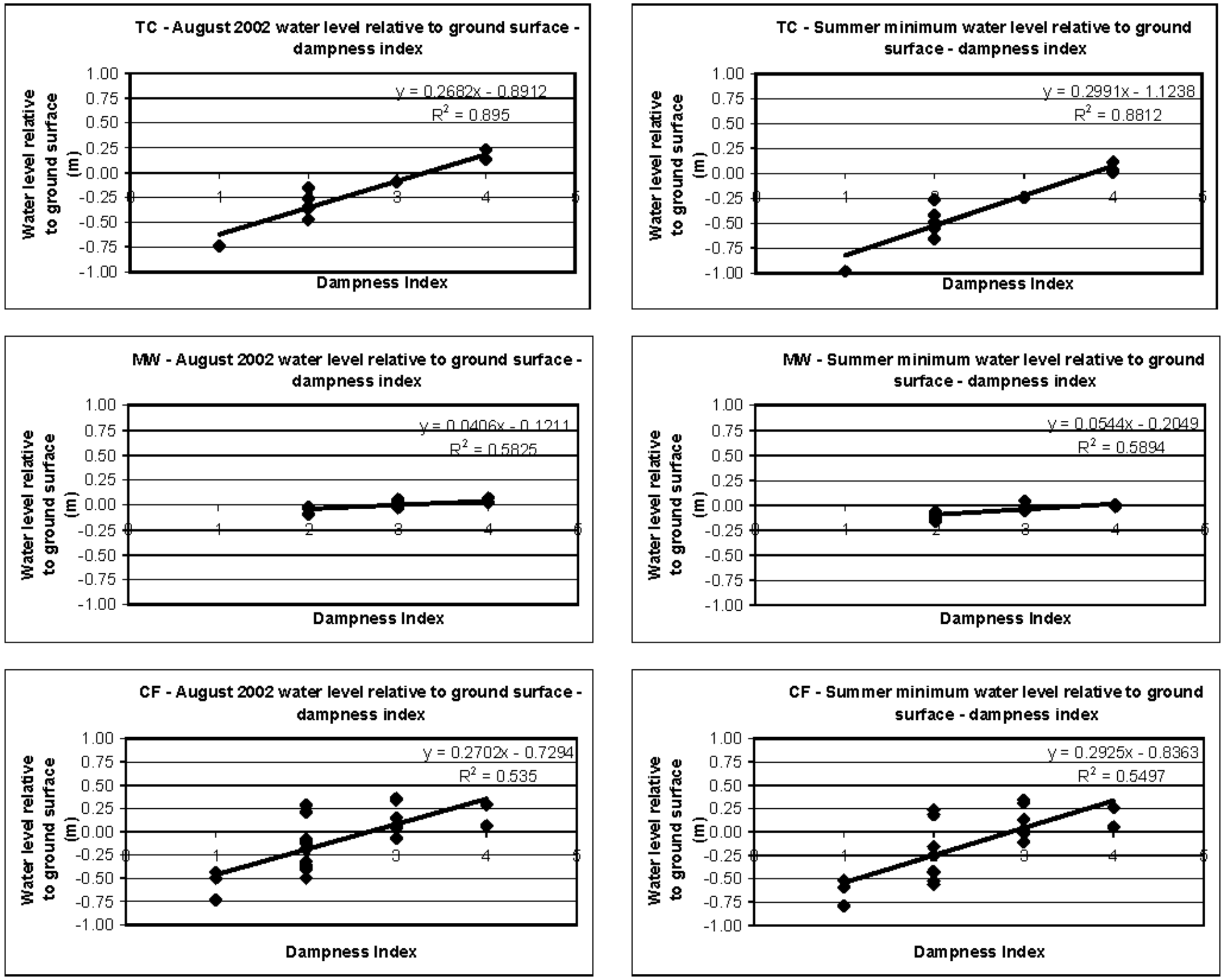

Figure 37 Relationship between August 2002 and summer minimum water levels and Dampness Index

Appendices

I Values of derived bydrological variables calculated from dipwell measurements over the duration of the project

- CI Chilton Foliat
- MI Market Weston Fen
- TI Thompson Common

II Detailed mollusc sample data collected August 2002

- CII Chilton Foliat
- MII Market Weston Fen
- TII Thompson Common

Appendix CI Chilton Foliat: Values of derived hydrological variables calculated from dipwell measurements over the duration of the project

Relative to Ordnance Datum (m)	A1	A2	A3	A4	BA	B0	B1	B2	B3	B4	D0	D1	D2	D3	CA	C0	C1	C2	C3	C4
max	100.64	100.64	100.46	100.63	100.45	100.40	100.67	100.54	100.43	100.56	100.55	100.58	100.43	100.53	100.57	100.53	100.78	100.63	100.37	100.36
min	100.14	100.26	100.16	100.41	100.37	100.35	100.19	100.24	100.18	100.36	100.44	100.42	100.25	100.13	100.46	100.46	100.34	100.24	100.14	100.11
average	100.31	100.40	100.34	100.50	100.39	100.37	100.37	100.35	100.27	100.43	100.48	100.49	100.32	100.30	100.50	100.49	100.52	100.37	100.24	100.21
range	0.50	0.38	0.30	0.22	0.09	0.04	0.48	0.30	0.24	0.20	0.12	0.17	0.18	0.40	0.10	0.07	0.44	0.39	0.23	0.24
ground level	*100.16*	*100.41*	*100.70*	*100.97*	*100.31*	*100.22*	*100.20*	*100.48*	*100.63*	*100.96*	*100.17*	*100.11*	*100.41*	*100.66*	*100.12*	*100.28*	*100.13*	*100.44*	*100.70*	*100.90*
Observations	45	45	45	45	5301	5300	45	45	45	45	5300	5300	5300	5300	5301	5300	45	45	45	45
% above ground	86.67	35.56	0.00	0.00	100	100	97.78	4.44	0.00	0.00	100	100	0.83	0	100	100	100.00	22.22	0.00	0.00
% above 10cm	53.33	15.56	0.00	0.00	23.66	100.00	62.22	0.00	0.00	0.00	100.00	100.00	0.00	0.00	100.00	100.00	100.00	8.89	0.00	0.00
% above 20cm	26.67	6.67	0.00	0.00	0.00	0.00	26.67	0.00	0.00	0.00	100.00	100.00	0.00	0.00	100.00	69.47	100.00	0.00	0.00	0.00
% above 30cm	17.78	0.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00	43.89	100.00	0.00	0.00	100.00	0.00	60.00	0.00	0.00	0.00

Relative to local ground level (m)	A1	A2	A3	A4	BA	B0	B1	B2	B3	B4	D0	D1	D2	D3	CA	C0	C1	C2	C3	C4
annual max	0.47	0.23	-0.24	-0.34	0.14	0.18	0.47	0.05	-0.21	-0.40	0.38	0.47	0.02	-0.13	0.44	0.26	0.66	0.19	-0.32	-0.55
summer max	0.18	0.06	-0.30	-0.43	0.09	0.17	0.18	-0.07	-0.34	-0.50	0.31	0.37	0.02	-0.13	0.36	0.25	0.50	-0.03	-0.43	-0.65
winter max	0.47	0.23	-0.24	-0.34	0.14	0.18	0.47	0.05	-0.21	-0.40	0.38	0.47	0.02	-0.15	0.44	0.26	0.66	0.19	-0.32	-0.55
annual min	-0.02	-0.15	-0.54	-0.56	0.05	0.13	-0.01	-0.25	-0.45	-0.60	0.26	0.31	-0.16	-0.53	0.34	0.18	0.22	-0.20	-0.56	-0.79
summer min	-0.01	-0.11	-0.43	-0.52	0.05	0.13	0.02	-0.25	-0.42	-0.59	0.26	0.31	-0.16	-0.53	0.34	0.18	0.24	-0.16	-0.56	-0.79
winter min	-0.02	-0.11	-0.43	-0.52	0.07	0.14	0.02	-0.25	-0.42	-0.59	0.30	0.38	-0.13	-0.45	0.37	0.20	0.22	-0.16	-0.56	-0.79
annual range	0.50	0.38	0.30	0.22	0.09	0.04	0.48	0.30	0.24	0.20	0.12	0.17	0.18	0.40	0.10	0.07	0.44	0.39	0.23	0.24
summer range	0.19	0.17	0.13	0.09	0.03	0.03	0.16	0.18	0.08	0.09	0.05	0.06	0.18	0.40	0.02	0.07	0.27	0.13	0.13	0.14
winter range	0.49	0.34	0.19	0.18	0.07	0.03	0.45	0.30	0.22	0.19	0.08	0.09	0.15	0.29	0.08	0.05	0.44	0.35	0.23	0.24
annual mean	0.15	-0.01	-0.36	-0.46	0.08	0.15	0.17	-0.14	-0.37	-0.52	0.30	0.38	-0.09	-0.36	0.37	0.22	0.39	-0.07	-0.46	-0.69
summer mean	0.08	-0.06	-0.37	-0.48	0.06	0.15	0.11	-0.18	-0.39	-0.54	0.28	0.34	-0.10	-0.41	0.35	0.20	0.33	-0.11	-0.50	-0.73
winter mean	0.20	0.02	-0.36	-0.45	0.10	0.16	0.21	-0.10	-0.35	-0.51	0.34	0.43	-0.06	-0.31	0.40	0.24	0.44	-0.04	-0.44	-0.67
annual % above ground	86.67	35.56	0.00	0.00	100	100	97.78	4.44	0.00	0.00	100	100	0.83	0	100	100	100.00	22.22	0.00	0.00
summer % above ground	95.00	5.00	0.00	0.00	100	100	100.00	0.00	0.00	0.00	100	100	0.20	0	100	100	100.00	0.00	0.00	0.00
winter % above ground	80.00	60.00	0.00	0.00	100	100	96.00	8.00	0.00	0.00	100	100	1.65	0	100	100	100.00	40.00	0.00	0.00
annual % 10 above ground	53.33	15.56	0.00	0.00	23.66	100.00	62.22	0.00	0.00	0.00	100.00	100.00	0.00	0.00	100.00	100.00	100.00	8.89	0.00	0.00
summer % 10 above ground	35.00	0.00	0.00	0.00	0.00	100.00	55.00	0.00	0.00	0.00	100.00	100.00	0.00	0.00	100.00	100.00	100.00	0.00	0.00	0.00
winter % 10 above ground	68.00	28.00	0.00	0.00	54.47	100.00	68.00	0.00	0.00	0.00	100.00	100.00	0.00	0.00	100.00	100.00	100.00	16.00	0.00	0.00
annual % 20 above ground	26.67	6.67	0.00	0.00	0.00	0.00	26.67	0.00	0.00	0.00	100.00	100.00	0.00	0.00	100.00	69.47	100.00	0.00	0.00	0.00
summer % 20 above ground	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	100.00	0.00	0.00	100.00	46.03	100.00	0.00	0.00	0.00
winter % 20 above ground	48.00	12.00	0.00	0.00	0.00	0.00	48.00	0.00	0.00	0.00	100.00	100.00	0.00	0.00	100.00	100.00	100.00	0.00	0.00	0.00
annual mean depth of inundation	0.17	0.10	n/a	n/a	0.08	0.15	0.17	0.04	n/a	n/a	0.30	0.38	-0.05	-0.26	0.37	0.22	0.39	0.09	n/a	n/a
summer mean depth of inundation	0.09	0.06	n/a	n/a	0.06	0.15	0.11	n/a	n/a	n/a	0.28	0.34	-0.07	-0.29	0.35	0.20	0.33	n/a	n/a	n/a
winter mean depth of inundation	0.26	0.10	n/a	n/a	0.10	0.16	0.22	0.04	n/a	n/a	0.34	0.43	-0.04	-0.26	0.40	0.24	0.44	0.09	n/a	n/a

Appendix MI Market Weston Fen: Values of derived hydrological variables calculated from dipwell measurements over the duration of the project

Relative to Ordnance Datum (m)	**A1**	**A2**	**A3**	**A4**	**B1**	**B2**	**B3**	**B4**	**C1**	**C2**	**C3**	**C4**
max	20.89	20.86	20.88	20.86	20.89	20.84	20.85	20.91	20.93	20.90	20.84	20.84
min	20.78	20.79	20.83	20.82	20.83	20.81	20.81	20.82	20.82	20.81	20.80	20.81
average	20.85	20.83	20.85	20.84	20.87	20.82	20.83	20.84	20.86	20.84	20.82	20.82
range	0.11	0.07	0.05	0.04	0.06	0.03	0.04	0.09	0.11	0.09	0.04	0.03
ground level	**20.94**	**20.85**	**20.89**	**20.83**	**20.93**	**20.81**	**20.83**	**20.79**	**20.95**	**20.82**	**20.83**	**20.80**
Observations	27	27	27	26	27	26	27	27	27	26	26	27
% above ground	0.00	11.11	0.00	57.69	0.00	96.15	44.44	100.00	0.00	88.46	38.46	100.00
% above 10cm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.70	0.00	0.00	0.00	0.00
% above 20cm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Relative to local ground level (m)	**A1**	**A2**	**A3**	**A4**	**B1**	**B2**	**B3**	**B4**	**C1**	**C2**	**C3**	**C4**
annual max	-0.05	0.01	-0.01	0.03	-0.03	0.03	0.03	0.13	-0.02	0.08	0.01	0.04
summer max	-0.06	0.00	-0.01	0.03	-0.03	0.03	0.03	0.13	-0.02	0.08	0.00	0.03
winter max	-0.05	0.01	-0.04	0.01	-0.04	0.02	0.01	0.07	-0.09	0.04	0.01	0.04
annual min	-0.16	-0.06	-0.06	-0.01	-0.09	0.00	-0.01	0.04	-0.13	-0.01	-0.03	0.01
summer min	-0.16	-0.06	-0.06	-0.01	-0.09	0.00	-0.01	0.04	-0.13	-0.01	-0.03	0.01
winter min	-0.07	-0.01	-0.06	-0.01	-0.07	0.00	-0.01	0.04	-0.12	0.00	-0.02	0.01
annual range	0.11	0.07	0.05	0.04	0.06	0.03	0.04	0.09	0.11	0.09	0.04	0.03
summer range	0.10	0.06	0.05	0.04	0.06	0.03	0.04	0.08	0.11	0.09	0.03	0.02
winter range	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.03	0.03	0.04	0.02	0.03
annual mean	-0.08	-0.02	-0.04	0.01	-0.06	0.02	0.01	0.06	-0.09	0.02	-0.01	0.02
summer mean	-0.10	-0.03	-0.03	0.01	-0.06	0.02	0.01	0.06	-0.07	0.03	-0.02	0.02
winter mean	-0.06	-0.01	-0.05	0.00	-0.06	0.01	0.00	0.05	-0.10	0.01	0.00	0.02
annual % above ground	0.00	11.11	0.00	57.69	0.00	96.15	44.44	100.00	0.00	88.46	38.46	100.00
summer % above ground	0.00	6.67	0.00	66.67	0.00	100.00	60.00	100.00	0.00	93.33	26.67	100.00
winter % above ground	0.00	16.67	0.00	45.45	0.00	90.91	8.33	100.00	0.00	81.82	54.55	100.00
annual % >10cm above ground	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.70	0.00	0.00	0.00	0.00
summer % >10cm above ground	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.67	0.00	0.00	0.00	0.00
winter % >10cm above ground	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
annual % >20cm above ground	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
summer % >20cm above ground	0.00	0.00	6.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
winter % >20cm above ground	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
annual mean depth of inundation	n/a	0.01	n/a	0.02	n/a	0.02	0.01	0.06	n/a	0.03	0.00	0.02
summer mean depth of inundation	n/a	n/a	n/a	0.02	n/a	0.02	0.02	0.06	n/a	0.04	0.00	0.02
winter mean depth of inundation	n/a	0.01	n/a	0.01	n/a	0.01	0.01	0.05	n/a	0.01	0.00	0.02

Appendix TI Thompson Common: Values of derived hydrological variables calculated from dipwell measurements over the duration of the project

Relative to Ordnance Datum (m)	**A1**	**A2**	**A3**	**A4**	**B1**	**B2**	**B3**	**B4**	**C1**	**C2**	**C3**	**C4**
max	33.03	32.83	32.79	32.78	32.82	32.80	32.79	32.79	32.93	32.84	32.78	32.78
min	32.18	32.26	32.31	32.34	32.51	32.34	32.36	32.36	32.67	32.38	32.37	32.38
average	32.56	32.64	32.63	32.62	32.67	32.64	32.64	32.63	32.83	32.70	32.64	32.63
range	0.85	0.57	0.48	0.44	0.31	0.46	0.43	0.43	0.26	0.46	0.41	0.40
ground level	**33.16**	**32.92**	**32.73**	**32.23**	**33.04**	**32.83**	**32.61**	**32.35**	**33.22**	**32.92**	**32.63**	**32.35**
Observations	17	26	26	26	11	26	26	26	9	26	26	26
% above ground	0.00	0.00	42.31	100.00	0.00	0.00	61.54	100.00	0.00	0.00	50.00	100.00
% above 10cm	0.00	0.00	0.00	100.00	0.00	0.00	42.31	92.31	0.00	0.00	34.62	88.46
% above 20cm	0.00	0.00	0.00	92.31	0.00	0.00	0.00	65.38	0.00	0.00	0.00	65.38

Relative to local ground level (m)	**A1**	**A2**	**A3**	**A4**	**B1**	**B2**	**B3**	**B4**	**C1**	**C2**	**C3**	**C4**
annual max	-0.13	-0.08	0.06	0.55	-0.22	-0.02	0.18	0.44	-0.29	-0.07	0.15	0.43
summer max	-0.49	-0.12	0.05	0.55	-0.23	-0.02	0.17	0.43	-0.31	-0.08	0.15	0.43
winter max	-0.13	-0.08	0.06	0.55	-0.22	-0.02	0.18	0.44	-0.29	-0.07	0.15	0.43
annual min	-0.98	-0.65	-0.42	0.11	-0.53	-0.48	-0.25	0.01	-0.55	-0.53	-0.26	0.03
summer min	-0.98	-0.65	-0.42	0.11	-0.53	-0.48	-0.25	0.01	-0.55	-0.53	-0.26	0.03
winter min	-0.94	-0.42	-0.26	0.22	-0.53	-0.34	-0.12	0.12	-0.30	-0.35	-0.10	0.10
annual range	0.85	0.57	0.48	0.44	0.31	0.46	0.43	0.43	0.26	0.46	0.41	0.40
summer range	0.49	0.53	0.47	0.44	0.30	0.46	0.42	0.42	0.24	0.45	0.41	0.40
winter range	0.81	0.34	0.32	0.33	0.31	0.32	0.30	0.32	0.01	0.28	0.25	0.33
annual mean	-0.59	-0.28	-0.10	0.39	-0.36	-0.18	0.03	0.28	-0.39	-0.22	0.02	0.28
summer mean	-0.72	-0.35	-0.16	0.34	-0.39	-0.24	-0.02	0.22	-0.44	-0.27	-0.04	0.22
winter mean	-0.51	-0.20	-0.04	0.45	-0.33	-0.12	0.08	0.33	-0.30	-0.16	0.07	0.33
annual % above ground	0.00	0.00	42.31	34.62	0.00	0.00	61.54	100.00	0.00	0.00	50.00	100.00
summer % above ground	0.00	0.00	23.08	7.69	0.00	0.00	46.15	100.00	0.00	0.00	30.77	100.00
winter % above ground	0.00	0.00	61.54	61.54	0.00	0.00	76.92	100.00	0.00	0.00	69.23	100.00
annual % >10cm above ground	0.00	0.00	0.00	100.00	0.00	0.00	42.31	92.31	0.00	0.00	34.62	88.46
summer % >10cm above ground	0.00	0.00	0.00	100.00	0.00	0.00	23.08	84.62	0.00	0.00	7.69	84.62
winter % >10cm above ground	0.00	0.00	0.00	100.00	0.00	0.00	61.54	100.00	0.00	0.00	61.54	92.31
annual % >20cm above ground	0.00	0.00	0.00	92.31	0.00	0.00	0.00	65.38	0.00	0.00	0.00	65.38
summer % >20cm above ground	0.00	0.00	0.00	84.62	0.00	0.00	0.00	53.85	0.00	0.00	0.00	53.85
winter % >20cm above ground	0.00	0.00	0.00	100.00	0.00	0.00	0.00	76.92	0.00	0.00	0.00	76.92
annual mean depth of inundation	n/a	n/a	0.03	0.39	n/a	n/a	0.12	0.28	n/a	n/a	0.12	0.28
summer mean depth of inundation	n/a	n/a	0.02	0.34	n/a	n/a	0.09	0.22	n/a	n/a	0.10	0.22
winter mean depth of inundation	n/a	n/a	0.04	0.45	n/a	n/a	0.14	0.33	n/a	n/a	0.13	0.33

Appendix CII Chilton Foliat: Detailed mollusc sample data collected 29 August 2002

	X	Y	*Vertigo moulinsiana*			Succineids	Columella edentula	Deroceras laeve	Deroceras reticulatum	Ashfordia granulata	Cepaea nemoralis	Arianta arbustorum	Trichia striolata	Trichica hispida	Lauria cylindracea	Euconulus alderi	Clausilia bidentata	Deroceras panormitanum	Cochlicopa lubrica	Arion subfuscus	Discus rotundatus	Arion ater agg.	Punctum pygmaeum	Dampness Index	Vegetation Height (m)
			Adult	Juvenile	Total																				
1	20.0	1.0	7	3	10	8	2			28														3	1.8
2	20.0	2.5	1	3	4	37	4			55														2	1.4
3	20.0	5.0	15	7	22	33	3			45														2	1.2
4	20.0	7.5	63	18	81	15	2			23														4	1.3
5	20.0	10.0	32	4	36	15				27														2	1.2
6	20.0	13.0	10	3	13	18	1			8														3	1.6
7	20.0	15.0	0	2	2	27	1			15														1	1.8
8	20.0	17.5	0	0	0	15	1			10		1	1											1	1.9
9	20.0	20.0	1	1	2	18				23		2												1	1.0
10	20.0	22.5	0	0	0	12					1	1	4											1	1.9
11	20.0	25.0	0	0	0	17	1			23			4											1	1.8
12	20.0	30.0	0	0	0	3	2			10		1	9			1								1	2.1
13	15.0	30.0	0	0	0	12	5			7	1	2	3											1	1.4
14	15.0	25.0	0	0	0	7	1			18		2	2	1										1	1.7
15	15.0	22.5	0	0	0	3	1			13	1	2	3											1	1.4
16	15.0	20.0	0	0	0	12	1			12		3	2											1	1.9
17	15.0	17.5	0	0	0	17			1	43		2	3	1					1					2	1.1
18	15.0	15.0	5	2	7	28				70		3	2			1								2	1.1
19	15.0	13.0	28	5	33	18	1		1	30		1												4	1.1
20	15.0	10.0	26	7	33	26	3			30		1	2											5	1.3
21	15.0	7.5	3	1	4	35	3			32	1	1												4	1.4
22	15.0	5.0	9	1	10	15	4	1		24														4	1.2
23	15.0	2.5	7	0	7	15				26														5	1.1
24	15.0	0.0	1	0	1	15				55														5	1.6
25	25.0	0.0	5	2	7	50	3			105					1		3				1			4	1.8
26	25.0	2.5	7	4	11	45	1			85											1			2	1.5
27	25.0	5.0	52	13	65	27	8	1	1	20							1							3	1.7
28	25.0	7.5	88	27	115	7	8			25							1							3	1.5
29	25.0	10.0	62	17	79	15				8						1								4	1.6
30	25.0	13.0	25	6	31	14	3		2	5														4	1.0
31	25.0	15.0	1	0	1	40	5			60		4	1		1		1					2		2	1.2
32	25.0	17.5	0	0	0	20				70		9	2		1	1	2							1	1.0
33	25.0	20.0	0	0	0	5	2			22		1	3			2	1							1	1.1
34	25.0	30.0	0	0	0	10				10			5											1	1.2
35	35.0	0.0	0	0	0	10	5			35					1		2							2	0.7
36	40.0	0.0	2	1	3	17	17			29							2							2	1.1
37	30.0	0.0	0	0	0	35	10		1	60							6							2	1.0
38	30.0	2.5	3	1	4	20	10			25		3												2	1.8
39	35.0	2.5	6	2	8	20	14			5			2											2	1.1
40	40.0	2.5	26	4	30	8				33							3			1				2	1.1
41	40.0	5.0	26	5	31	12	6			15		3												3	1.8
42	35.0	5.0	12	7	19	10	14			22														2	1.0
43	30.0	5.0	33	7	40	10	8			10														2	1.5
44	30.0	7.5	58	17	75	20	5			36						2								3	2.2
45	30.0	10.0	38	12	50	14				7														5	2.1
46	35.0	7.5	22	11	33	10	4			8														3	1.1
47	40.0	7.5	15	2	17	12	1			8														3	2.0
48	35.0	10.0	24	4	28	17		1	1	6		1								1				4	1.1
49	40.0	10.0	13	4	17	22		1	1	48					1					1				4	1.2
50	40.0	12.5	1	2	3	33	2		2	85		1			1					2				2	1.2
51	40.0	15.0	0	0	0	50	3		1	75		7	3			2	1							2	1.2
52	40.0	17.5	0	0	0	14		1		35		6	4				3							1	1.2

	X	Y	*Vertigo moulinsiana* Adult	Juvenile	Total	Succineids	Columella edentula	Deroceras laeve	Deroceras reticulatum	Ashfordia granulata	Cepaea nemoralis	Arianta arbustorum	Trichia striolata	Trichica hispida	Lauria cylindracea	Euconulus alderi	Clausilia bidentata	Deroceras panormitanum	Cochlicopa lubrica	Arion subfuscus	Discus rotundatus	Arion ater agg.	Punctum pygmaeum	Dampness Index	Vegetation Height (m)
53	40.0	30.0	0	0	0	10		2	3	26	2		7								1			1	1.0
54	35.0	12.5	7	2	9	21	3			75					2									2	1.2
55	30.0	12.5	16	3	19	17	3			12														3	1.3
56	30.0	15.0	1	0	1	40	5			100							3		1	1				1	1.1
57	30.0	17.5	0	0	0	30	4		1	60		1	3	1			2							1	1.9
58	30.0	20.0	0	0	0	10	4			50		1	3				2							1	2.1
59	30.0	30.0	0	0	0	20				40	2	5	7											1	1.1
60	35.0	15.0	1	0	1	35	2			115			3		1		1							1	1.1
61	35.0	17.5	0	0	0	25	8			115		5	1				3			1				1	1.1
62	35.0	20.0	0	0	0	12	2		2	30		2	13										1	1	1.1
63	35.0	30.0	0	0	0	6			1	38	1	4	13						1	1				1	1.1
64	10.0	0.0	2	0	2	12				39														5	2.0
65	5.0	0.0	0	0	0	18	5			60							2							4	1.8
66	0.0	0.0	4	1	5	20	5			85		1												4	1.3
67	0.0	2.5	2	5	7	25	8		2	50		3	1	1										2	1.0
68	0.0	5.0	6	3	9	44	3	1		12		2				1				1				2	1.1
69	0.0	7.5	28	9	37	14	2			2										1	1			2	1.0
70	0.0	10.0	14	4	18	17		1		1														2	1.1
71	0.0	12.5	12	5	17	25				40														3	1.7
72	0.0	15.0	6	4	10	35	3			60		5												3	1.2
73	0.0	17.5	0	1	1	22	5			25		3			1									1	2.0
74	0.0	20.0	0	0	0	18	6			55		1					3							1	1.5
75	0.0	22.5	0	0	0	18	3			32	1	11	3							1				1	1.4
76	0.0	30.0	0	0	0	5				10	1		3	1										1	0.6
77	5.0	2.5	3	6	9	37	12		1	45		1												2	0.9
78	5.0	5.0	12	13	25	19	17	1		23		1												2	0.7
79	5.0	7.5	24	18	42	10	2			4										1				2	0.7
80	5.0	10.0	18	12	30	33				12													1	2	1.3
81	5.0	12.5	4	2	6	60			1	60						1								4	1.7
82	10.0	21.5	0	0	0	18	7			80			2											5	1.6
83	10.0	5.0	5	9	14	15	4		1	28		1								1				2	1.4
84	10.0	7.5	6	9	15	24	14			57		3				1								2	1.0
85	10.0	10.0	20	8	28	20			1	35		2		1										4	0.8
86	10.0	13.5	12	5	17	17	1			42														3	0.8
87	10.0	15.0	2	0	2	15	4	1		150		1	1		3	1	2							2	1.1
88	10.0	17.5	0	0	0	10				80		3	1		2	1	3			1				1	1.2
89	10.0	20.0	0	0	0	15	4			40		3	9			3	2						1	1	1.0
90	10.0	30.0	0	0	0	8	1			15	2		12						1					1	1.0
91	5.0	15.0	13	4	17	38	3	1	1	30														3	1.2
92	5.0	17.5	0	0	0	33	3			65		12				1	2							1	1.3
93	5.0	20.0	0	0	0	9	6		1	15		4	6		2									1	1.2
94	5.0	30.0	0	0	0	2				16			3											1	0.9

Note: grid origin is in south-east corner of study area. X coordinates extend west and Y coordinates north

Appendix MII Market Weston Fen: Detailed mollusc sample data collected 22 August 2002

Sample No.	X	Y	*Vertigo moulinsiana*			Succineids	*Deroceras laeve*	*Deroceras reticulatum*	*Ashfordia granulata*	*Cepaea spp.*	*Trichia hispida*	*Vertigo antivertigo*	Dampness Index	Vegetation Height (m)
			Adult	Juvenile	Total									
1	0	0								1			2	0.3
2	2.5	0					1			12			2	0.4
3	5	0							1	23			4	0.1
4	5	2.5				1				6			3	0.5
5	2.5	2.5							1				2	0.3
6	0	2.5								2			2	0.4
7	0	5				1				9			3	1.1
8	2.5	5								2			2	0.3
9	5	5								2			3	1.1
10	5	7.5				2				7			3	1.2
11	2.5	7.5								8	1		2	1.1
12	0	7.5	1		1	1				2			3	1.3
13	0	10								3			3	1.4
14	15	20	1	1	2					2			4	2.1
15	17.5	20	3	10	13	1				3			3	1.8
16	12.5	20	4	2	6	1				2			4	1.7
17	2.5	10								10	1		3	1.2
18	5	10				1				6			2	1.6
19	5	12.5	2		2	1				6			4	2
20	2.5	12.5	2		2	1				8	1		2	1.7
21	0	12.5	1	1	2					7			2	1.8
22	0	15	1	3	4	2				15			1	1.8
23	2.5	15								16			2	1.9
24	5	15	1		1	1				6			4	1.2
25	5	17.5								4			4	2
26	2.5	17.5	1	2	3	1				12	1		2	1.6
27	0	17.5		1	1	2				6			2	1.5
28	0	20		2	2					3	1		3	1.5
29	2.5	20		1	1					4			2	1.5
30	5	20	4	1	5	1				6			3	2.1
31	2.5	22.5				2				3			3	1.5
32	0	22.5	1	2	3	3				1			3	1.7
33	12.5	22.5	4	1	5	1				2			4	2
34	10	22.5	5	1	6	1				2			4	1.9
35	7.5	22.5		1	1	3							4	2.2
36	7.5	20	2		2	1				3			4	2.2
37	10	20				3				2			2	1.9
38	12.5	17.5	4	2	6					15			3	2.2
39	10	17.5	1		1					4			3	2.1
40	7.5	17.5	1	1	2					2			4	2.1
41	7.5	15	2		2				1	7			3	2.1

Sample No.	X	Y	*Vertigo moulinsiana*			Succineids	*Deroceras laeve*	*Deroceras reticulatum*	*Ashfordia granulata*	*Cepaea spp.*	*Trichia hispida*	*Vertigo antivertigo*	Dampness Index	Vegetation Height (m)
			Adult	Juvenile	Total									
42	10	15	4	2	6	2			1	3			4	2.1
43	12.5	15	3	1	4				1	2			3	2
44	12.5	12.5	1	1	2					5			4	2.2
45	10	12.5	1		1					10			4	2.3
46	7.5	12.5								2			4	2
47	7.5	10				1				3			3	1.9
48	10	10								3			4	1.9
49	12.5	10	3	2	5					4			4	1.6
50	12.5	7.5								3			3	1.6
51	10	7.5		1	1					10			2	1.5
52	7.5	7.5								23			2	1.4
53	7.5	5				1				7			2	1.4
54	10	5								20			2	1.3
55	12.5	5				3				13			3	1.5
56	12.5	2.5								28			2	1.2
57	10	2.5								15			2	0.9
58	7.5	2.5								14			2	1
59	7.5	0	1		1	4				23			2	0.9
60	10	0				1				8			2	0.6
61	12.5	0				2				8			2	0.6
63	15	22.5	4	3	7	1				2			4	1.1
65	15	17.5	3	2	5	1							3	1.9
66	15	15	6	2	8					4			4	2.1
69	15	12.5	11	5	16					2			3	2.1
70	15	10		2	2	2				4			4	1.4
73	15	7.5				1				14			4	1.2
74	15	5				2			2	3			3	1.3
75	15	2.5				2				3		1	2	1.1
76	15	0				1				8			2	0.9
77	17.5	0		1	1	1				8			2	1
78	17.5	2.5				2		3		10			2	1.3
79	17.5	5	1	1	2	1		1		4			4	1.9
80	17.5	7.5	3	1	4					2			4	1.7
81	17.5	10	1		1					7			3	2
82	17.5	12.5	5	2	7					4			4	2.1
83	17.5	15	2	1	3					5			4	2.2
84	17.5	17.5	1	1	2					6			3	2.1
86	17.5	22.5	4	1	5	1			2	5			4	1.3

Note: grid origin is in extreme west corner of study area. X coordinates extend east and Y coordinates north.

Appendix TII Thompson Common: Detailed mollusc sample data collected 20 August 2002

Sample No.	*Vertigo moulinsiana*			Suuineids	*Deroceras laeve*	*Deroceras reticulatum*	*Cepaea* sp.	*Arion ater*	*Trichia hispida*	*Vertigo pygmaea*	*Vertigo antivertigo*	*Euconulus* sp.	*Zonitoides nitidus*	*Punctum pygmaeum*	*Nesovitrea hammonis*	Dampness Index	Vegetation Height (m)
	Adult	Juv.	TOTAL														
1	13	3	16													3	1
2	4	1	5	2			2									2	1
3							7									1	0.7
4	26	7	33	1												5	1.1
5	9	4	13	1												3	1
6	4	1	5									1	1			2	0.7
7	24	8	32				1						1			5	1.1
8	10	1	11				3									3	1.1
9	12	4	16													4	1
10	9	3	12	4			2					1				5	1
11	10	2	12													4	1.2
12	13	3	16	3			3				1					5	1.2
13	24	8	32		1		1									4	1.1
14	8	2	10	1			3				1	2				4	1
15	9		9				1									5	1.2
16	2		2	7			1					1		1		4	1.3
17	19	2	21	1			1									5	1.1
18	11	5	16	2							1	2				5	1.4
19	14	2	16	2			1									5	1.5
20	5	4	9	1			1									4	1.1
21	1	2	3	3			1									3	1.2
22	2	2	4	3			2		1			1				3	0.9
23	5	8	13	1								1				4	1.1
24	13	3	16													5	1
25	10	2	12	1			2		1							3	1.1
26	4	3	7	1			1					1				2	1.2
27	6	4	10	3			1		2			1				2	1
28	6	1	7	1												2	1.4
29							3									2	0.9
30							3			1						1	0.8
31							2			7						1	0.7
32							1									2	0.6
33	14	6	20	2			6		1							2	0.6
34	4	7	11				1									2	0.9
35						1	16		1							2	0.7
36							6			7						1	0.6
37				1			7									1	0.8

Sample No.	*Vertigo moulinsiana*			Suuineids	*Deroceras laeve*	*Deroceras reticulatum*	*Cepaea* sp.	*Arion ater*	*Trichia hispida*	*Vertigo pygmaea*	*Vertigo antivertigo*	*Euconulus* sp.	*Zonitoides nitidus*	*Punctum pygmaeum*	*Nesovitrea hammonis*	Dampness Index	Vegetation Height (m)
	Adult	Juv.	TOTAL														
38	9	1	10				3									2	0.7
39	5	4	9	1			5		2							5	1.2
40	8	2	10				4					1				3	1.2
41	2	1	3				3					2		1		1	1
42					1		4			1						1	0.5
43										1						1	0.6
44	3		3				4									2	0.7
45	12	3	15	1			4									3	0.9
46	4	6	10									2				3	0.7
47							5		1							1	0.4
48							4			1						1	0.4
49							4									1	0.4
50							12	1	2	1						1	0.7
51	1		1				2					1			1	1	0.8
52						1	4		2							1	0.4
53							1							1		1	0.3
54							1									1	0.3
55							2									1	0.3
56							8			2				2		1	0.4
57							4									1	1.5
58							13									1	0.6
59							4					1				1	0.5
60	3	1	4	1			1									2	0.6

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