Classification and ordination of selected ponds of County Durham

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CLASSIFICATION AND ORDINATION OF SELECTED PONDS OF COUNTY DURHAM

by

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THE PONDS

BEARPARK
BISHOP MIDDLEHAM
CARR HOUSE
CASSOP
COOT
CROXDALE HALL OXBOE
CRYSTALS POND
EAST FARM
FRANKLAND
LANGLEY FUR FARM
MALTON
MILL HOUSE
NORTH BRASSIDE CLAYPIT
PADDOCK PLANTATION
RAISBY
ROSA SHAFTO
SEATON CAREW
TYLERY
WINGATE
WINGATE FAR POND

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ABSTRACT

Macro flora and macro invertebrates were sampled at 20 ponds in County Durham, and information on forty eight environmental variables was also collected for each site.

The environmental variables, plant species records and numbers of each species of corixidae (Hemiptera-Heteroptera) and water beetles (Coleoptera) occurring in each pond were used as the basis of various methods of ordination and indicator species analysis.

A preliminary classification of ponds into five groups is proposed. Information on the species and environmental features which characterize each group are presented.

1 INTRODUCTION

Ponds are highly individual habitats, the flora and fauna vary widely, and often even within a small geographical area (Friday 1981). This variability makes them interesting from an ecological point of view as they are populated by a wide variety of species with unique physiological and behavioural properties; however the same variability makes it difficult to establish the causes of inter-pond variation, and to assess the value of a pond for nature conservation.

The understanding of pond ecology lags behind that of most freshwater and terrestrial ecosystems and this is reflected when assessments of ponds for nature conservation are made. The assessments tend to be haphazard, separating only neglected from unneglected ponds and failing to distinguish between long established water bodies with uncommon or rare species and easily replaced ponds with a wide variety of common plant and animal species (Pond Action 1989).

Various management techniques exist to control the effects of factors such as vegetation succession, shade, water quality and silt accumulation. However the effects of these techniques are understood only in the most general terms (Brooks & Agate, 1981). Pond management thus remains a mixture of cautious dredging, weed cutting, shade control and maintenance of habitat diversity.

Experimental studies are needed to refine pond management, but these are hampered by a lack of understanding of the causes of the variation between ponds. Much of this variation between ponds was explained on the basis of chance (Talling, 1950) but recent work in Oxfordshire (Biggs & Langley, 1989) and Scotland (Jeffries, 1989) has shown that ponds can be classified into groups on the basis of similarities in the communities they support. This suggests that environmental factors rather than chance alone, may influence which species inhabit a particular pond.

This study investigates the relationships between the plants, macro-invertebrates and environmental factors of a number of ponds in County Durham. An attempt has been made to classify the ponds into recognisable groups, the members of which are likely to behave in similar ways under experimental conditions. A discussion of the use of such a classification in furthering the understanding of pond ecology and its use in nature conservation is presented.

2 METHODS

2.1 FIELD SURVEY

Twenty ponds were chosen to represent a range of physico-chemical and habitat conditions. Given the limited time available, studies were restricted to ponds under 155m altitude and less than $2000m^2$ surface area. A number of these lie on the coal measures, several are situated on the Magnesium limestone and one is a sand dune pond.

A standard method was employed for each pond staying as close to the National Pond Survey (NPS) procedure as possible. (see Appendix 1 for a copy of the field recording sheet).

Initial visits were made in April 1991 to assess the suitability of each pond for inclusion in the study on the grounds of access and size, as it was not always possible to decide from maps. In May, the physical features (2.1.1) of each pond and the plant species present were identified (2.1.3). The macro-invertebrate samples were collected on two occasions, once in June, and once in July (2.1.4). Water samples were collected and basic water chemistry measurements made (2.1.2) in all the ponds over a two day period in July, and any additional plant species which had appeared since May were recorded.

The following information was obtained from each site:

2.1.1 A DESCRIPTION OF THE MAIN PHYSICAL FEATURES OF THE POND AND ITS SURROUNDINGS

(i) The initial task at each site was to walk the perimeter of the pond to record vegetation, and to assess the relative importance of different water sources (eg: ground water, runoff, direct precipitation). The latter was completed without a detailed hydrological survey.

(ii) The presence of surface inflows and outflows was then recorded. If present, the width and depth of flow in the channel was measured and an estimate of the flow category made.

(iii) Thirdly, land use in three zones around the pond and in the catchment of any streams which drain into the pond, was recorded. The zones were: (a) Upto 5m from the pond (immediate perimeter), (b) 5-25m from the pond, (c) 25-100m from the pond, (d) catchment. This was estimated from 1:25000 OS maps.

(iv) The proximity of the pond to other wetlands and water bodies was recorded. The connection between the pond and any neighbouring wetlands was assessed to distinguish between permanent and temporary connections.

(v) The proportion of the pond margin overhung by trees and/or shrubs was measured. The proportion of the pond as a whole overhung by trees and/or shrubs was also assessed and recorded. They were categorised as follows: 0 = no shade, 1 = 1-20%, 2 = 21-40%, 3 = 41-60%, 4 = 61-80%, 5 = 81-100%.

(vi) Estimates of the area of the pond occupied by emergent, floating leaved and submergent plants were made. These depended on growth form rather than species. For example, water starwort (Callitritche sp.) could be recorded in both submerged and floating leaved categories; and stands of reeds (Typha sp.) with duckweed (Lemna sp.) growing between the stems could be recorded in both submerged and floating leaved categories.

(vii) Finally the base material of the pond was identified (eg: clay, gravel, butyl) a sample of sediment taken and its composition noted.

2.1.2 BASIC WATER CHEMISTRY

(i) Water clarity was estimated on a scale of 1-4 as the water was too shallow for a secchi disc to be useful.

(ii) Five water samples were collected at random locations 2m from the shore and 20cm below the surface at each site. pH and conductivity were measured in the laboratory using the appropriate meters.

(iii) An oxygen meter was used to measure oxygen levels in each of the ponds. This data was not used in the analysis as the effects of wave action, temperature, time of day and proximity to plants meant measurements could not be standardised. It was felt this may have produced misleading results.

(iv) A note was made of any pollution eg oil, large quantities of dumped rubbish.

2.1.3 WETLAND PLANT SPECIES

(i) Page 4 of the NPS. field recording sheet was used to record all wetland plants within the outer boundary of the pond. The identification guides used were:

CLAPHAM A.R. TUTIN T.G. and **MOORE D.M.** (1988) Flora of the British Isles. 3rd Edition:
Cambridge University Press.

HALEM S. SINKER C. and **WOLSELY L.** (1975) British Water Plants:
Reprinted from Field Studies 4

WIGGINTON M.J. and **GRAHAM G.G.** (1981) Guide to the identification of the more difficult vascular plant species:
Nature Conservancy Council.

2.1.4 MACRO INVERTEBRATES

(i) With the aim of collecting as many species as possible, all the main habitats and micro habitats in the pond were identified (suitable microhabitats included flooded marginal grasses, stands of water lily, inflow areas, open water etc). Each pond was sampled for a total of six minutes (the time of the net in the water) with the sample time divided equally between micro habitats.

Trials show that 5 sweeps with a 1mm mesh net will obtain at least 85% of species in a pond. However pond nets are renowned for undersampling certain elements of the fauna - most notably leeches (see MACAN 1977, for critique). Therefore species lists may not be complete, Nonetheless, this technique was deemed suitable for a comparison of pond communities.

(ii) The net was used vigorously to dislodge animals from vegetation and banks. Occasional long sweeps captured fallen or escaping animals. In ponds with gravely or stoney substrates the coarse sediment was disturbed (by kicking) to bring animals into the water column.

(iii) In addition to the six minute sample a few minutes was spent searching for and collecting conspicuous animals. For example hard substrates were searched for firmly attached animals and stones were lifted to look for flat worms etc.

(iv) Each sample was then placed in a container and labelled. When possible, the sample was sorted immediately, otherwise it was stored overnight in the refrigerator.

(V) Each sample was sorted in a white tray with water of 3-5mm depth. All macro-invertebrates were removed with forceps, and sorted into higher taxa.

(vi) Hemiptera (water bugs) and Coleoptera (water beetles) were identified to species level. The identification guides used were:

FITTER R. and MANUEL R. (1986) Collins Field Guide to Freshwater Life:
Collins, London.

FRIDAY L.E. (1988) A Key to Adult British Water Beetles:
(AIDGAP KEY) Field Studies Council Publication 1989.

MACAN T.T. (1965) A Revised Key to the British Water Bugs (Hemipter-Heteroptera) 2nd Edition:
Freswater Biology Association. Scientific Publications No 16.

MACAN T.T. (1959) A Guide to Freshwater Invertebrate Animals:
Longman, London.

2.1.5 HISTORY AND USE OF THE PONDS

(i) Information was noted about the age of the pond, wether or not it dries out, changes in pond management and any use which influences the ecology of the pond (eg fishing, nature conservation, cattle watering).
(ii) The presence or absence of amphibians and fish was recorded but no samples were collected.

2.2 ANALYSIS OF DATA

Computer files were compiled containing records of the plant species, identified macroinvertebrate species and the environmental variables from each pond.

2.2.1 The data was classified using the TWINSPAN (TWo Way INdicator SPecies ANalysis) programme (HILL 1979). This classifies samples on the basis of their species composition; or it classifies species on the basis of their occurance in samples. The data is divided at its centre of gravity to form both positive and negative samples, producing a hierarchial division of samples that is best represented in the form of a dendrogram.

It is generally accepted that this method has its faults (HILL and GAUCH, 1980) as it produces the arch effect.

2.2.2 Ordination of ponds was achieved using DECORANA (DEtrended CORrespondance ANAlysis) (TER BRAAK, 1988) which produces diagrams where similar samples or species are closer to each other and dissimilar ones are some distance apart, and CANOCO (CANOnical COrrespondance analysis) which demonstrates a relationship between environmental variables. The programme selects the linear combination of environmental variables that maximise the dispersion of the scores assigned to each species giving the first axis. Subsequent axes are subject to the constraint of being uncorrelated to axis 1.

3 RESULTS

3.1 ENVIRONMENTAL VARIABLES

3.1.1 CLASSIFICATION AND ORDINATION OF PONDS ON THE BASIS OF THEIR ENVIRONMENTAL VARIABLES

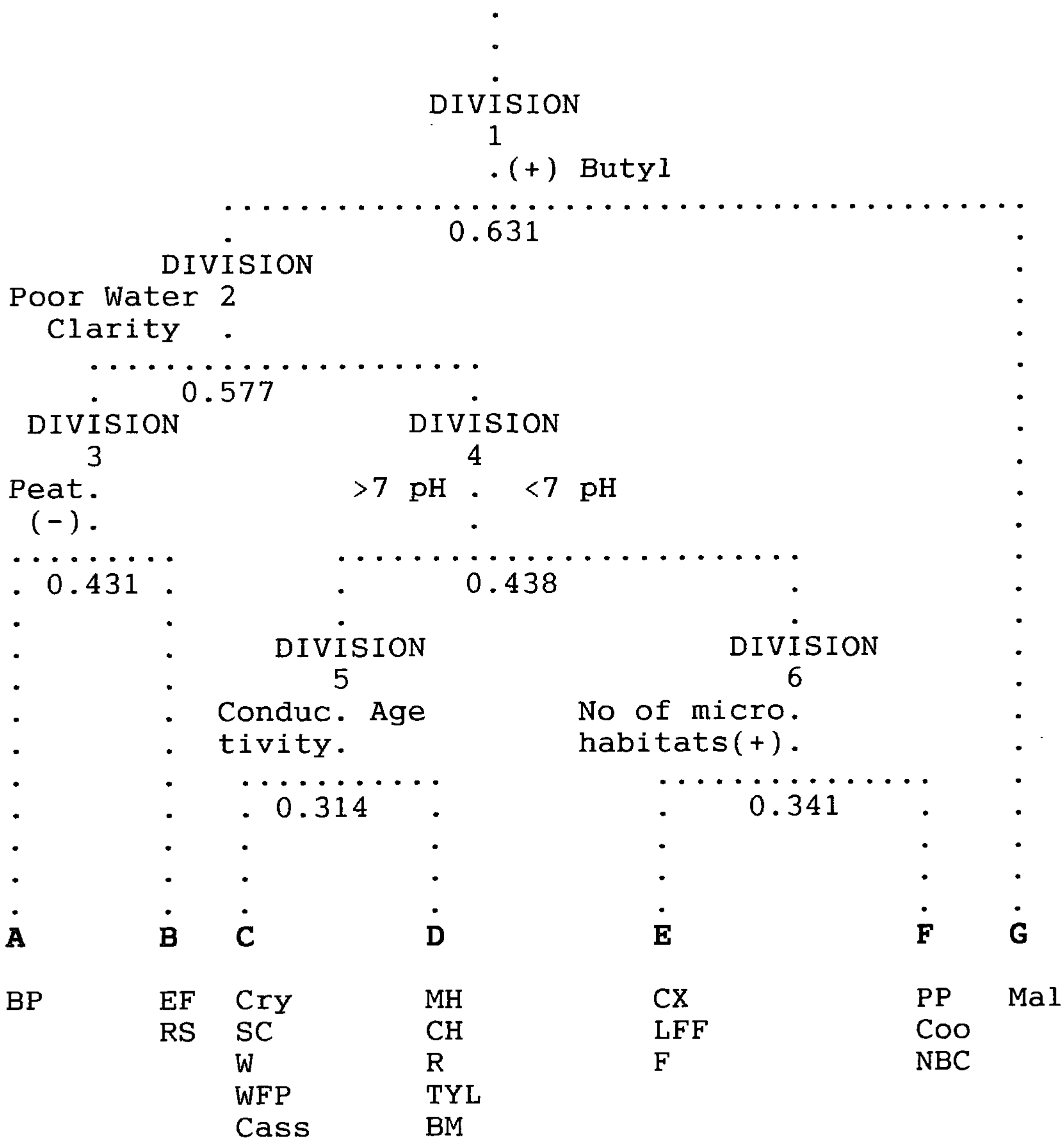
The classification of the 20 ponds on the basis of their environmental attributes by TWINSPAN showed one pond (Malton) seperating at the first level (Figure 1). This is the only pond with a butyl lining. Division 2 resulted in the seperation of three ponds: Bearpark, East Farm and Rosa Shafto. The positive indicator for their seperation is poor water clarity. The remaining sixteen ponds divided into two groups on the basis of pH, and further according to age, and number of micro habitats. Since two way indicator species analysis is a divisive technique, the division of the samples into progressively smaller groups throughout is continued only for as long as seems useful, in this case seven groups are formed at level 4.

In order to more clearly demonstrate the environmental conditions that typify each of the groups of ponds, the more notable features of each group are listed for each in Table 1.

Detrended correspondence analysis (DCA) was carried out using the same field survey data to illustrate the relationship between the ponds. Figure 2 presents an Axis 1 by Axis 2 DCA ordination plot of the ponds. Further variation in the data set could be displayed using Axis 3 and Axis 4, but most of the variation is

Figure 1

TWINSPAN CLASSIFICATION OF PONDS BY ENVIRONMENTAL VARIABLES



KEY TO THE PONDS

BP	BEARPARK
BM	BISHOP MIDDLEHAM
CH	CARR HOUSE
Cass	CASSOP
Coo	COOT
CX	CROXDALE HALL OXBOE
Cry	CRYSTALS POND
EF	EAST FARM
F	FRANKLAND
LFF	LANGLEY FUR FARM
Mal	MALTON
MH	MILLHOUSE
NBC	NORTH BRASSIDE
PP	PADDOCK PLANTATION
R	RAISBY
RS	ROSA SHAFTO
SC	SEATON CAREW
TYL	TYLERY
W	WINGATE
WFP	WINGATE FAR POND

TABLE 1

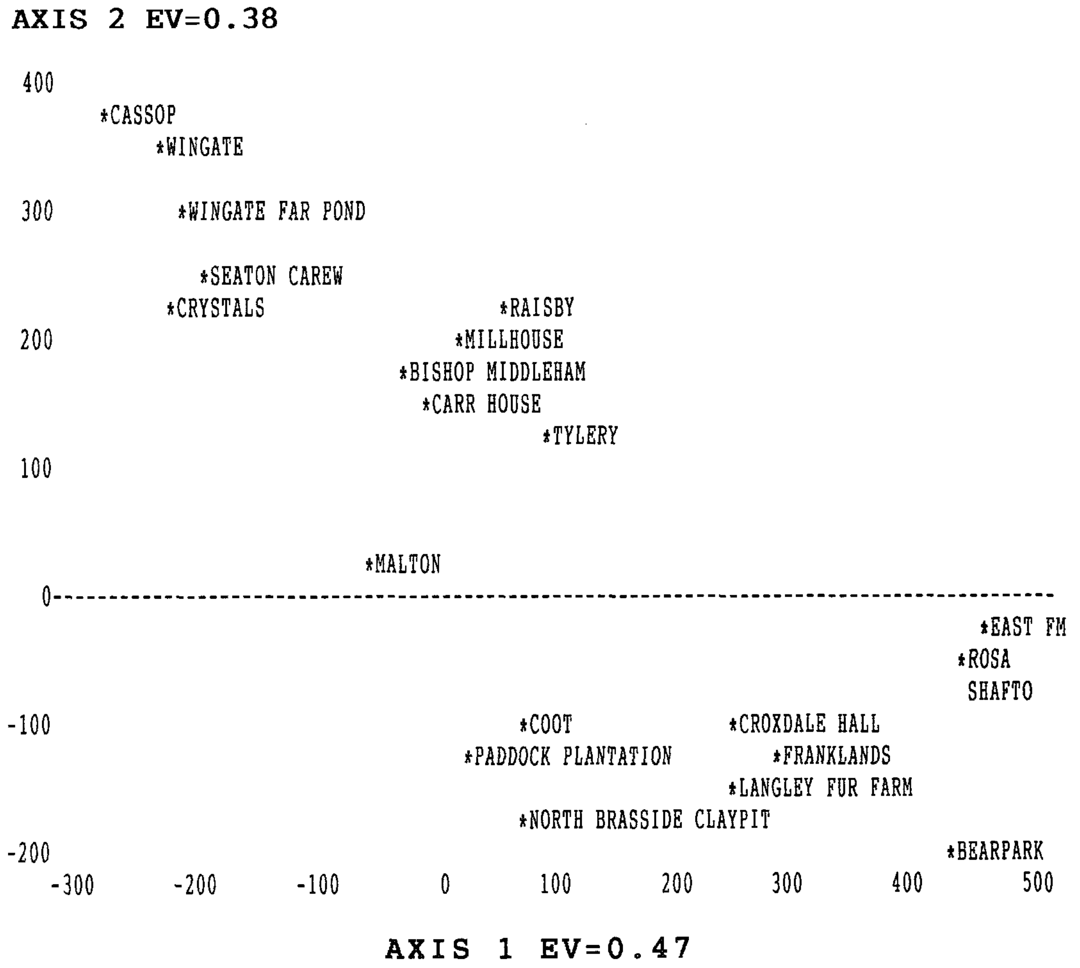
SOME IMPORTANT ENVIRONMENTAL FEATURES OF THE SEVEN GROUPS OF PONDS GENERATED BY TWO-WAY INDICATOR SPECIES ANALYSIS (Figure 1)

GROUP (no of ponds)	mean pH (range)	mean Conductivity (range)	Geology	Base/ Sediment	Land Use <5m	Water Clarity
A (1)	5.54	453ms	CM	Peat	Mire Pasture	Brown (peat stained)
B (2)	6.43 (5.93-6.93)	628ms	CM	Clay/Mud Ooze Leaves	Over 50% Woodland	Polluted Turbid
C (5)	8.11 (7.21-8.49)	1611ms	ML	Gravel/ Sand	Grassland Scrub	Clear
D (4)	7.48 (7.23-7.84)	855ms	CM	Gravel/ Sand	Moor/Bog Grassland	Slight Green
E (3)	6.94 (6.9-6.97)	756ms	CM	Gravel/ clay mud	Woodland Grassland	Clear
F (3)	6.86 (6.81-6.93)	448ms	CM	Clay/Mud	Woodland Pasture	Clear
G (1)	6.97	811ms	CM	Butyl	Grassland	Clear

CM = Coal Measures
ML = Magnesian Limestone

FIGURE 2

Ordination of ponds based on DECORANA of environmental data



shown on these first two axes. The eigenvalues can be thought of as an expression of the variance accounted for by each axis and are as follows: Axis 1 = 0.47; Axis 2 = 0.38. Axis 1 appears to be associated with the nature of the bedrock that the ponds lie on. Those lying over the Magnesian limestone are given negative loadings (eg: Cassop, Wingate, Wingate Far Pond), those ponds lying over coal measures have positive loadings (eg:Rosa Shafto and East Farm). Axis 2 is associated with pH and conductivity. Ponds with acid waters and low conductivity measures have negative loadings on this axis (eg: Croxdale Hall Oxboe, Franklands, Bearpark). Those with high pH, and higher levels of dissolved ions (conductivity) have positive loadings (eg:Raisby, Bishop Middleham, Seaton Carew). Only one pond occupies a slightly anomolous position in relation to this crude division. Malton with its butyl lining is not influenced by the underlying geology and has pH just above neutral (7.28). Mans influence in altering both the physical and chemical characteristics of this pond means it fails to conform to the general pattern created within this ordination.

3.2.2 CLASSIFICATION AND ORDINATION OF PONDS ON THE BASIS OF PLANT SPECIES COMPOSITION

i) Indicator species analysis

Classification of the ponds on the basis of their plant species by TWINSPAN (Figure 3) resulted in one pond (Bearpark, group L) separating at level 1. The

TABLE 2

WETLAND PLANT SPECIES RANKED BY CONSTANCY
(% of ponds species occur in)

Typha latifolia	65%
Lemna minor	65%
Potamogeton natans	65%
Phragmites australis	55%
Juncus effusus	45%
Mentha aquatica	40%
Eleocharis palustris	40%
Menyanthes trifoliata	40%
Equisetum fluviatile	35%
Hippuris vulgaris	35%
Iris pauedacorus	30%
Callitritche stagnalis	30%
Potamogeton berchtoldii	25%
Elodea canadensis	25%
Caltha palustris	20%
Nymphae alba	15%
Veronica beccabunga	15%
Sparganium erectum	20%
Ranunculus aquatilis	20%
Hydrocotyle vulgaris	15%
Alisma plantago-aquatica	15%
Apium nodiflorum	15%
Ranunculus trichophyllus	10%
Glyceria fluitans	10%
Juncus inflexus	10%
Juncus bulbosus	10%
Potamogeton pectinatus	10%
Juncus gerardi	5%
Nasturtium officionale	5%
Potentilla palustris	5%
Myriophyllum spicatum	5%
Ranunculas peltatus	5%
Ranunculus flammula	5%
Ranunculus scleratus	5%

Figure 3

TWINSPAN CLASIFICATION OF PONDS BY PLANT SPECIES

```
                                        .
                                        .
                                     DIVISION
                                        1
                           T.latifolia . J.bulbosus
                                   (-) . (+)
                           ....................................
                           .        0.540                     .
                     DIVISION                                 .
                        2                                     .
              A.nodiflorum. S.erectum                         .
              R.peltatus  . M.spicatum                        .
                      (-) . (+)                               .
                   .........................                  .
                   .     0.366             .                  .
              DIVISION                  DIVISION              .
                 4                         5                  .
        R.aquatilis.H.vulgaris    E.palustris.S.erectum       .
                 .                         .                  .
        ......................    ....................        .
        .       0.522        .    .      0.371       .        .
        .                    .    .                  .        .
        .                    .    .                  .        .
        H                    I    J                  K        L

        BM                   CRY  LFF                MH      BP
        CH                   Cass Mal                RS
                             SC   PP                 R
                             W    Coo                EF
                             WFP  F
                                  CX
                                  NBC
                                  TYL
```

KEY TO THE PONDS

BP	BEARPARK
BM	BISHOP MIDDLEHAM
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Cry	CRYSTALS POND
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F	FRANKLAND
LFF	LANGLEY FUR FARM
Mal	MALTON
MH	MILLHOUSE
NBC	NORTH BRASSIDE
PP	PADDOCK PLANTATION
R	RAISBY
RS	ROSA SHAFTO
SC	SEATON CAREW
TYL	TYLERY
W	WINGATE
WFP	WINGATE FAR POND

TABLE 3

SOME IMPORTANT MACRO-FLORA INDICATOR SPECIES TYPICAL OF THE FIVE GROUPS OF PONDS GENERATED BY TWO-WAY INDICATOR SPECIES ANALYSIS (Figure 3)

GROUP (Number of ponds)	PLANT SPECIES	
H (2)	Ranunculus aquatilis	Potamogeton berchtoldii
I (5)	Hippuris vulgaris Callitritche stagnalis	Myriophylum spicatum Apium nodiflorum
J (8)	Eleocharis palustris Elodea canadensis	Mentha aquatica Alisma plantago aquatica
K (4)	Sparganium erectum	Menyanthes trifoliata
L (1)	Juncus bulbosus	

remaining ponds (n=19) form four groups at level 3 of the divisions. The first dichotomy used Juncus bulbosus as a positive indicator, and Typha latifolia as a negative indicator (remaining ponds). Division 2 seperated ponds into two further groups. Sparganium erectum and Menyanthes trifoliata were the positive indicators for groups J and K, and Apium nodiflorum and Ranunculus peltatus were negative indicators for groups H and I. Similarly, the presence of Eleocharis palustris and Sparganium erectum seperated group J from K.

In order to more clearly identify the plant species that are typically found in each of the groups, the more notable species are listed for each in Table 3.

ii) General relationship between flora and environmental factors.

Ponds in group K have low species richness and are dominated by plant species assemblages indicative of low pH conditions, eg Menyanthes trifoliata, Sparganium erectum. Groups H, I and J on the other hand are more species rich. Group J supports species associated most often with neutral or mesotrophic conditions (pH 7) eg: Eleocharis palustris and Mentha aquatica. Group I consists of ponds containing plant species with a preference for high pH conditions, eg Myriophylum verrucosum and Hippuris vulgaris as well as plants frequently associated with limestone, eg Callitritche stagnalis and Apium nodiflorum. Group H is not dissimilar to group I. Bishop Middleham and Carr House ponds which form this TWINSPAN group are ancient ponds and as well as containing plant species that prefer elevated pH, they support a number of less common species.

iii) Ordination

Multivariate direct gradient analysis (i.e. canonical ordination) using plant species and measured environmental variables produced the graphs shown in figures 4 and 5. CANOCO (CCA) extracts dominant patterns of variation in the species data by ordination of plant species and determines the relationship of this pattern to environmental features. Because direction of variation of some of the environmental variables is similar to that of others, minor variables were removed to improve the clarity of the plot and ease interpretation. This left seven variables, the bi-plots of which are shown as arrows representing the direction of variation in the variables over the whole dimension of the ordination. The length of the arrow relates to the rate of change in that variable - important variables have longer arrows.

The ordination of ponds shown in Figure 4 (pond plant assemblages with respect to environmental variables) supports the results of the TWINSPAN by illustrating the position of ponds relating directly to pH, conductivity and geology.

The canonical coefficients (c values) that define the two axes and the correlations of the environmental variables (r values) with these axes in both figure 4 and 5, were: pH ((c-0.047, r-0.64), Conductivity (c-0.039, r-0.58), Water clarity (c-0.026, r-0.727), ML (c-0.035, r-0.521) and Clay/Mud (c-0.047, r-0.147) are positively correlated with this axis. Ranked canonical coefficients of axis 2 showed: pH (c-0.057, r-0.562), Clay/Mud (c-0.047, r-0.581) and CM (c-0.039, r-0.544) as being the foremost variables influencing this axis.

Ponds in TWINSPAN group I (Figure 4) with species indicative of high pH conditions eg: Apium nodiflorum, Myriophylum spicatum and Hippuris vulgaris conditions were oriented with the arrows representing pH and water clarity. Group H ponds were placed along the same orientation as conductivity, these ponds although not dissimilar to those of group I in their environmental features support plant species not common in the other sites eg Ranunculus aquatilis and Potamogeton lucens. Group J ponds were placed opposite pH and conductivity close to CM (coal measures). This pond group consists of ponds with low pH (under pH 7) lying over coal measures with clay and sediments, supporting plant species characteristic of oligotrophic conditions: Eleocharis palustris, Myriophylum trifoliata, Alisma plantago-aquatica. Rosa Shafto, East Farm, Raisby and Millhouse which make up TWINSPAN group K are oriented with Rubbish/pollution, conditions which suit Sparganium

FIGURE 4

CCA Ordination of ponds on the basis of plant species and environmental variables.

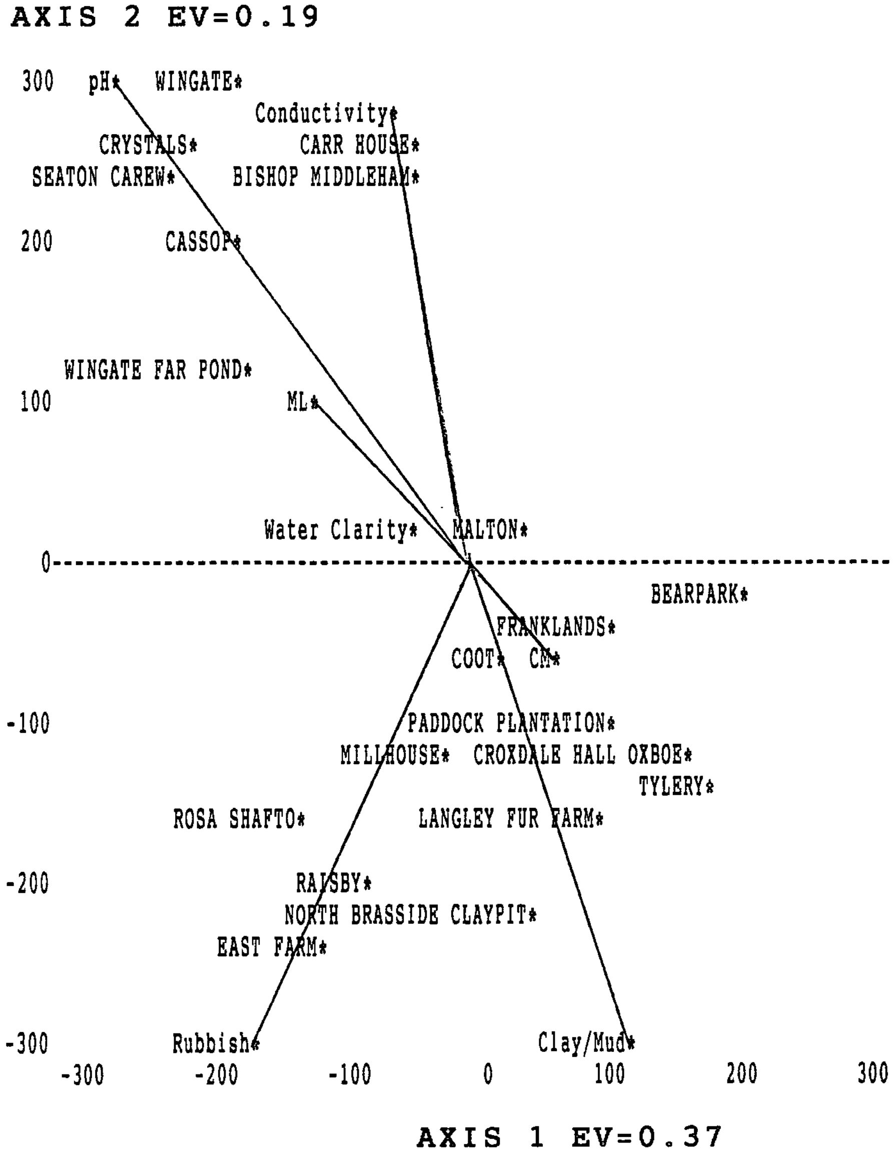
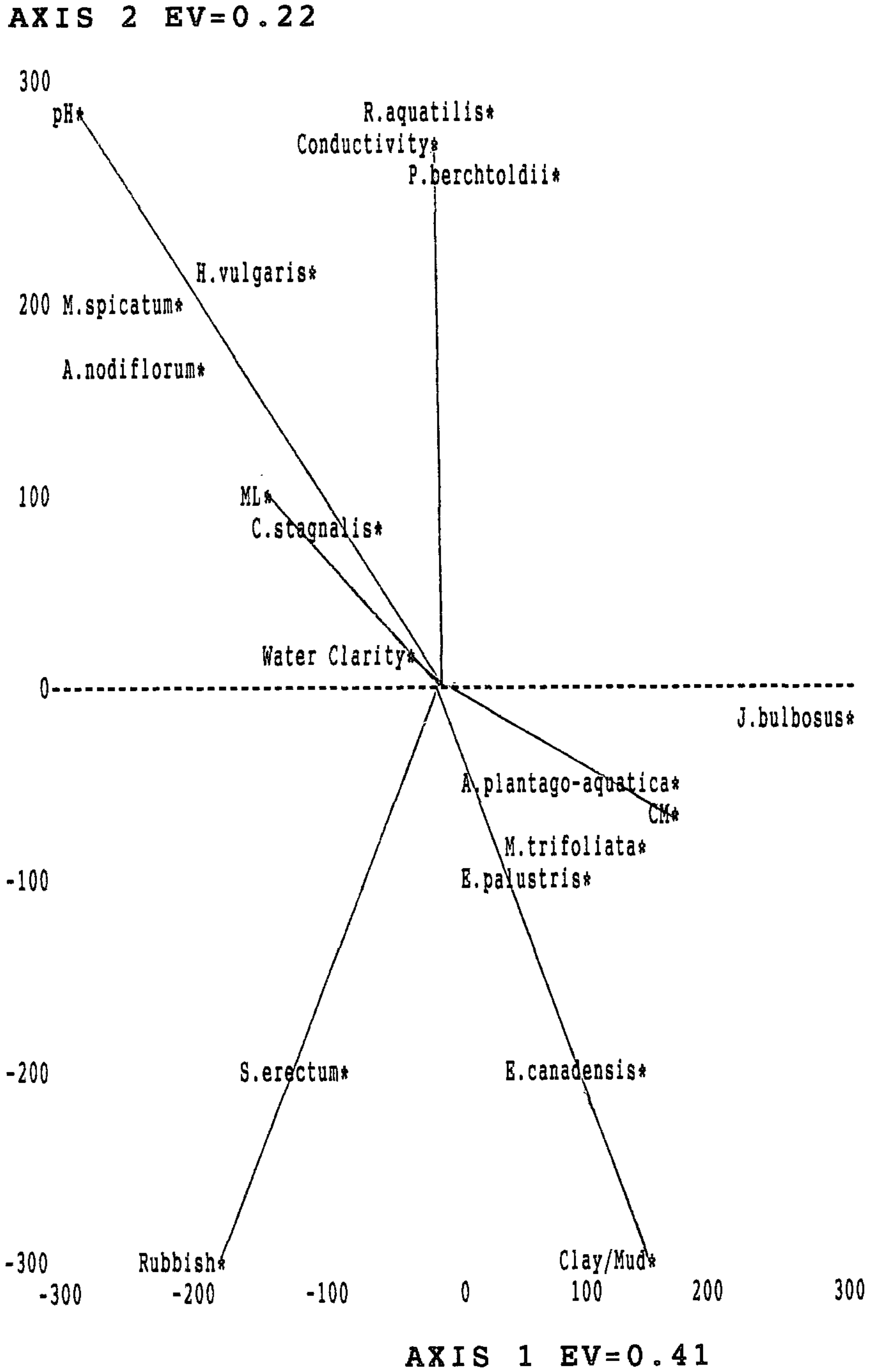


FIGURE 5

CCA Ordination of plant species on the basis of environmental variables.



erectum. Group L Bearpark lies opposite water clarity and supports the plant species *Juncus bulbosus* which is often associated with dystrophic conditions.

Although many plant species appear to be relatively catholic in their taste of habitat, (only twelve of the thirty four plant species recorded are shown in figure 5 as the others had small loadings on both axes and are not specific to any groups in the ordination). The evidence suggests that pH is the most important influence determining their distribution.

3.3 MACRO-INVERTEBRATES

3.3.1 GENERAL DISTRIBUTION OF FAUNA

Fourteen species of Hemiptera and sixteen species of Coleoptera were identified (Table 8) of which *Sigara scotti*, *Callicorixa praeusta* and *Notonecta glauca* were the most widespread corixids occuring at 40-50% of the ponds. *Gerris lacustris* was found only at one site.

Hygrotus inaequalis, *Haliplus fluviatilis*, and *Hydrobius fuscipes* were the most common water beetle species occuring at 30-40% of ponds, 4 of the species were identified only from 1 pond: *Helophorus aequalis*, *Helophorus grandis*, *Helophorus minutus* and *Hydroporus palustris*.

The highest number of Hemiptera and Coleoptera species that any pond was found to suport was 8, and a near normal distribution of species is apparent.

TABLE 4

MACRO-INVERTEBRATE SPECIES RANKED BY CONSTANCY

(% of ponds species occur in)

HEMIPTERA (Water Bugs)

Callicorixa praeusta	50%
Hesperacorixa sahlbergi	40%
Notonecta glauca	40%
Sigara dorsalis	25%
Sigara fossarum	25%
Sigara scotti	20%
Sigara lateralis	20%
Gerris lacustris	10%
Cymatia bonsdorffi	10%
Sigara nigrolineata	10%
Sigara distincta	5%
Sigara selecta	5%
Gerris thoracicus	5%

COLEOPTERA (Water Beetles)

Hygrotus inaequalis	30%
Haliplus fluviatilis	30%
Hydrobiusus fuscipes	30%
Haliplus lineolatus	25%
Haliplus fulvus	25%
Haliplus apicalis	20%
Haliplus confinis	15%
Laccophilus minutus	15%
Noterus clavicornis	15%
Haliplus ruficollis	10%
Laccobius bipunctatus	10%
Haliplus riparis	10%
Helophorus aequalis	5%
Helophorus grandis	5%
Helophorus minutus	5%
Hydroporus palustris	5%

3.3.2 CLASSIFICATION AND ORDINATION OF PONDS ON THE BASIS OF HEMIPTERAN AND COLEOPTERAN SPECIES

i) Indicator species analysis

A HEMIPTERA

Classification of the 17 ponds on the basis of their Hemipteran species by TWINSPAN (Figure 6 A) resulted in four groups at level 2 of the division.

The first dichotomy has Notonecta glauca as a positive indicator resulting in groups M and N, and Hesperacorixa sahlbergi as a negative indicator resulting in groups O and P. Division 2 seperated the twelve ponds into two groups. Callicorixa praeusta was a positive indicator for group N and Sigara dorsalis was negative indicator for group M. Groups O and P were created at division 3 with Gerris lacustris as the indicator species.

B COLEOPTERA

Classification of the 19 ponds (Bearpark had no water beetles) on the basis of their water beetle species by TWINSPAN (Figure 6B) also resulted in four groups at level 2 of the divisions. Haliplus lineolatus is a positive indicator for groups Q and R, and Hydrobius fuscipes is the negative indicator at this dichotomy for groups S and T. Groups Q and R arise at division 2 with Laccophilus minutus as negative indicator for group R, and at division 3 Haliplus apicalis is indicator for group T.

Figure 6

TWINSPAN CLASSIFICATION OF PONDS ON THE BASIS OF MACRO-INVERTEBRATE SPECIES.

A HEMIPTERA

DIVISION 1

N.glauca(+) . (-)H.sahlbergi

0.711

DIVISION 2

S.dorsalis. C.praeusta
(-) . (+)

0.638

DIVISION 3

G.lacustris.
(-) .

0.662

M		N	O	P
CRY	WFP	CX	BP	PP
SC	BM	F	RS	Coo
W	CH	NBC	R	
Cass		Tyl		
		Mal		

B COLEOPTERA

DIVISION 1

H.lineolatus(+) . (-) H.fuscipes

0.849

DIVISION 2

.(-)L.minutus

0.562

DIVISION 3

.(-)H.apicolis

0.645

Q	R	S	T
R	F	Coot	SC
RS	Tyl	Cass	W
MH	CX	CH	NBC
EF	BM	Mal	WFP
Cry	LFF		
PP			

KEY TO THE PONDS

BP	BEARPARK	Mal	MALTON
BM	BISHOP MIDDLEHAM	MH	MILLHOUSE
CH	CARR HOUSE	NBC	NORTH BRASSIDE
Cass	CASSOP	PP	PADDOCK PLANTATION
Coo	COOT	R	RAISBY
CX	CROXDALE HALL OXBOE	RS	ROSA SHAFTO
Cry	CRYSTALS POND	SC	SEATON CAREW
EF	EAST FARM	TYL	TYLERY
F	FRANKLAND	W	WINGATE
LFF	LANGLEY FUR FARM	WFP	WINGATE FAR POND

TABLE 5

SOME IMPORTANT MACRO-INVERTEBRATE SPECIES TYPICAL OF THE FOUR GROUPS OF PONDS GENERATED BY TWO-WAY INDICATOR SPECIES ANALYSIS. (Figure 6)

A GROUP (No of sites)	**HEMIPTERA**	
M (6)	Sigara dorsalis	Callicorixa praeusta
N (7)	Callicorixa praeusta Hesperacorixa sahlbergi	Corixa punctata Notonecta glauca
O (3)	Gerris lacustris	Sigara scotti
P (4)	Sigara distincta	Sigara scotti

B GROUP (No of sites)	**COLEOPTERA**	
Q (4)	Laccophilus minutus	Haliplus fulvus
R (8)	Laccobius bipunctatus	Haliplus fulvus Haliplus fluviatilis
S (3)	Haliplus fluviatilis	
T (4)	Haliplus apicalis	Haliplus lineolatus

In order to more clearly identify the species that are typically found in each of the groups, the more notable species are listed for each in Table 5.

ii) Ordination.

Using CANOCO as in 3.2.2, four environmental variable bi-plots are shown in Figure 7 (Hemiptera) and two in Figure 8 (Coleoptera). These CCA Ordinations support the TWINSPAN results seen in Figure 6 and illustrate the importance of water chemistry and percentage cover of emergent vegetation on the distribution of macro-invertebrates.

A HEMIPTERA

The canonical coefficients (c values) that define the two axes, and correlations of the environmental variables (r values) with these axes in Figure 7 were: pH (c-0.024, r-0.19), Conductivity (c-0.041, r-0.34) was negatively correlated with axis 1, while Scrub (c-0.032, r-0.27) and percentage cover of emergent vegetation(c-0.38, r-0.27) were positively correlated with this axis. Ranked coefficients of axis 2 showed pH (c-0.028, r-0.29), Conductivity (c-0.032, r-0.38), Scrub (c-0.021, r-0.29) were negatively correlated, and percentage cover of emergent vegetation (c-0.021, r-0.29) positively correlated.

Ponds in TWINSPAN group M (Figure 6) appear on the graph closest to arrows representing pH and conductivity, and support species such as Sigara dorsalis and Notonecta

FIGURE 7

CCA Ordination of ponds by Corixid species and environmental variables

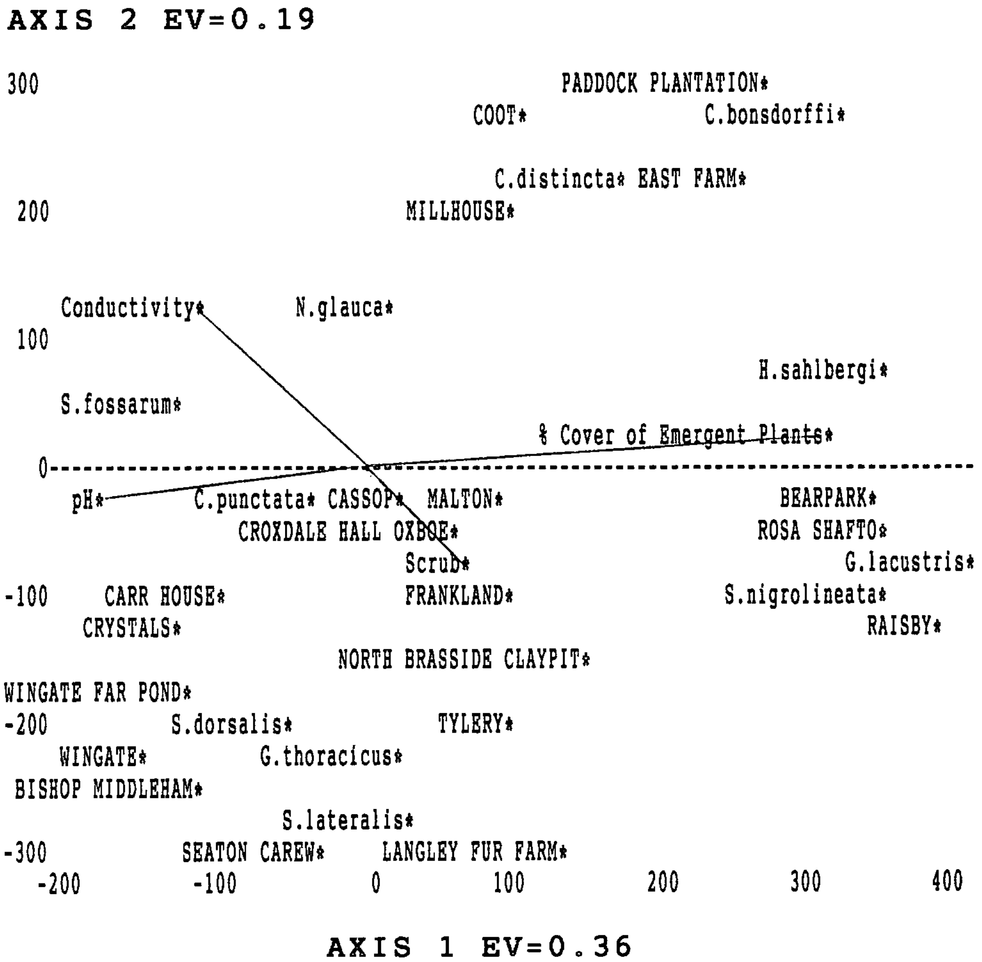
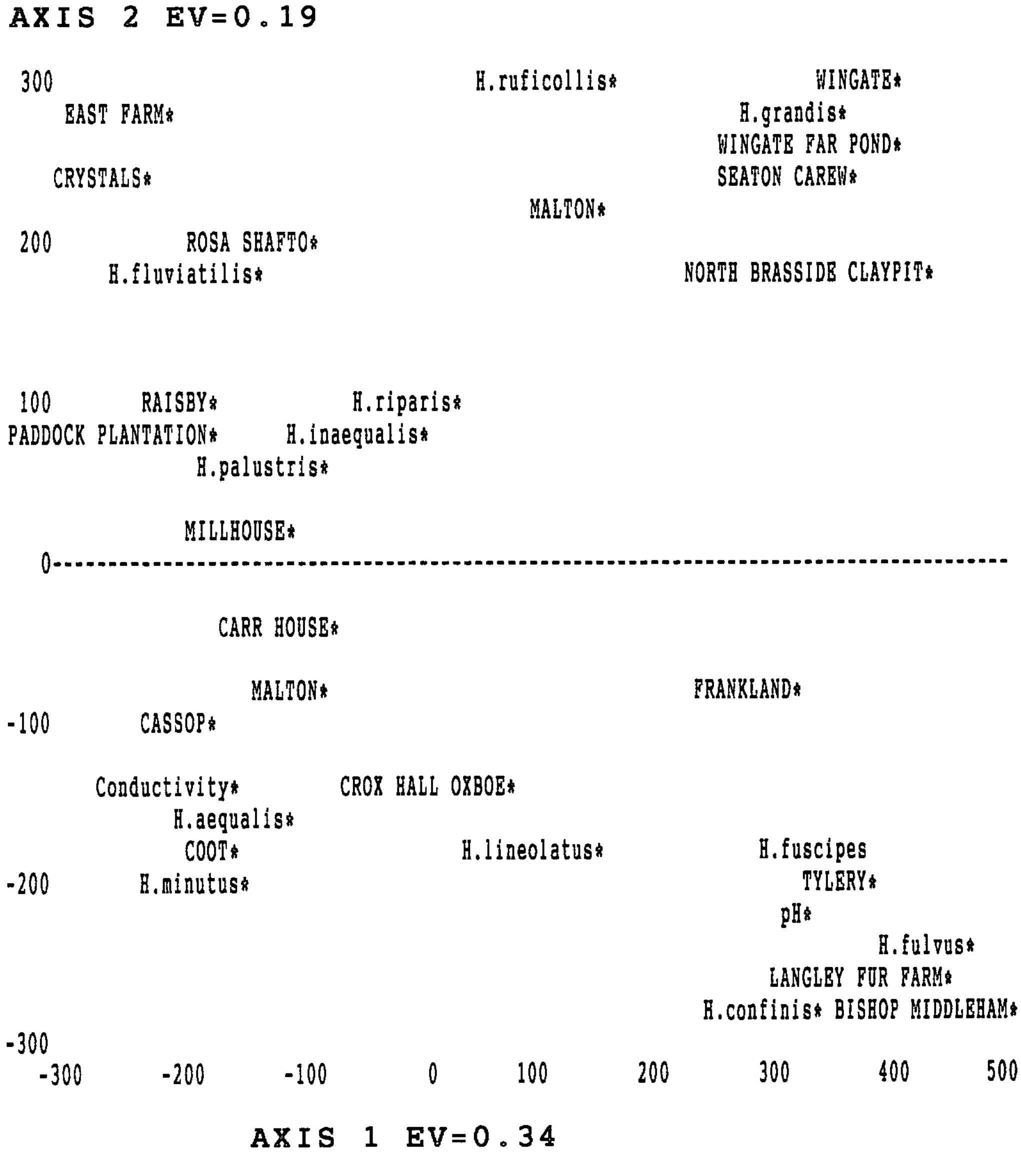


FIGURE 8

CCA Ordination of ponds by Coleopteran species and environmental variables



Distances of env variables?

glauca. Group N ponds lie close to the bi-plot for scrub, although many species lie in the area of ordination between these two groups, suggesting that they are not dissimilar, such species include: Notonecta glauca, Gerris thoracicus, and Sigara lateralis. Bearpark, Rosa Shafto and Raisby ponds which form TWINSPAN group O, in Figure 6, all have low pH and high percentage cover of emergent plants. Such conditions appear favourable to the corixid species: Sigara nigrolineata and Gerris lacustris. Group P ponds being of an acid nature are oriented opposite pH and Conductivity and the species Hesperacorixa sahlbergi and Cymatia bonsdorffi seem to prefer such conditions.

B COLEOPTERA

The canonical coefficients (c values) that define the two axes, and correlations of the environmental (r values) with these axes in Figure 8 were: pH (c-0.38, r0.47) negatively correlated with axis 1. While Conductivity (c-0.42,r0.32) was positively correlated. Both these also influence axis 2 negatively: pH (c-0.19, r-0.37), Conductivity (c-0.09, r-0.32).

Ponds in TWINSPAN group Q (Figure 6) are oriented opposite pH, these ponds all have a pH less than pH 7. Ponds in group R, are oriented opposite conductivity, a number of water beetle species are associated with these ponds including Haliplus lineolatus, and Haliplus fluviatilis. Coot, Cassop, Malton and Carr House ponds which make up group S provide conditions which appear favourable to Helophorus aequalis and Helophorus aequalis. Finally TWINSPAN group T which has high conductivity supports species such as Hydrobius fuscipes, Haliplus fulvus and Haliplus confinis.

4 DISCUSSION

Analysis of the data indicates a strong relationship between the plant and animal species assemblages identified in the ponds, and their chemistry, most notably their pH. The apparent patterns could clearly be of ecological importance.

4.1 FACTORS INFLUENCING GENERAL MACRO-FLORA DISTRIBUTION.

Almost any substrata, provided it is sufficiently well illuminated will be colonised by vegetation. The distribution of this vegetation within a pond is usually found to be: emergents plants in the shallower water, submerged plants in the deepest and floating leaved plants in the zone inbetween.

The distribution of aquatic plants between waterbodies is determined by a number of factors. PEARSALL (1920) considered substrate and depth to be the most important factors in the Lake District. SPENCE (1967) regarded water chemistry of lakes as highly significant in determining the distribution of plants, and ORMEROD et al (1987) have shown that assemblages of plants in Wales were related strongly to pH.

Clearly some macrophyte species are restricted to nutrient poor waters with others more typical of nutrient rich sites, but many are more catholic in their requirements. Species most characteristic of acid waters include, Juncus bulbosus, and Sparganium erectum. Species commonly associated with high pH sites are Myriophyllum spicatum and Potamogeton lucens. Intermediate assemblages consist of ubiquitous species eg Potamogeton natans or ones associated with mesotrophic or neutral pH conditions such as Ranunculus aquatilis, Apium nodiflorum and Veronica beccabunga. Macrofloral similarities are greatest between ponds of similar pH which suggest that successful colonisation of at least some ponds is restricted by chemical or associated factors.

4.2 FACTORS INFLUENCING GENERAL INVERTEBRATE FAUNA DISTRIBUTION.

Although the general character of the communities is set by water chemistry, there is considerable variation in the details of the faunal assemblages, even in ponds of similar pH. Each pond environmnent is created by a multiplicity of abiotic and biotic factors operating in unique combinations. It is not always logical to argue that physical and chemical factors explain the distribution of a species, some investigation should be made into species behaviour, particularly egg laying, source of colonising species nearby, competition and predation. Favourable conditions rely on a variety of physical, chemical, biological and other factors falling within certain limits, and precise values for these limits will vary according to the intensity of other factors.

The lack of variety and general scarcity of macro-invertebrates in acid ponds could be due to an impoverished food supply, or physiological effects of acid related factors, but is probably due to a suite of factors, both chemical and biotic which are directly or indirectly a consequence of pH. The toxic effects of pH have been demonstrated experimentally for a number of freshwater invertebrate groups (BELL 1971).

When considering the distribution of these invertebrates their method of dispersion must be taken into account, many of the corixidae and most water beetle species when adult can take to the wing and migrate, therefore, if a species is absent from a pond it can be assumed that it is because conditions are unsuitable, not because it has never reached it. WALTON (1943) records Notonecta landing on the shiny black top of a car and on wet tar, it appears then that water to an airborne bug is no more than a shiny surface. Nevertheless each species appears confined to a relatively well defined range of conditions. Unfortunately little is known of the reasons why any given species occurs in a habitat where certain features are typical. Ultimately then a place to live is found by a process of trial and error.

VIERSSEN and VERHOEVEN 1983, and BROERING and NIEDRINGHAUS 1988 found that corixid species had high tolerances of different environmental conditions and that communities changed only slowly when conditions change. EYRE and BALL 1986, EYRE, FRASER and RUSHTON 1988 and EYRE and FOSTER 1989 found that aquatic coleoptera allowed subtle differences in habitat to be identified as aquatic Coleoptera exhibited more obvious differences relating to acidity than Heteroptera, therefore providing greater possibilities for use in environmental work on water acidification.

The immediate surroundings of ponds may influence the chances of ponds being discovered by actively dispersing organisms, but surrounding vegetation and land use are likely to be of greater importance in their effect on water chemistry. MACAN (1954) suggests that one of the features that might make a pond unsuitable for colonising species (Corixidae) is the presence of an established population.

4.3 RELATIONSHIPS BETWEEN MACRO-FLORA AND INVERTEBRATE FAUNA IN PONDS

In 1987 ORMEROD et al proposed three hypotheses concerning the relationship between plants and animals in stream habitats, these also apply to the pond environment:

1 Invertebrates may be dependant on specific floral assemblages directly for food supply, or indirectly as they provide a surface area for epiphytic growth and trapping detritus.

2 Different plant species provide different micro-habitats in which invertebrates may avoid predators, or lurk unseen in search of prey.

3 The relationship between plants ad animals may be influenced independently by other factors such as chemistry.

In general the distribution of plants between ponds agrees with the conclusions of MACAN (1954). However the pattern of distribution of corixids and beetles does not emerge so clearly. It is worth noting that most widespread species of Hemiptera are those which are known to fly readily: Callicorixa praeusta, Notonecta glauca, Sigara scotti, and Sigara distincta.

4.4 PONDS IN COUNTY DURHAM

County Durham supports a large number of small water bodies, resulting in variable colonisation causing very variable communities. Consequently most of the ponds support unstable populations which will obscure distribution patterns of highly mobile macro-invertebrates CRISP (1963) suggests this reason for the obscure distribution of Corixidae he found.

Overall therefore, whilst published data indicates links between macro floral assemblages, invertebrates and pond acidity. pH measurements from different water bodies can meaningfully be compared only if they are all taken at approximately the same time and in a comparable way, since the pH of a given water body may vary both spatially and temporally, and with different methods of measurement. Concentrations and relative abundance of dissolved substances in ponds will also vary more than in most permanent water bodies due to evaporation. There is a need for much further work at the biochemical and physiological levels, and also into the mechanisms by which factors such as the vegetation structure influence distribution of species in the field, all of which it has not been possible to cover in this study.

4.5 CONSERVATION

Ponds provide an important habitat for aquatic plants and animals in Britain, they are a diminishing resource and it is estimated 41% of County Durham ponds have been lost in the last 100-150 years (JEFFRIES and MILLS 1989). The protection or rennovation of existing ponds, and the construction of new ponds, are both believed to make a significant contribution to the conservation of freshwater communities.

Recognition of groups of ponds following the development of a classification has two important consequences for the conservation of ponds:

1 It ensures a representative cross section of ponds in any area can be selected for protection greatly increasing the understanding of factors shaping pond communities.

2 Descriptions of the variety of ponds using classification techniques is an important stage in developing a conservation strategy. It provides a means of assessing wether or not a pond is reaching its full potential for wildlife, lays the foundation for studies needed to improve practical management techniques. (POND ACTION 1989).

4.6 PROPOSED CLASSIFICATION OF PONDS SAMPLED IN PRESENT STUDY

As an overview of the methods used in this study, the ponds have been placed in different groups which are described below. Within each of these groups ponds may be divided into further categories using other attributes. As with all systems of classification there are exceptions which do not fit well into any of them. eg: Malton and Seaton Carew.

GROUP 1

BEARPARK

Found as residual open water on mires, or occupying former peat cuttings, typically shallow with peat shoreline and bottom. The water is acid and stained brown by dissolved humic acid, there is very low productivity. Juncus bulbosus is macrophytic indicator species (according to RATCLIFFE 1977, other characteristic species include: Menyanthes trifoliata, Potamogeton polygonifolius and Carex limosa.

Such peaty shored ponds might support an abundant carnivorous invertebrate fauna as the shallow conditions are ideal hunting grounds for the species that rely for food on terrestrial invertebrates that fall into the water, Bearpark , the only pond in this study to fall into this group was found only to support the Hemipteran species: Gerris lacustris and Sigara scotti.

GROUP 2

CASSOP, CRYSTALS, WINGATE FAR POND, WINGATE.

Lying over magnesian Limestone, these ponds have very clear water, and pH over 7.5. They support an abundant macrophyte community to a great depth. Sediment is generally low in organic material so there is little food for benthic invertebrates, and the most productive invertebrate communities are those associated with the macrophytes and the littoral zone. Characteristic plant species include Eleocharis palustris and Equisetum fluviatile and macro-invertebrate species include Sigara dorsalis, Callicorixa praeusta, Haliplus apicalis and Haliplus lineolatus.

GROUP 3

ROSA SHAFTO, RAISBY, PADDOCK PLANTATION, EAST FARM.

These ponds are artificially enriched or polluted. The water may be deep green with algae, limiting the depth to which light penetrates. Most of the characteristic and abundant plant and animal species are widespread and fairly common eg: Juncus effusus, Glyceria fluitans, Potamogeton natans and Ranunculus aquatilis. Notonecta glauca, Sigara scotti, Hygrotus inaequalis and Hydrobus fuscipes are typical fauna. These ponds are often unmanaged and consequently have a pond margin colonised by scrub which may cause heavy shade and result in leaf litter accumulation in the water.

GROUP 4

BISHOP MIDDLEHAM, MILL HOUSE, CROXDALE HALL OXBOE, CARR HOUSE.

Frequently shallow, these ponds are ancient and support emergent vegetation over a large area with little open water. They may support a varied community of plants and animals with rare species present. Plant species often associated with such ponds include: Potamogeton praelongus and Menyanthes trifoliata. So many macro-invertebrate species may be found amongst the vegetation that it is difficult to define characteristic species.

GROUP 5

COOT, LANGLEY FUR FARM, NORTH BRASSIDE CLAYPIT, TYLERY, FRANKLAND.

Formed by flooding of gravel pits or disused factory ponds, these ponds are often deep, with vegetation of any kind occupying only a small area around the perimeter. Characteristic plant species include Eleocharis palustris and Mentha aquatica, common macro-invertebrates are: Sigara distincta and Laccobius minutus.

4.7 CONCLUSION

The methods used in this study allowed ponds to be placed in groups on the basis of their plant and invertebrate communities. Furthermore these groups of ponds showed some similarity and consistency in their measured environmental variables, indicating that chance alone was not the cause of the species assemblages found.

Although this study remains largely descriptive it does point to some ways in which experiments could throw light on the mechanisms leading to the establishment of plant and animal communities in future.

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Finally I would like to thank my family and Nick for their support from start to finish of this project.

APPENDIX 1

Blank Copy of National Pond Survey Recording Sheet

NATIONAL POND SURVEY Field recording sheet (1)

Site name ____________________

Grid reference ____________________

Nearest town or village ____________________

County ____________________

Surveyors ____________________

Date ____________________

Altitude ____________________

Geology ____________________

1. Water source

Rank the importance of the following water sources (? - where unsure):

WATER SOURCE	RANK
Ground water/water table	
Spring	
Runoff & near surface water	
Stream	
Ditch	
Foodwater	
Direct precipitation	

2. Inflows and outflows

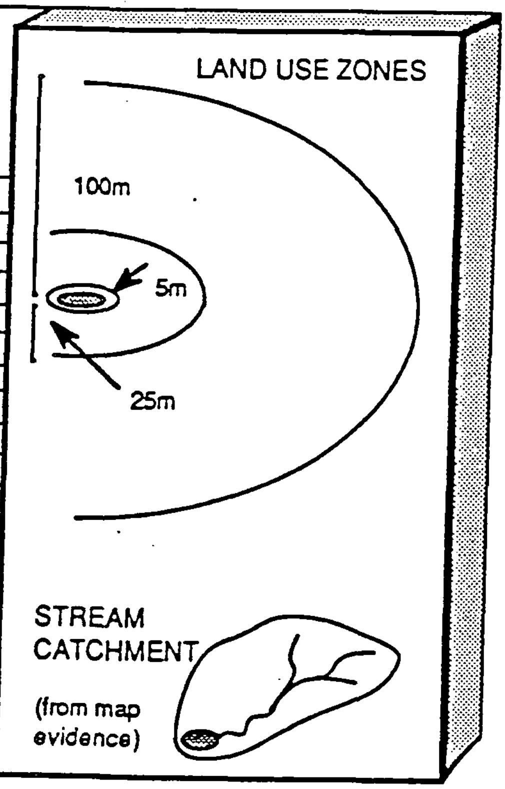
Estimate the width, depth & flow category of inflows and outflows. Flow category: 1: trickle, 2: slow, 3: moderate, 4: fast.

	Average width (m)	Average depth (cm)	Flow Category
INFLOW			
OUTFLOW			

3. Surrounding land-use

Estimate the percentage of surrounding land-use within the three land-use zones and the catchment.

LAND-USE	<5m	5-25m	25-100m	Catchment
Deciduous woodland				
Coniferous woodland				
Scrub				
Moor/lowland heath				
Bog				
Fen/Marsh				
Unimproved grassland				
Improved grassland				
Arable				
Parks & gardens				
Urban				
Paths & tracks				
Roads				
Other (please state)				
____________				
____________				
____________				



4. Adjacent wetlands & waterbodies

Record the presence of waterbodies within 500m of the pond (including those mentioned in Box 2). Record whether the pond is connected to adjacent water bodies or wetlands (P - permanant connection, T - temporary connection (including flooding), N - not connected).

Waterbody/wetland	Wetlands /waterbodies adjacent to the pond <10m (Connections)	10-250m (Connections)	250-500m (Connections)
Pond/lake			
Ditch/small stream			
Stream/river			
Fen/bog/marsh			
Other (specify)			

NATIONAL POND SURVEY Field recording sheet (2)

5. Water quality

pH ____________________ Conductivity ____________________

Alkalinity ____________________ Calcium ____________________

Water clarity (tick one box)

Very clear	Clear	Moderately clear	Turbid
☐	☐	☐	☐

Water colour ____________________ Probable source of colour ____________________

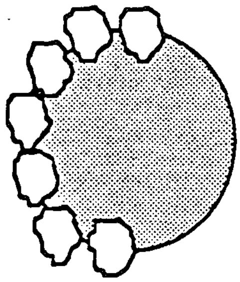
Note any pollution present (eg oil, large quantities of dumped rubbish) ____________________

6. Overhanging trees and shrubs

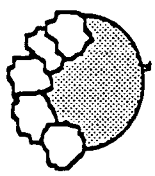
Categories
- 0 = no shade
- 1 = 1%-20%
- 2 = 21%-40%
- 3 = 41%-60%
- 4 = 61%-80%
- 5 = 81%-100%

Proportion of margin overhung (scale of 0-5) ☐

Proportion of pond overhung (scale of 0-5) ☐



50% of margin overhung (Category 3).
15% of pond overhung (Category 1).



50% of margin overhung (Category 3).
35% of pond overhung (Category 2).

7. Plant cover

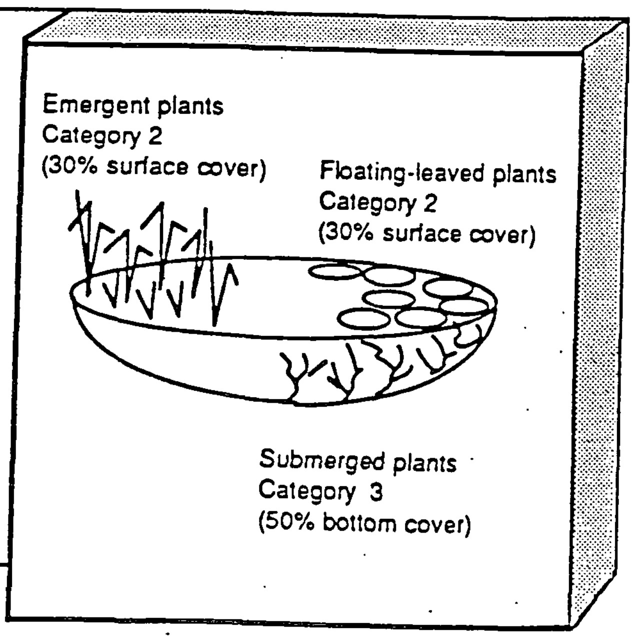
Estimate the percentage cover in the following categories:

- 1 = <20%
- 2 = 21-40%
- 3 = 41-60%
- 4 = 61-80%
- 5 = 81-100%

Emergent plants (scale of 1-5) ☐

Floating-leaved plants (scale of 1-5) ☐

Submerged plants (scale of 1-5) ☐



NATIONAL POND SURVEY Field recording sheet (3)

8. Plant species list.
Use the attached species list (Page 4).

9. History and use of the pond

How old is the pond (give an 'at least x years' if exact dates unknown) ________

What is the origin of the pond?

____

Does the pond dry out annually? ________

If so for how many months? ________

When did the pond last dry out? ________

How many times in the last 50yrs has the pond dried out?

____

Who uses the pond and how frequently?

____

____

When was the pond last dug out? ________

10. Amphibians and fish

Note the presence (and, where known, the abundance) of fish and amphibians.

____

____

____

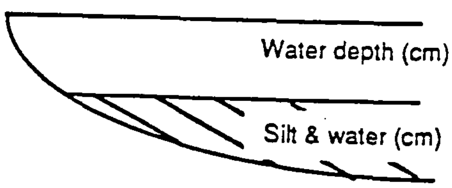
____

____

____

____

11. Sediment and water depths



	Transect A (longest dimension) 1/4	1/2	3/4	Transect B (perpendicular to A) 1/4	3/4
Water depth (cm)					
Silt & water (cm)					

POND BASE
Tick the following

- Clay
- Butyl synthetic ________
- Concrete ________
- Gravel/sand ________
- Bed rock (specify) ________
- Other (specify) ________

SEDIMENT
Rank the following where possible

- Whole leaves & twigs ________
- Decomposed leaves & twigs ________
- Organic debris < 5mm ________
- Org. & inorganic debris < 1mm ________
- Organic & inorganic oose ________
- Others (specify) ________

12. Micro-habitats sampled for macro-invertebrates

1. ________
2. ________
3. ________
4. ________
5. ________
6. ________
7. ________
8. ________
9. ________
10. ________
11. ________
12. ________

Areas sampled for additional species ________

____

NATIONAL POND SURVEY FIELD RECORDING SHEET(4)

SUBMERGED, FLOATING AND EMERGENT PLANTS

Acorus calamus
Agrostis stolonifera
Alisma lanceolatum
Alisma plantago-aquatica
Apium inundatum
Apium nodiflorum
Aponogeton distachyos
Azolla filiculoides
Baldellia ranunculoides
Berula erecta
Butomus umbellatus
Callitriche hamulata
Callitriche hermaphroditica
Callitriche obtusangula
Callitriche platycarpa
Callitriche stagnalis
Callitriche truncata
Callitriche sp. (undetermined)
Caltha palustris
Cardamine amara
Carex acuta
Carex acutiformis
Carex elata
Carex lasiocarpa
Carex nigra
Carex paniculata
Carex pseudocyperus
Carex riparia
Carex rostrata
Carex vesicaria
Catabrosa aquatica
Ceratophyllum demersum
Ceratophyllum submersum
Cicuta virosa
Cladium mariscus
Crassula helmsii
Egeria densa
Elatine hexandra
Eleocharis acicularis
Eleocharis palustris
Eleogiton fluitans
Elodea canadensis
Elodea nuttallii
Equisetum fluviatile
Equisetum palustre
Eriophorum angustifolium
Glyceria declinata
Glyceria fluitans
Glyceria maxima
Glyceria plicata
Glyceria sp. (fine leaved)
Groenlandia densa
Hippuris vulgaris
Hottonia palustris
Hydrocharis morsus-ranae
Hydrocotyle vulgaris
Iris pseudacorus
Isoetes lacustris
Isolepis setacea
Juncus bulbosus
Juncus effusus
Lagarosiphon major
Lemna gibba
Lemna minuscula
Lemna minor
Lemna trisulca
Lemna polyrhiza
Littorella uniflora
Lobelia dortmanna
Lythrum portula
Mentha aquatica
Menyanthes trifoliata
Myosotis laxa
Myosotis scorpioides
Myosotis secunda
Myosoton aquaticum
Myriophyllum alterniflorum
Myriophyllum spicatum
Myriophyllum verticillatum
Nasturtium microphyllum
Nasturtium officinale
Nuphar lutea
Nymphaea alba
Nymphoides peltata
Oenanthe aquatica
Oenanthe fistulosa
Oenanthe fluviatilis
Phalaris arundinacea
Phragmites australis
Pilularia globulifera
Polygonum amphibium
Polygonum hydropiper
Potamogeton alpinus
Potamogeton berchtoldii
Potamogeton coloratus
Potamogeton crispus
Potamogeton friesii
Potamogeton gramineus
Potamogeton lucens
Potamogeton natans
Potamogeton obtusifolius
Potamogeton pectinatus
Potamogeton polygonifolius
Potamogeton praelongus
Potamogeton pusillus
Potamogeton trichoides
Potamogeton hybrid(s)
Potentilla palustris
Ranunculus aquatilis
Ranunculus baudotii
Ranunculus circinatus
Ranunculus flammula
Ranunculus fluitans
Ranunculus hederaceus
Ranunculus omiophyllus
Ranunculus peltatus
Ranunculus penicillatus
Ranunculus sceleratus
Ranunculus trichophyllus
Rorippa amphibia
Rumex hydrolapathum
Sagittaria sagittifolia
Schoenoplectus lacustris
ssp lacustris
ssp tabernaemontani
Sparganium angustifolium
Sparganium emersum
Sparganium erectum
Sparganium minimum
Stratiotes aloides
Subularia aquatica
Typha angustifolia
Typha latifolia
Utricularia australis
Utricularia intermedia
Utricularia vulgaris
Veronica anagallis-aquatica
Veronica beccabunga
Veronica catenata
Veronica scutellata
Wolffia arrhiza
Zannichellia palustris

Algae:
Chara sp.
Nitella sp.
Tolypella sp.
Enteromorpha sp
Filamentous
planktonic

Bryophytes:
Fontinalis antipyretica
Riccia fluitans
Ricciocarpus natans
Sphagnum sp.

OTHER WETLAND PLANTS

Alopecurus geniculatus
Anagallis tenella
Andromeda polifolia
Angelica archangelica
Angelica sylvestris
Barbarea intermedia
Barbarea stricta
Barbarea vulgaris
Bidens cernua
Bidens tripartita
Blysmus compressus
Calamagrostis canescens
Calamagrostis epigejos
Cardamine pratensis
Carex curta
Carex demissa
Carex diandra
Carex disticha
Carex flacca
Carex hostiana
Carex laevigata
Carex lepidocarpa
Carex limosa
Carex otrubae
Carex panicea
Carex pendula
Carex pulicaris
Carex spicata
Cirsium dissectum
Cirsium palustre
Conium maculatum
Crepis paludosa
Cyperus longulus
Dactylorhiza fuchsii
Dactylorhiza incarnata
Dactylorhiza majalis:
D. majalis ssp. praetermissa
D. majalis ssp. purpurella
Deschampsia caespitosa
Drosera rotundifolia
Eleocharis multicaulis
Eleocharis quinqueflora
Eleocharis uniglumis
Epilobium adenocaulon
Epilobium hirsutum
Epilobium nerteroides
Epilobium obscurum
Epilobium palustre
Epilobium parviflorum
Epilobium tetragonum
Epipactis palustris
Erica tetralix
Eriophorum latifolium
Eriophorum vaginatum
Eupatorium cannabinum
Filipendula ulmaria
Frangula alnus
Galium boreale
Galium palustre
Galium uliginosum
Geum rivale
Hypericum elodes
Hypericum tetrapterum
Impatiens capensis
Impatiens glandulifera
Impatiens noli-tangere
Isolepis cernua
Juncus acutiflorus
Juncus articulatus
Juncus bufonis
Juncus compressus
Juncus conglomeratus
Juncus inflexus
Juncus subnodulosus
Achillea ptarmica
Alnus glutinosa
Alopecurus aequalis
Lotus uliginosus
Lycopus europaeus
Lysimachia nummularia
Lysimachia vulgaris
Lythrum salicaria
Mimulus guttatus
Mimulus luteus
Molinia caerulea
Montia fontana
Myrica gale
Narthecium ossifragum
Oenanthe crocata
Oenanthe lachenalii
Osmunda regalis
Parnassia palustris
Pedicularis palustris
Petasites hybridus
Pinguicula vulgaris
Polygonum lapathifolium
Polygonum persicaria
Potentilla erecta
Pulicaria dysenterica
Ranunculus lingua
Rhynchospora alba
Rorippa palustris
Rorippa sylvestris
Rumex maritimus
Rumex palustris
Sagina procumbens
Salix sp.
Schoenus nigricans
Trichophorum cespitosum
Scrophularia auriculata
Scutellaria galericulata
Senecio aquaticus
Senecio fluviatilis
Sium latifolium
Solanum dulcamara
Stachys palustris
Stellaria alsine
Stellaria palustris
Symphytum officinale
Thalictrum flavum
Thelypteris palustris
Tofieldia pusilla
Triglochin palustris
Urtica dioica
Valeriana dioica
Viola palustris

ADDITIONAL WETLAND PLANT SPECIES:
(record rare or very local wetland species not listed above)

APPENDIX 2

LIST OF WETLAND PLANT SPECIES IDENTIFIED

PLANT/POND MATRIX

LIST OF MACRO-INVERTEBRATE SPECIES IDENTIFIED

MACRO-INVERTEBRATE/POND MATRIX

LIST OF WETLAND PLANT SPECIES IDENTIFIED
(In alphabetical order)

Agrostis stolonifera	(Creeping Bent)
Alisma plantago-aquatica	(Water plantain)
Apium nodiflorum	(Fools watercress)
Callitritche stagnalis	(Common water starwort)
Caltha palustris	(Marsh marigold)
Eleocharis palustris	(Common spike rush)
Elodea canadensis	(Canadian waterweed)
Equisetum fluviatile	(Water horse tail)
Glyceria fluitans	(Floating sweet grass)
Hippuris vulgaris	(Marestail)
Hydrocotyle vulgaris	(Marsh pennywort)
Iris psuedacorus	(Yellow iris)
Juncus bulbosus	(Bulbous rush)
Juncus effusus	(Soft rush)
Juncus gerardi	(Saltmarsh rush)
Juncus inflexus	(Hard rush)
Lemna minor	(Common duckweed)
Mentha aquatica	(Water mint)
Menyanthes trifoliata	(Bogbean)
Myriophyllum spicatum	(Spiked water milfoil)
Nasturtium officionale	(Watercress)
Nymphae alba	(White water lily)
Phragmites australis	(Common reed)
Potamogeton berchtoldii	(small pondweed)
Potamogeton natans	(Broad leaved pondweed)
Potamogeton pectinatus	(fennel pondweed)
Potentilla palustris	(Marsh cinquefoil)
Ranunculus aquatilis	(Common water crowfoot)
Ranunculus flammula	(Lesser spearwort)
Ranunculas peltatus	(Pond water crowfoot)
Ranunculus scleratus	(Celery leaved buttercup)
Ranunculus trichophyllus	(Thread leaved crowfoot)
Sparaganium erectum	(Branched bur reed)
Typha latifolia	(Great reedmace)
Veronica beccabunga	(Brooklime)

PLANT/POND MATRIX

PONDS / PLANTS	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
Alisma plantago-aquatica									X	X						X				
Apium nodiflorum				X			X										X			
Callitritche stagnalis				X			X		X									X	X	X
Caltha palustris									X					X					X	X
Eleocharis palustris			X			X			X	X	X		X	X				X		
Elodea canadensis				X	X		X		X					X						
Equisetum fluviatile				X		X			X	X	X		X					X		
Glyceria fluitans									X		X									
Hippuris vulgaris				X	X								X	X			X		X	X
Hydrocotyle vulgaris	X						X							X						
Iris pauedacorus				X		X			X	X	X							X		
Juncus bulbosus	X													X						
Juncus effusus			X	X		X	X	X	X		X		X			X	X		X	
Juncus gerardi																	X			
Juncus inflexus		X													X					
Lemna minor		X	X		X	X		X			X	X	X	X	X	X				X
Mentha aquatica		X	X			X				X		X		X					X	X
Menyanthes trifoliata				X		X	X	X						X	X	X			X	
Myriophyllum spicatum									X											
Nasturtium officionale						X														
Nymphae alba						X			X				X							
Phragmites australis				X		X		X	X	X	X				X	X		X	X	X
Potamogeton berchtoldii		X	X							X		X			X					
Potamogeton natans			X	X	X	X	X		X	X	X	X	X				X			X
Potamogeton pectinatus									X										X	
Potentilla palustris																	X			
Ranunculus aquatilis		X	X								X	X								
Ranunculus flammula											X									
Ranunculas peltatus			X																	
Ranunculus scleratus																	X			
Ranunculus trichophyllus									X	X										
Sparganium erectum								X				X			X	X				
Typha latifolia		X		X		X		X		X	X	X	X	X	X			X	X	X
Veronica beccabunga		X					X		X											

THE PONDS

A BEARPARK
B BISHOP MIDDLEHAM
C CARR HOUSE
D CASSOP
E COOT
F CROXDALE HALL OXBOE
G CRYTALS POND
H EAST FARM
I FRANKLAND
J LANGLEY FUR FARM
K MALTON
L MILLHOUSE
M NORTH BRASSIDE
N PADDOCK PLANTATION
O RAISBY
P ROSA SHAFTO
Q SEATON CAREW
R TYLERY
S WINGATE
T WINGATE FAR POND

LISTS OF MACRO-INVERTEBRATE SPECIES IDENTIFIED (In alphabetical order)

HEMIPTERA (Water Bugs)

Callicorixa praeusta
Corixa punctata
Cymatia bonsdorffi
Hesperacorixa sahlbergi
Gerris lacustris
Gerris thoracicus
Notonecta glauca
Sigara distincta
Sigara dorsalis
Sigara fossarum
Sigara lateralis
Sigara nigrolineata
Sigara scotti
Sigara selecta

COLEOPTERA (Water Beetles)

Haliplus apicalis
Haliplus confinis
Haliplus fluviatilis
Haliplus fulvus
Haliplus lineolatus
Haliplus riparis
Haliplus ruficollis
Helophorus aequalis
Helophorus grandis
Helophorus minutis
Hydrobius fuscipes
Hydroporus palustris
Hygrotus inaequalis
Laccophilus minutus
Laccobius bipunctatus
Noterus clavicornis

MACRO-INVERTEBRATE/POND MATRIX

PONDS	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
HEMIPTERA																				
Callicorixa praeusta		X	X	X	X	X			X	X	X						X			X
Cymatia bonsdorffi															X	X				
Hesperacorixa sahlbergi					X				X		X	X		X			X	X	X	
Gerris lacustris	X														X					
Gerris thoracicus																	X			
Notonecta glauca						X				X	X		X	X			X	X	X	
Sigara distincta								X												
Sigara dorsalis		X	X				X												X	X
Sigara fossarum						X		X		X					X				X	
Sigara lateralis				X		X										X		X		
Sigara nigrolineata					X								X							
Sigara scotti	X				X									X		X				
Sigara selecta																	X			

PONDS	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
COLEOPTERA																				
Haliplus apicalis																	X	X	X	X
Haliplus confinis									X	X	X									
Haliplus fluviatilis		X	X	X					X										X	X
Haliplus fulvus						X						X		X	X	X				
Haliplus lineolatus						X		X	X				X			X				
Haliplus riparis				X							X									
Haliplus ruficollis										X										X
Helophorus minutus											X									
Hydrobius fuscipes				X			X					X					X		X	X
Hydroporus palustris										X										
Hygrotus inaequalis			X					X			X		X		X		X			
Laccophilus minutus									X					X			X			
Laccobius bipunctatus					X	X					X	X								
Noterus clavicornis					X					X					X					
Helophorus aequalis									X											
Helophorus grandis																			X	

THE PONDS

A BEARPARK
B BISHOP MIDDLEHAM
C CARR HOUSE
D CASSOP
E COOT
F CROXDALE HALL OXBOE
G CRYSTALS POND
H EAST FARM
I FRANKLAND
J LANGLEY FUR FARM
K MALTON
L MILL HOUSE
M NORTH BRASSIDE
N PADDOCK PLANTATION
O RAISBY
P ROSA SHAFTO
Q SEATON CAREW
R TYLERY
S WINGATE
T WINGATE FAR POND

APPENDIX 3

Results Tables

TABLE 1
PHYSICAL FEATURES OF THE PONDS

TABLE 2
WATER SOURCE

TABLE 3
LAND USE

TABLE 4
OVERHANGING TREES/SHRUBS AND PLANT COVER

TABLE 5
POND BASE AND SEDIMENT CONTENTS

TABLE 6
BASIC WATER CHEMISTRY

TABLE 1

MAIN PHYSICAL FEATURES OF THE PONDS

POND	1	2	3	4	5	6	7	8	9	10
ALTITUDE	100	75	150	95	70	40	20	155	85	45
GEOLOGY	CM	ML	CM	ML	CM	CM	ML	CM	CM	CM
INFLOW	N	N	N	Y	Y	Y	N	N	N	N
OUTFLOW	Y	N	N	Y	Y	Y	N	N	Y	N
W B <5M	N	N	N	N	N	N	N	N	N	N
W B 10-250M	N	N	N	N	Y	N	Y	N	Y	Y
CLARITY	4	3	3	3	3	2	3	4	3	2
RUBBISH	1	2	1	2	1	1	4	4	2	1
MICROHABITAT	1	3	5	7	2	6	3	3	5	5
AGE	100	150	150	100	30	100	15	100	50	50
LENGTH (m)	40	40	35	80	20	150	40	30	60	40
WIDTH (m)	15	15	20	25	15	10	15	20	20	30

POND	11	12	13	14	15	16	17	18	19	20
ALTITUDE	80	100	100	100	125	85	10	60	125	125
GEOLOGY	CM	CM	CM	CM	ML	CM	CM	CM	ML	ML
INFLOW	Y	N	Y	N	Y	N	N	Y	Y	N
OUTFLOW	N	N	Y	N	N	N	N	N	N	Y
W B <5M	N	Y	Y	N	N	N	N	Y	Y	Y
W B 10-250M	N	Y	Y	Y	N	N	Y	Y	N	N
CLARITY	3	4	3	1	3	4	3	3	2	2
RUBBISH	1	3	2	2	3	4	2	3	2	2
MICROHABITAT	5	2	2	3	3	3	4	3	4	3
AGE	10	150	50	100	50	90	30	50	20	20
LENGTH (m)	25	30	35	25	50	20	15	25	25	30
WIDTH (m)	10	15	20	10	30	20	15	10	12	20

GEOLOGY: ML=Magnesian Limestone, CM=Coal Measures, Y=Yes, N=No
WATER CLARITY: v. clear(1), clear(2), moderately clear(3), turbid(4)
RUBBISH: none(1), small ammount(2), much(3), v.much(4). WB=Waterbody
AGE 100= At least 100 years old. SIZE: maximum length, and average width.
MICROHABITAT: number of microhabitats present in the pond.

TABLE 2

WATER SOURCE

POND	1	2	3	4	5	6	7	8	9	10
GROUND WATER	1	?	1	2				?	1	1
RUNOFF	3	1			2		1	1	2	
STREAM				1	1	1				
FLOODWATER	2	2	2							
DIRECT PRECIPITATION		3						2	3	

POND	11	12	13	14	15	16	17	18	19	20
GROUND WATER		1	1	1	2	2	1	1	1	1
RUNOFF						1			?	?
STREAM	1				1					
DIRECT PRECIPITATION	2						2	2	2	2

Rank 1-4 by importance (? where unsure)

TABLE 3

PERCENTAGE LAND USE

POND	1	2	3	4	5	6	7	8	9	10
WOODLAND <5M		20		10	90			50	10	50
SCRUB <5M			10	10			80		30	50
MOOR/BOG <5M	90		80	70						
GRASSLAND <5M	10	80	10				20	30	50	
MANMADE <5M				10	10			20	10	
WOODLAND 5-100M		10		15	60			50	30	35
SCRUB 5-100M	15		15	10			25		40	30
MOOR/BOG 5-100	50		10	60						
GRASSLAND 5-100M	20	80	75				10	30	20	
ARABLE 5-100M	5			10			65			20
MANMADE 5-100M		10		5	40			20	10	5

POND	11	12	13	14	15	16	17	18	19	20
WOODLAND <5M						70	90	20	5	10
SCRUB <5M	90	90						80	35	60
MOOR/BOG <5M			10		80		10			
GRASSLAND <5M	10	10	80	90	20		90	60	30	
MANMADE <5M				10						
WOODLAND 5-100M	20			10				20	5	10
SCRUB 5-100M	60	50			15	10	35	15	50	75
MOOR/BOG 5-100M			10		50					
GRASSLAND 5-100M	20		60	75	15		35	5	15	
ARABLE 5-100M		50				15		30	30	15
MANMADE 5-100M			30	15	20	5	30	30		

MANMADE= Roads, Paths, Tracks, Buildings.

TABLE 4

OVERHANGING TREES/SHRUBS AND PLANT COVER

POND	1	2	3	4	5	6	7	8	9	10
MARGIN OVERHUNG	0	1	1	1	5	2	2	2	1	1
POND OVERHUNG	0	1	1	1	1	1	1	1	1	1
EMERGENT	2	5	2	2	1	3	1	4	2	2
FLOATING LEAVED	1	2	3	1	1	1	1	1	2	1
SUBMERGED	1	1	5	2	1	1	1	1	1	1

POND	11	12	13	14	15	16	17	18	19	20
MARGIN OVERHUNG	0	3	1	0	0	2	0	1	0	1
POND OVERHUNG	0	1	1	0	0	1	0	1	0	1
EMERGENT	3	5	1	3	1	2	1	2	4	2
FLOATING LEAVED	2	1	1	1	3	2	2	1	1	2

1=1-20%, 2=21-40%, 3=41-60%, 4=61-80%, 5=81-100%

TABLE 5

POND BASE AND SEDIMENT CONTENTS

POND	1	2	3	4	5	6	7	8	9	10
POND BASE										
CLAY/MUD					Y	Y		Y		Y
BUTYL										
GRAVEL/SAND		Y	Y	Y			Y		Y	
PEAT	Y									
SEDIMENT CONTENT										
WHOLE LEAVES + TWIGS					2	2				3
DEC LEAVES AND TWIGS				3	3			2	2	2
DEBRIS <5mm				1			1		1	
DEBRIS <1mm		2		2						
ORG + INORG OOZE	1	1	1		1	1	2	1	3	1

POND	11	12	13	14	15	16	17	18	19	20
POND BASE										
CLAY/MUD			Y	Y		Y				
BUTYL	Y									
GRAVEL/SAND		Y			Y		Y	Y	Y	Y
PEAT										
SEDIMENT CONTENT										
WHOLE LEAVES + TWIGS			1			2			3	3
DEC LEAVES + TWIGS	3					3	4	2		
ORGANIC DEBRIS <5mm	2			3			3		1	1
DEBRIS <1mm				2			2	1	2	2
ORG + INORG OOZE	1	1	2	1	1	1	1	3		

Y=Yes, SEDIMENT CONTENT: Ranked according to amount present. DEBRIS: Organic and Inorganic debris

TABLE 6

BASIC WATER CHEMISTRY

POND	1	2	3	4	5	6	7
pH	5.54	7.35	7.5	7.21	6.93	6.9	8.23
CONDUCTIVITY ms	453	952	738	773	446	688	1609

POND	8	9	10	11	12	13	14
pH	6.93	6.97	6.94	7.28	7.34	6.83	6.81
CONDUCTIVITY ms	768	811	769	298	874	394	504

POND	15	16	17	18	19	20
pH	7.84	5.93	8.66	7.23	8.49	7.99
CONDUCTIVITY ms	926	488	1784	881	1960	1930

ms = microsiemens

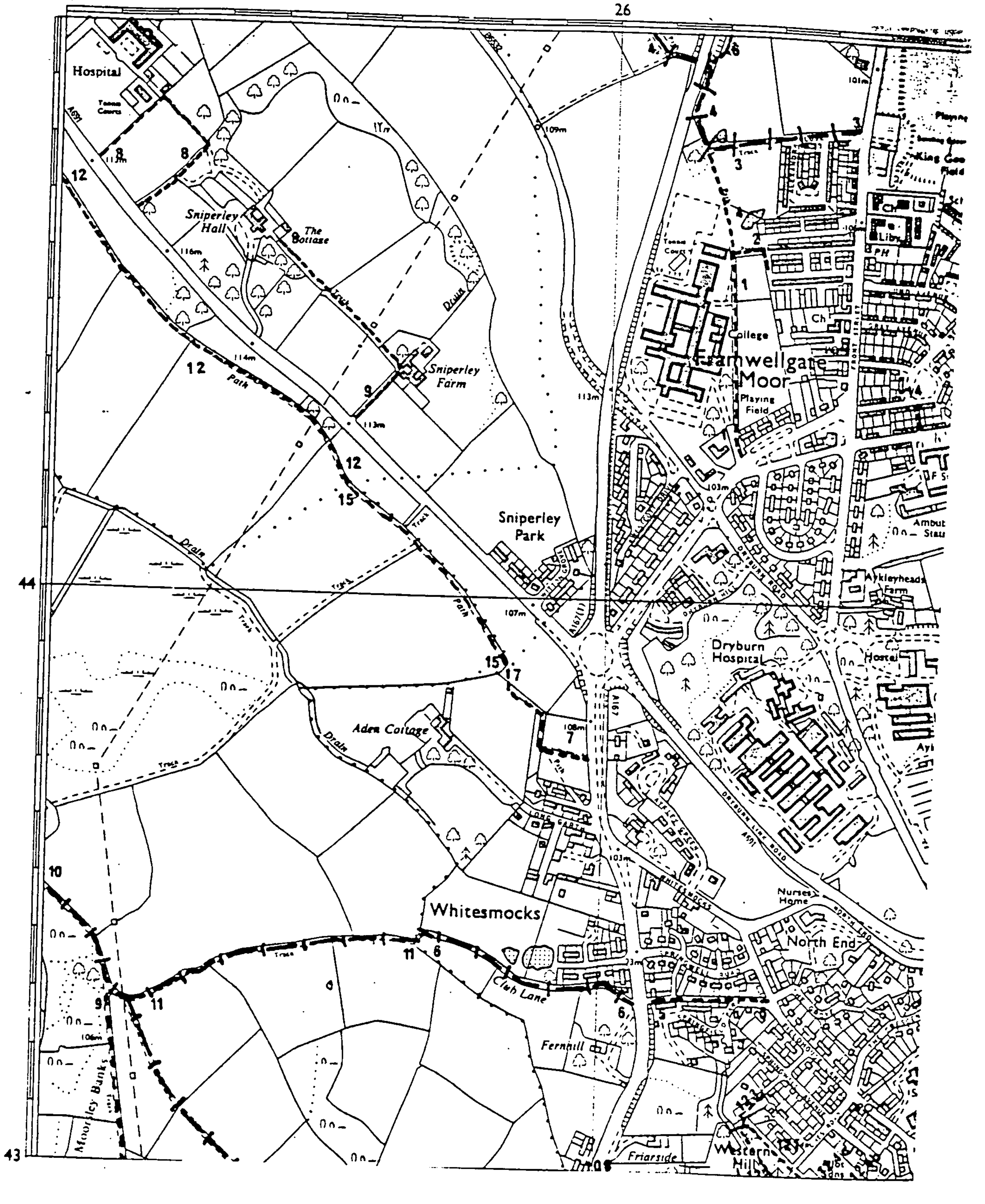
APPENDIX 4

MAPS, SITE DESCRIPTIONS AND SPECIES LISTS FOR THE PONDS.

(no maps for Seaton Carew and The Wingate ponds)

BEARPARK

NZ 254433



BEARPARK

This pond is situated in one of the last remaining lowland mire systems in County Durham, the peaty area directly adjacent has been burnt in the past and is now heavily grazed.
Attempts have been made recently to drain the pond but have so far been unsuccessful.

PLANTS

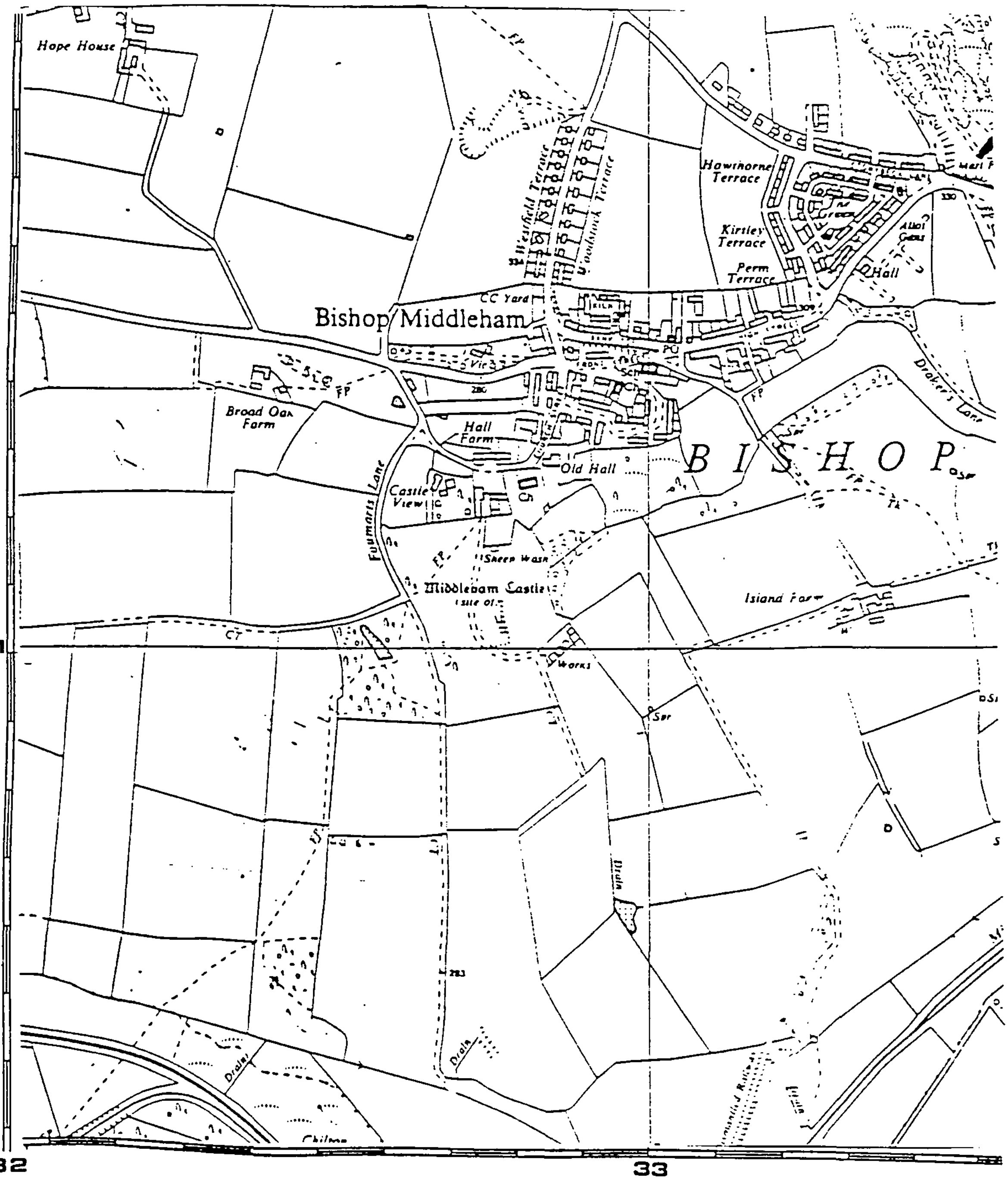
Juncus bulbosus
Hydrocotyle vulgaris

HEMIPTERA

Gerris lacustris
Sigara scotti

BISHOP MIDDLEHAM

NZ 325 310



BISHOP MIDDLEHAM

This ancient farm pond situated on the Magnesian Limestone lies in heavily grazed pasture.
It is shallow, and in dry conditions forms two seperate ponds.

PLANTS

Juncus inflexus
Lemna spp
Mentha aquatica
Potamogeton berchtoldii
Ranunculus aquatilis
Typha latifolia
Veronica beccabunga

HEMIPTERA

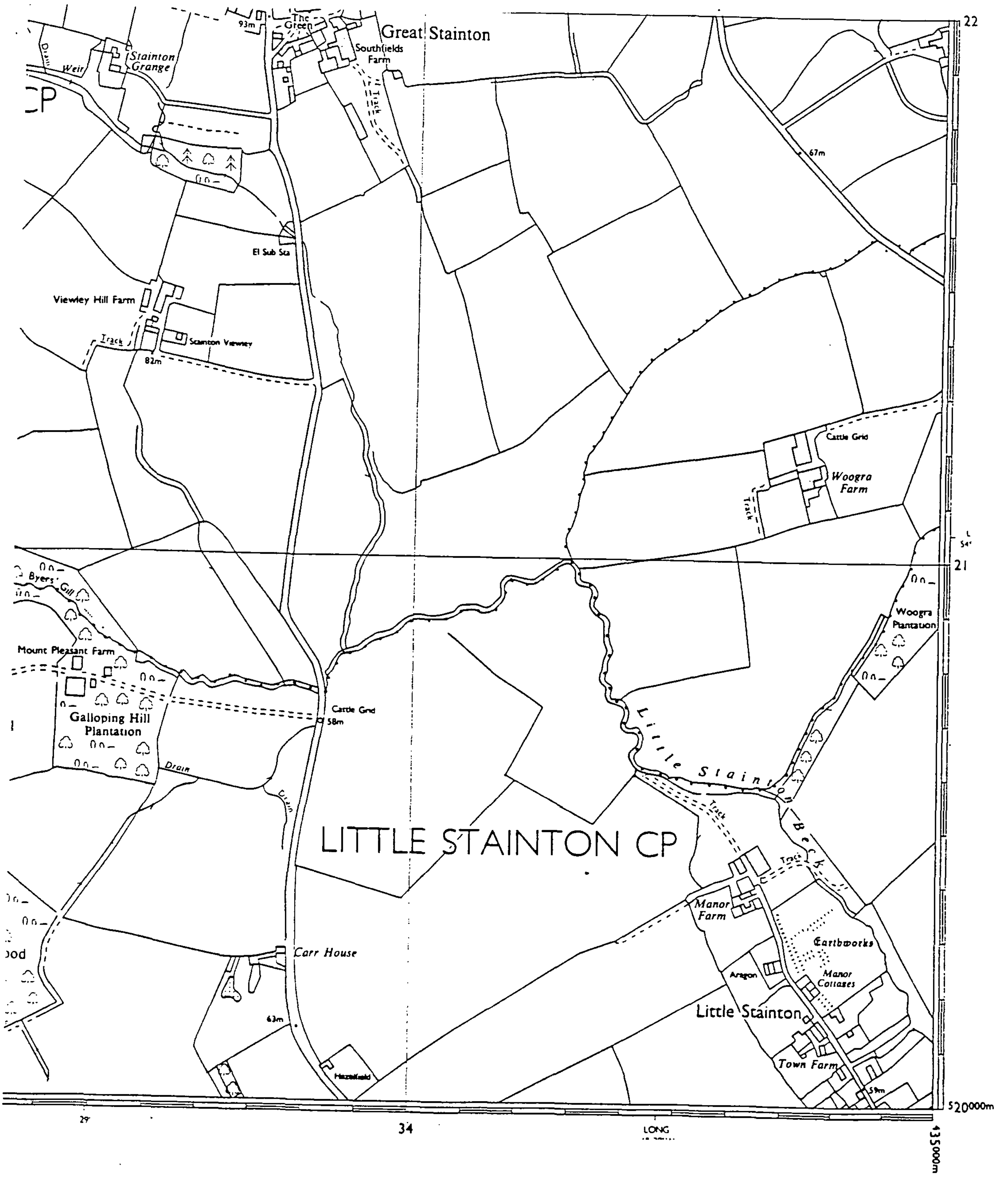
Callicorixa praeusta
Sigara dorsalis

COLEOPTERA

Haliplus fluviatilis

CARR HOUSE

NZ 337202



CARR HOUSE

This old farm pond is situated on the edge of the Magnesian Limestone, bordered to one side by broom and scrub, the area is heavily grazed by sheep.

PLANTS

Eleocharis palustris
Juncus effusus
Lemna spp
Mentha aquatica
Potamogeton berchtoldii
Potamogeton natans
Ranunculus peltatus
Ranunculus aquatilis

HEMIPTERA

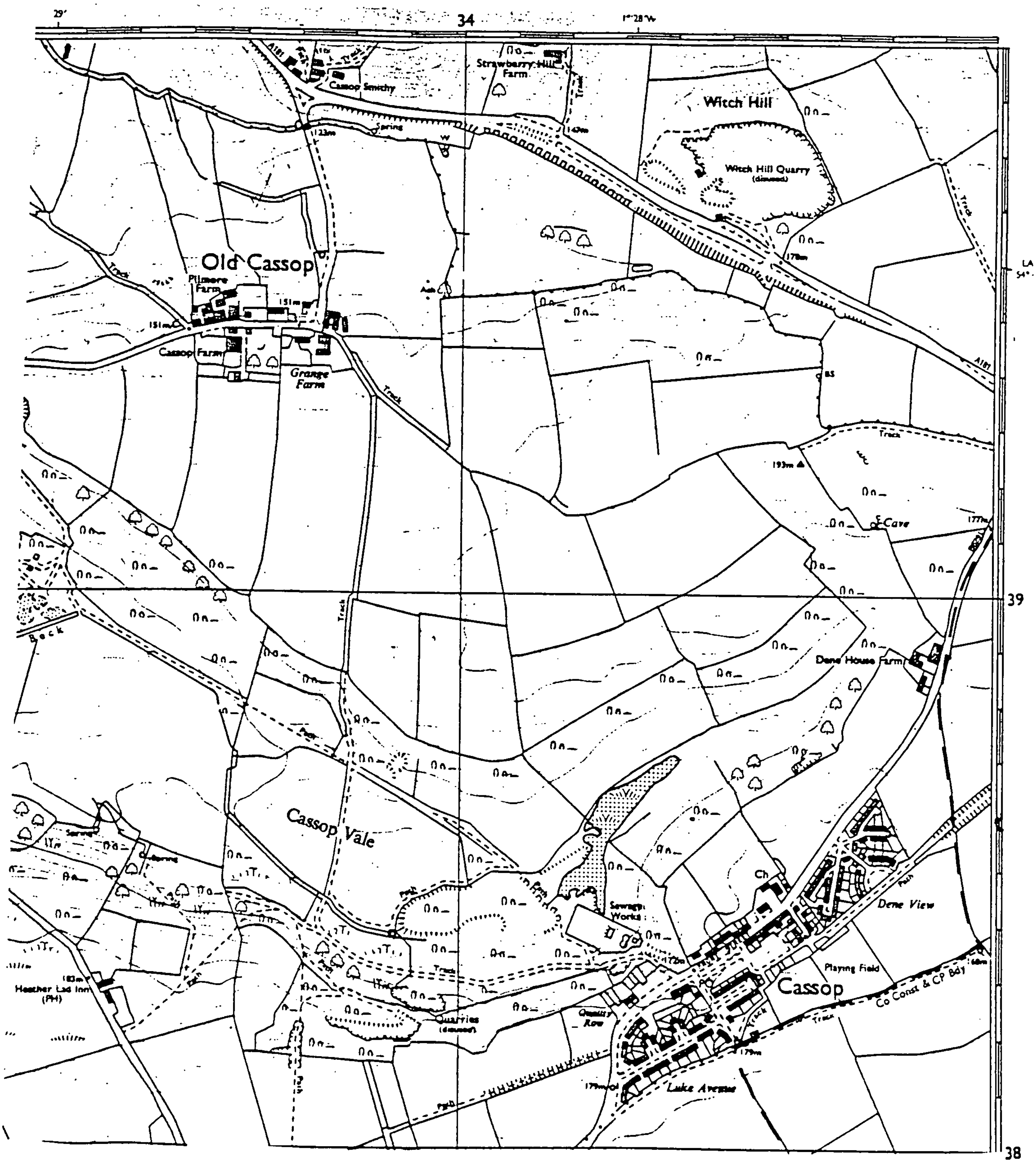
Callicorixa praeusta
Sigara dorsalis

COLEOPTERA

Haliplus fluviatilis
Hygrotus inaequalis

CASSOP

NZ 343385



CASSOP

This large attractive pond is a designated SSSI,lying on the Magnesian Limestone, it is used by local fishermen and there are many well worn paths around it.

PLANTS

Apium nodiflorum
Callitritche stagnalis
Elodea canadensis
Equisetum fluviatile
Hippuris vulgaris
Iris psuedacorus
Juncus effusus
Menyanthes trifoliata
Phragmites australis
Potamogeton natans

HEMIPTERA

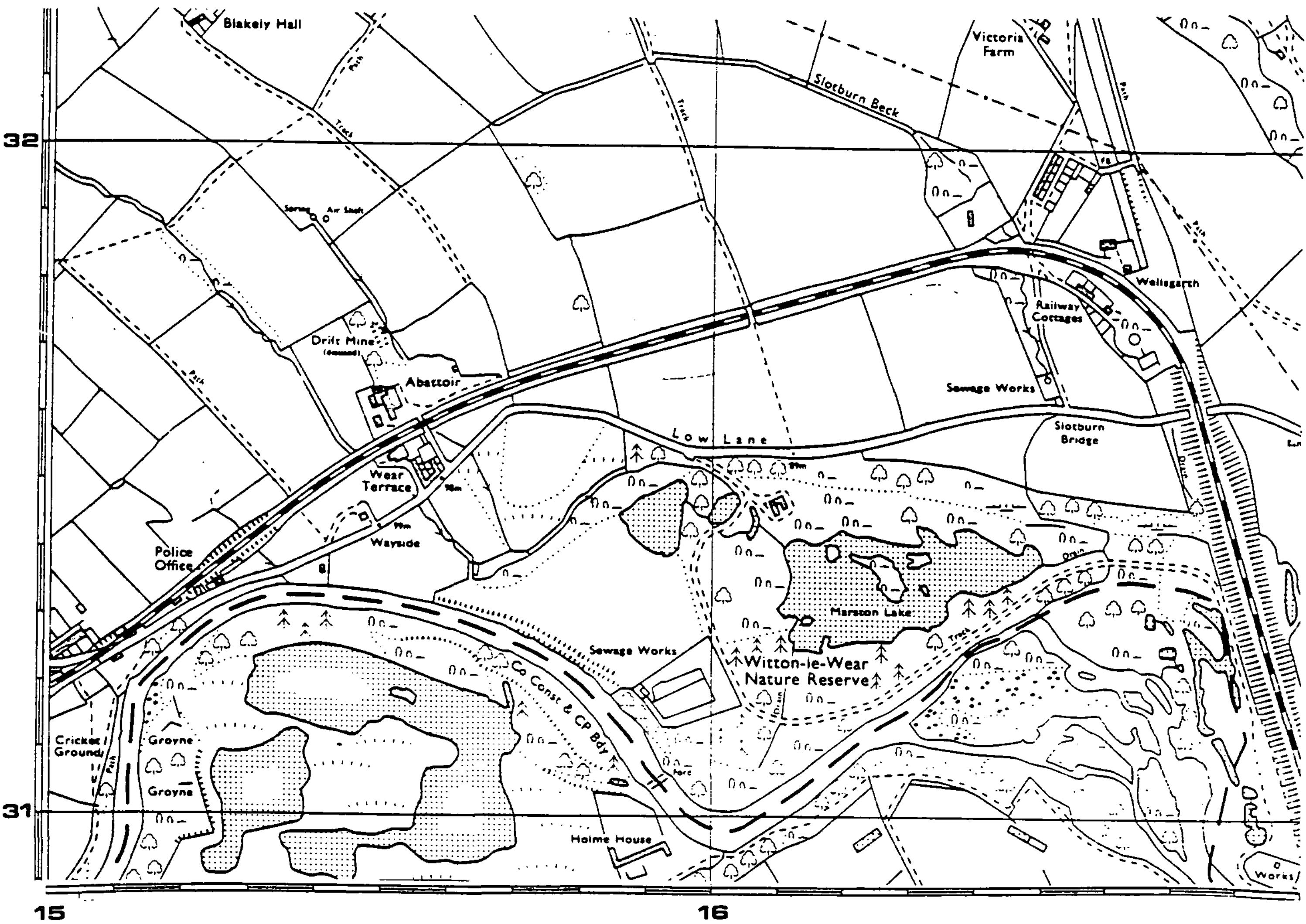
Callicorixa praeusta
Sigara lateralis

COLEOPTERA

Haliplus fluviatilis
Haliplus riparis
Hydrobius fuscipes

COOT POND

NZ 160314



COOT POND

Previously a gravel pit, this pond is now one of three at Durham Wildlife Trust Headquarters.(Witton le Wear)

PLANTS

Elodea canadensis
Hippuris vulgaris
Lemna spp
Potamogeton natans

HEMIPTERA

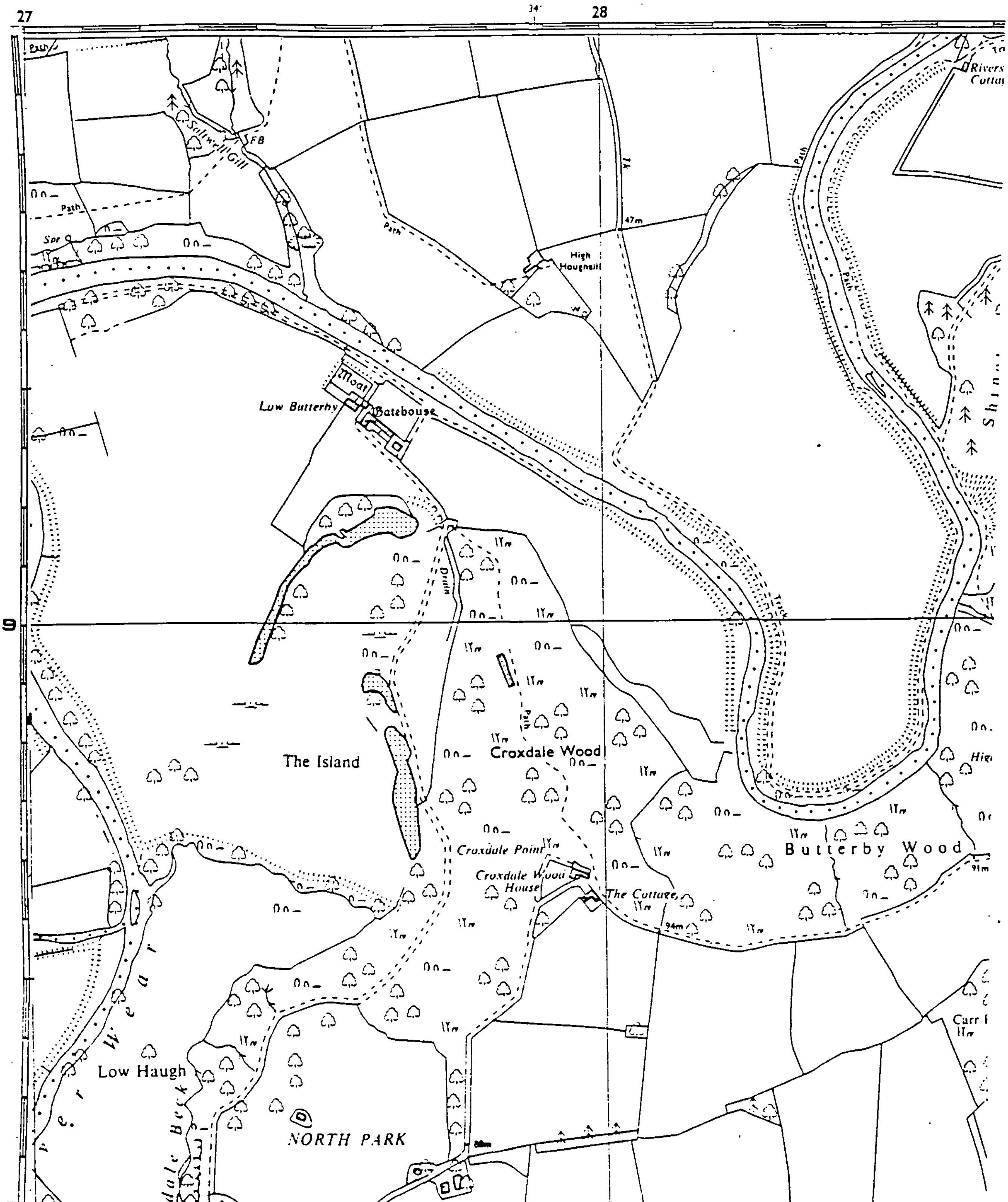
Callicorixa praeusta
Hesperacorixa sahlbergi
Sigara nigrolineata
Sigara scotti

COLEOPTERA

Laccobius bipunctatus
Noterus clavicornis

3

CROXDALE HALL OXBOE
NZ 276386



CROXDALE HALL OXBOE

This large, very attractive oxboe of the Wear is a SSSI, bordered to one side by arable land, cattle graze along one edge.

PLANTS

Eleocharis palustris
Equisetum fluviatile
Iris psuedacorus
Juncus effusus
Lemna minor
Mentha aquatica
Menyanthes trifoliata
Nasturtium officionale
Nymphae alba
Phragmites australis
Potamogeton natans
Typha latifolia

HEMIPTERA

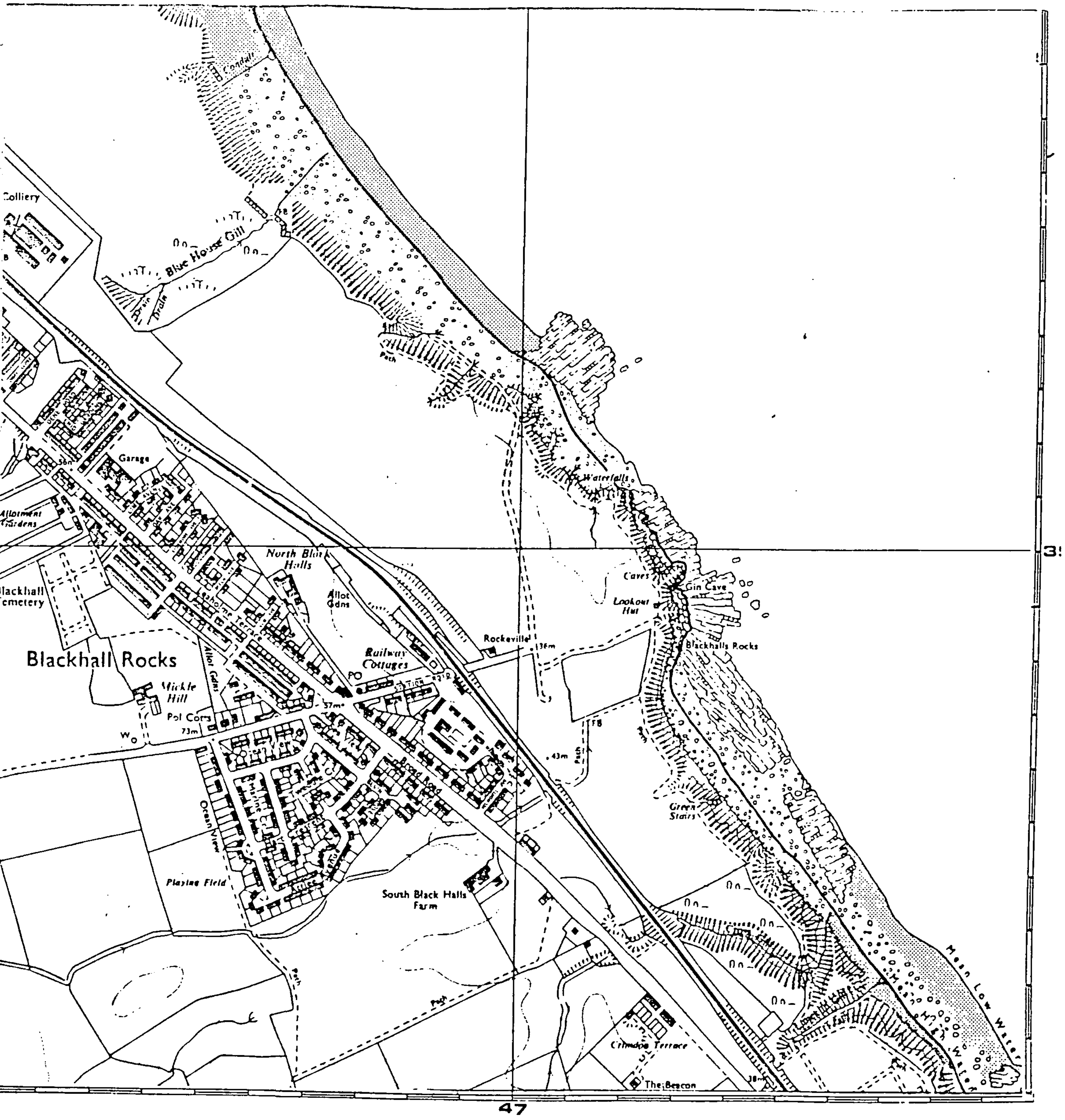
Callicorixa praeusta
Sigara fossarum
Sigara lateralis
Notonecta glauca

COLEOPTERA

Haliplus lineolatus
Haliplus fulvus

CRYSTALS POND

NZ 465394



CRYSTALS POND

This pond was created when farm rubbish was dumped in one of the wet gullies characteristic of this area, it lies at the top of the cliffs on Magnesian Limestone and is flanked to the West by gorse and broom scrub.

PLANTS

Apium nodiflorum
Callitritche stagnalis
Elodea canadensis
Hydrocotyle vulgaris
Juncus effusus
Menyanthes trifoliata
Potamogeton natans
Veronica beccabunga

HEMIPTERA

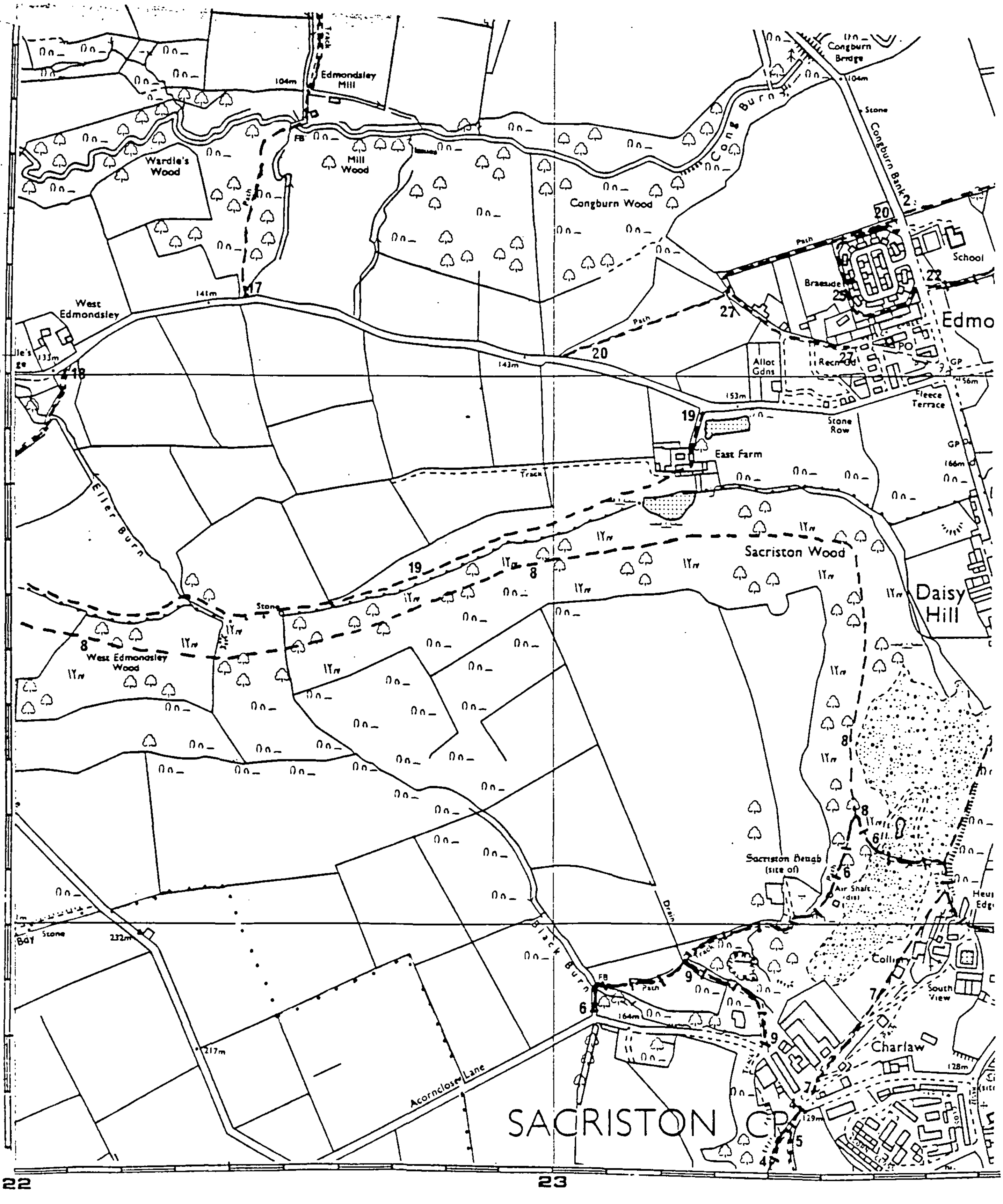
Sigara dorsalis

COLEOPTERA

Hydrobius fuscipes

EAST FARM

NZ 232488



EAST FARM

This farm pond is bordered to the south by Sacriston wood, it contains a lot of rubbish, but supports a varied flora and fauna.

PLANTS

Juncus effusus
Lemna minor
Menyanthes trifoliata
Phragmites australis
Sparganium erectum
Typha latifolia

HEMIPTERA

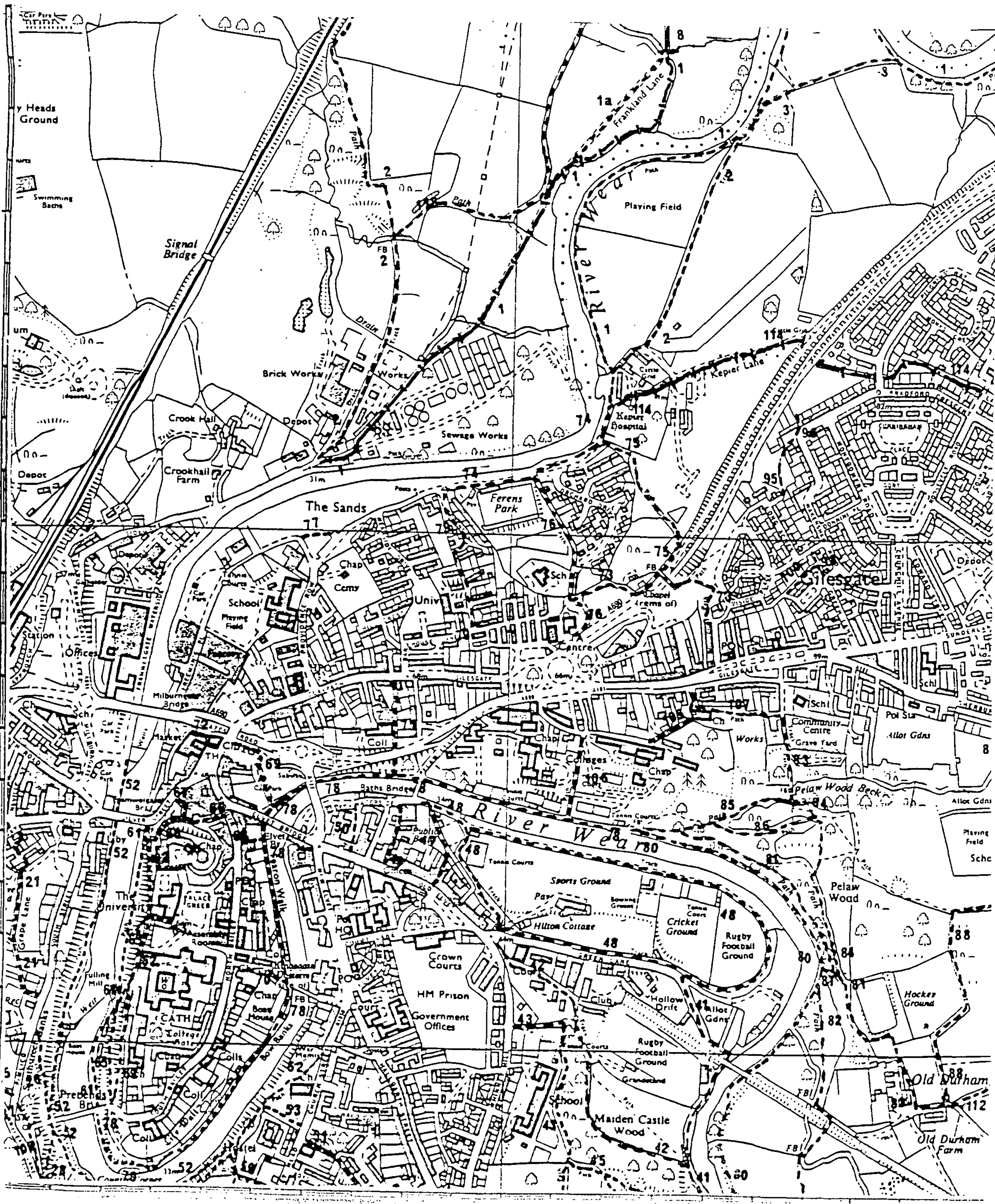
Sigara distincta
Sigara fossarum

COLEOPTERA

Haliplus lineolatus
Hygrotus inaequalis

FRANKLAND

NZ 274434



FRANKLAND

This old, large flooded brickworks pond lies very close to Durham City near to the railway, access is difficult in places.

PLANTS

Alisma plantago-aquatica
Callitritche stagnalis
Caltha palustris
Eleocharis palustris
Elodea canadensis
Equisetum fluviatile
Glyceria fluitans
Iris psuedacorus
Juncus effusus
Myriophyllum spicatum
Nymphae alba
Phragmites australis
Potamogeton natans
Potamogeton pectinatus
Ranunculus trichophyllus
Typha latifolia
Veronica beccabunga

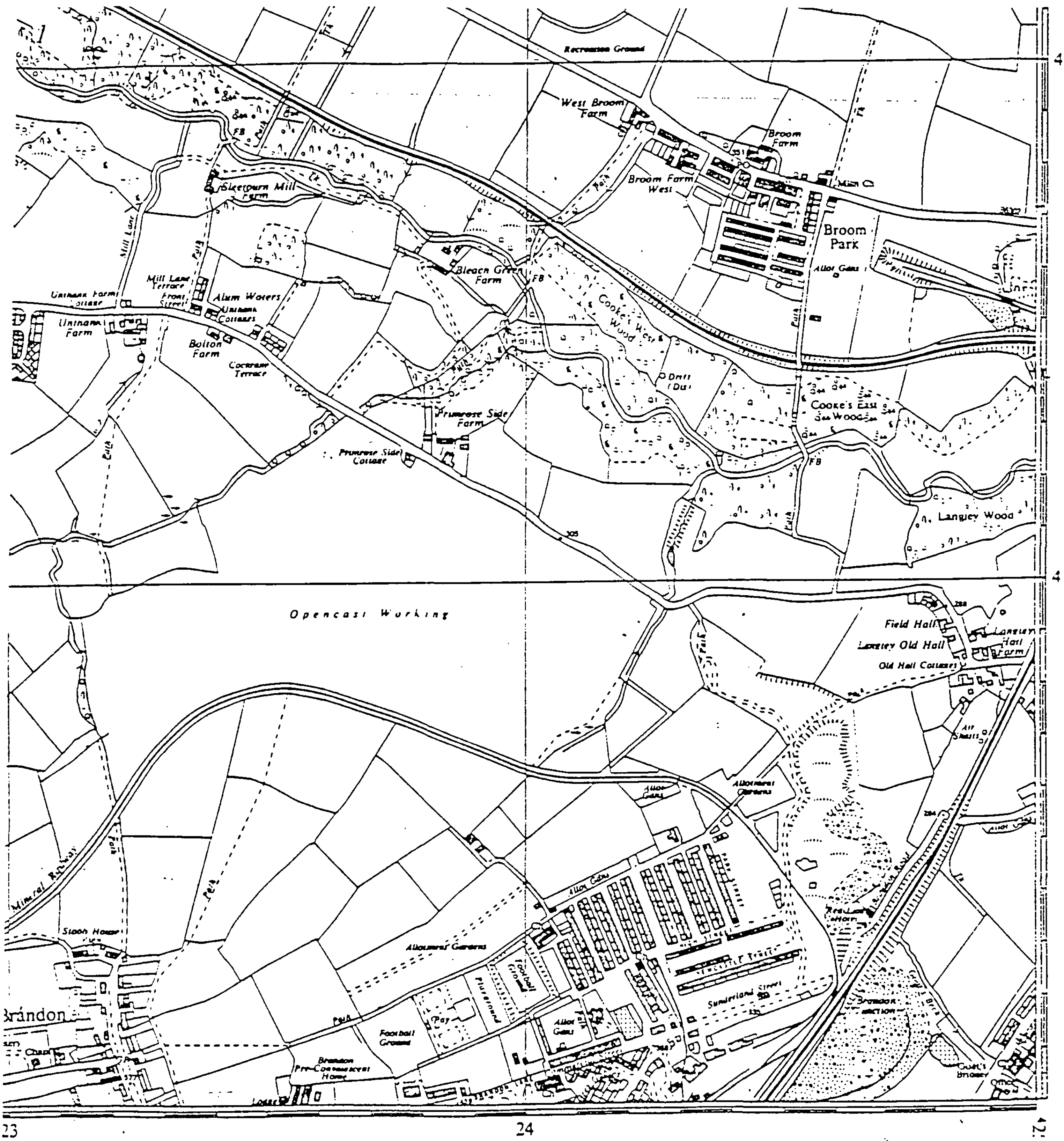
HEMIPTERA

Callicorixa praeusta
Hesperacorixa sahlbergi

COLEOPTERA

Haliplus confinis
Haliplus lineolatus
Haliplus fluviatiles
Laccobius bipunctatus
Noterus clavicornis

LANGLEY FUR FARM
NZ 249409



LANGLEY FUR FARM

This pond is surrounded by rough grassland, gorse, broom and bramble plus a variety of tree species (making access difficult at times). It lies in a deep hollow (possibly a bomb crater) close to the river Deerness and within the site of an old mink farm.

PLANTS

Alisma plantago-aquatica
Eleocharis palustris
Equisetum fluviatile
Iris psuedacorus
Mentha aquatica
Phragmites australis
Potamogeton berchtoldii
Potamogeton natans
Ranunculus trichophyllus
Typha latifolia

HEMIPTERA

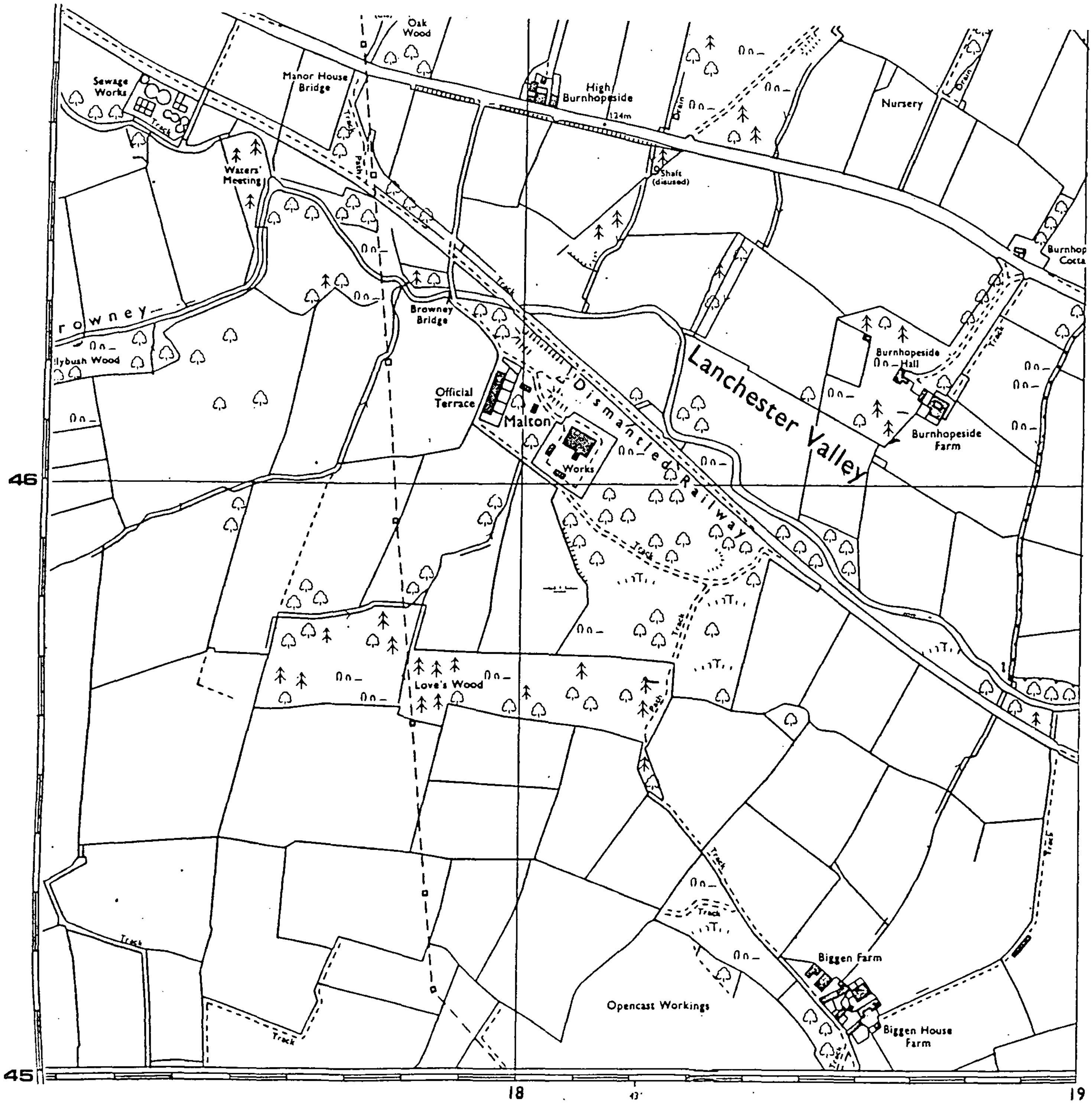
Callicorixa praeusta
Notonecta glauca
Sigara fossarum

COLEOPTERA

Haliplus confinis
Haliplus ruficollis
Hydroporus palustris
Hygrotus inaequalis
Laccobius bipunctatus

MALTON

NZ 184455



MALTON

This pond was created in 1985 when a nearby pond was reclaimed for agriculture. Bottom mud and animals (including three newt species) were introduced from the old pond into the 1m deep, butyl lined pond that now forms an attractive part of Malton Nature Reserve.

PLANTS

Eleocharis palustris
Equisetum fluviatile
Glyceria fluitans
Iris pseudacorus
Juncus effusus
Lemna spp
Phragmites australis
Potamogeton natans
Ranunculus aquatilis
Ranunculus flammula
Typha latifolia

HEMIPTERA

Callicorixa praeusta
Hesperacorixa sahlbergi
Notonecta glauca

COLEOPTERA

Haliplus confinis
Haliplus riparia
Helophorus minutus
Laccobius bipunctatus

MILL HOUSE
NZ 268313

MILL HOUSE

This old pond lies in arable land with some gorse and bramble scrub immediately surrounding it. Drying up rapidly it is in need of some attention if it is to survive, another small pond lies just to the north of it in a similar state.

PLANTS

Lemna minor
Mentha aquatica
Potamogeton berchtoldii
Potamogeton natans
Ranunculus aquatilis
Sparganium erectum
Typha latifolia

HEMIPTERA

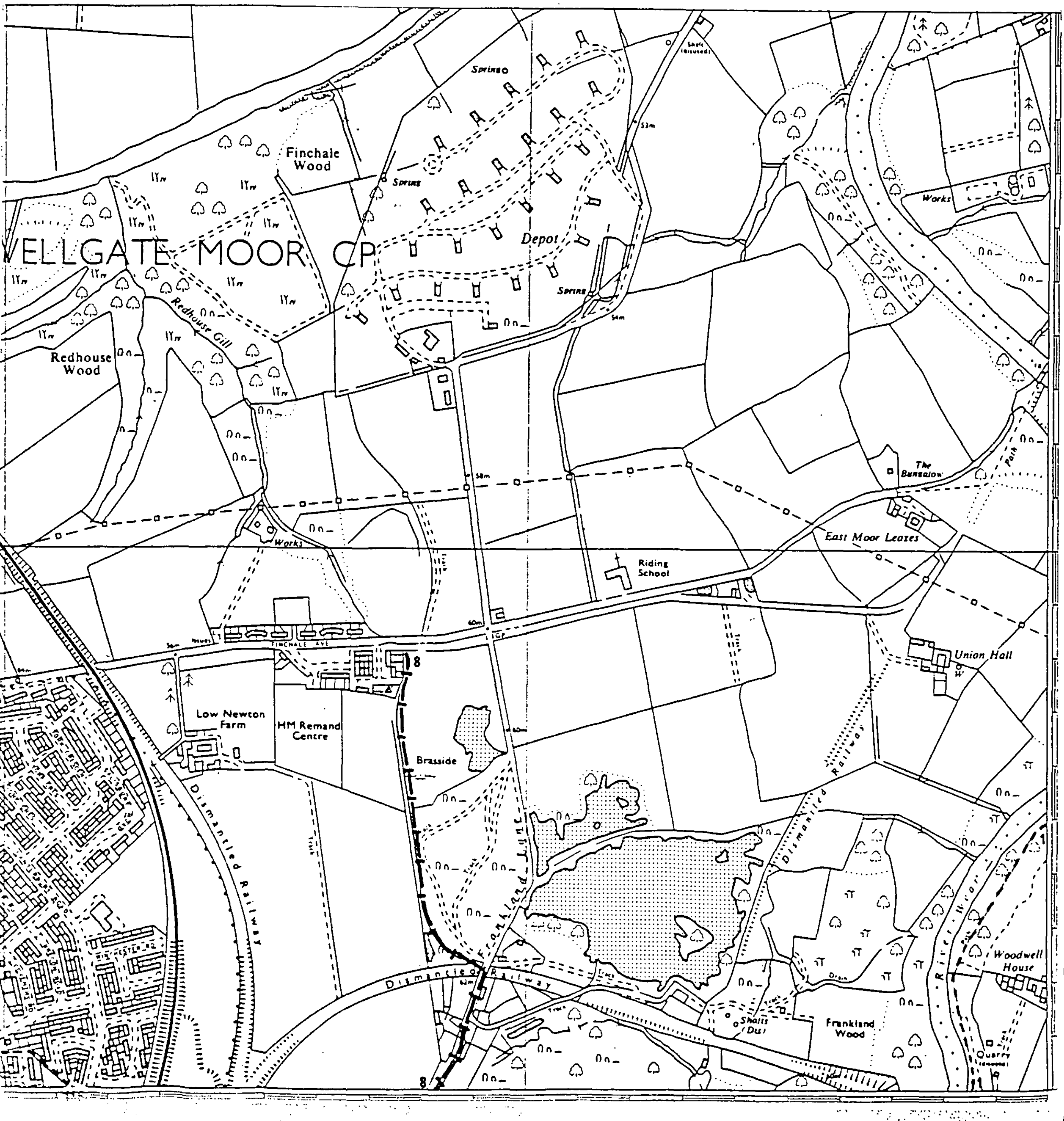
Hesperacorixa sahlbergi

COLEOPTERA

Haliplus fulvus
Hydrobius fuscipes
Hygrotus inaequalis

NORTH BRASSIDE CLAYPIT

NZ 291469



NORTH BRASSIDE CLAYPIT

This former claypit is now a steeply sided pond close to much a larger pond which is extensively fished. There is an inflow from the larger pond, also a former claypit.

PLANTS

Eleocharis palustris
Equisetum fluviatile
Hippuris vulgaris
Juncus effusus
Lemna spp
Nymphae alba
Potamogeton natans
Typha latifolia

HEMIPTERA

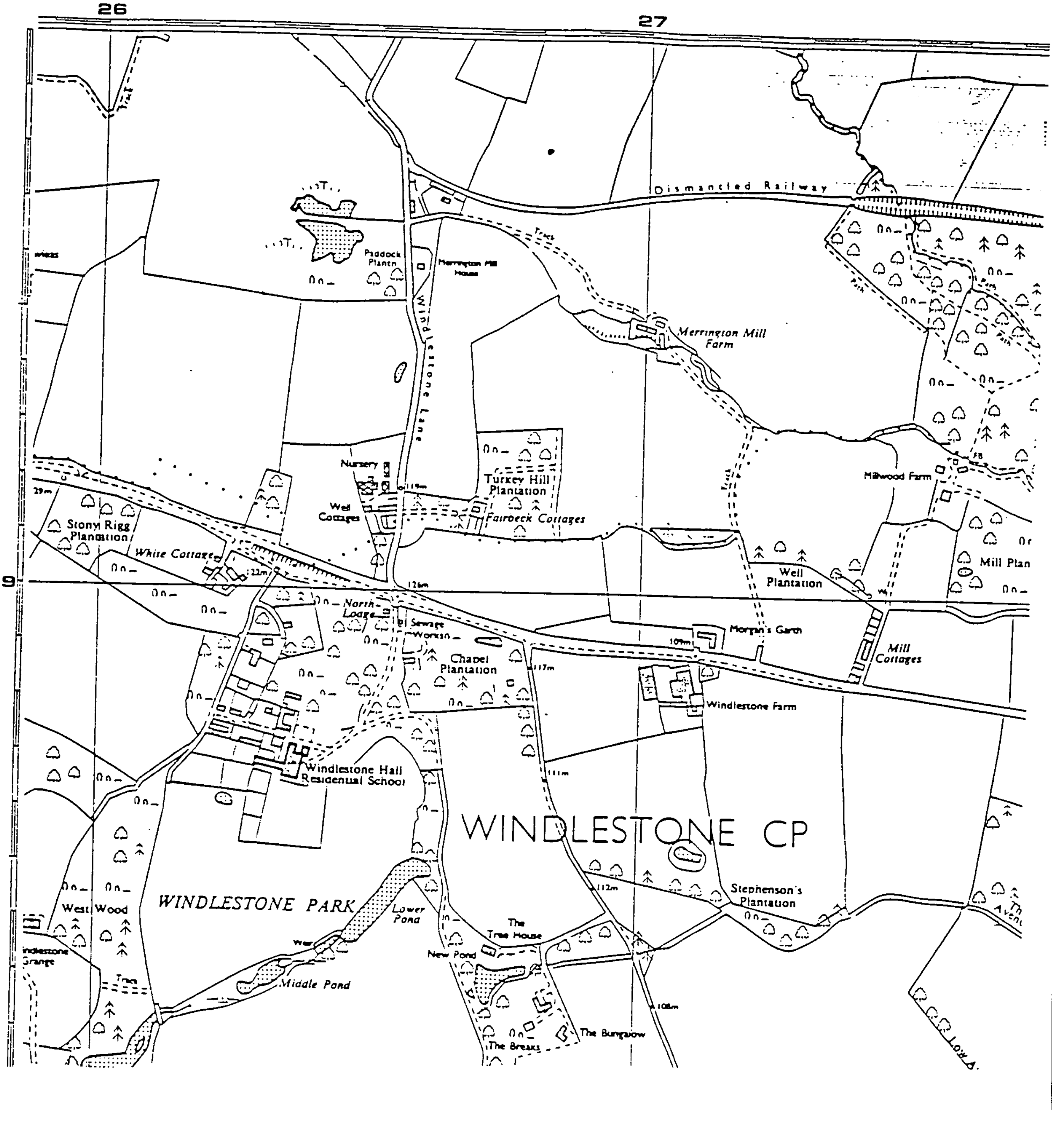
Sigara nigrolineata
Notonecta glauca

COLEOPTERA

Haliplus lineolatus

PADDOCK PLANTATION

NZ 264297



PADDOCK PLANTATION

This small farm pond lies in pasture close to an area of wetland in the nearby woods.

PLANTS

Caltha palustris
Eleocharis palustris
Elodea canadensis
Hippuris vulgaris
Hydrocotyle vulgaris
Juncus bulbosus
Lemna minor
Mentha aquatica
Menyanthes trifoliata
Typha latifolia

HEMIPTERA

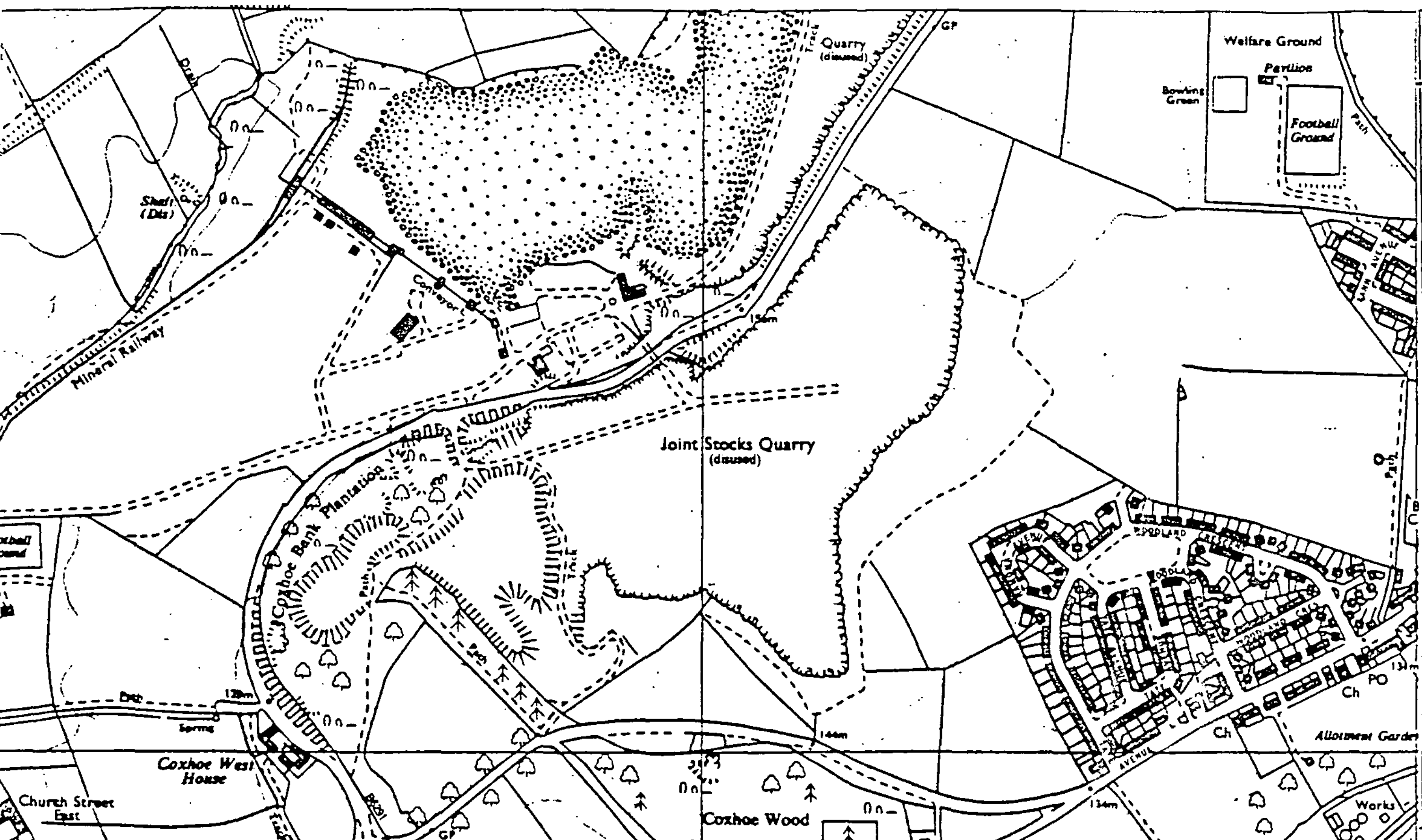
Hesperacorixa sahlbergi
Sigara scotti
Notonecta glauca

COLEOPTERA

Haliplus fulvus
Laccophilus minutus
Noterus clavicornis

RAISBY

NZ 331352



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RAISBY

This pond lies in a very marshy area on the Magnesian Limestone close to Raisby quarry Nature Reserve, the surrounding area is grazed by cattle.

PLANTS

Juncus inflexus
Lemna minor
Menyanthes trifoliata
Phragmites australis
Potamogeton berchtodii
Sparganium erectum
Typha latifolia

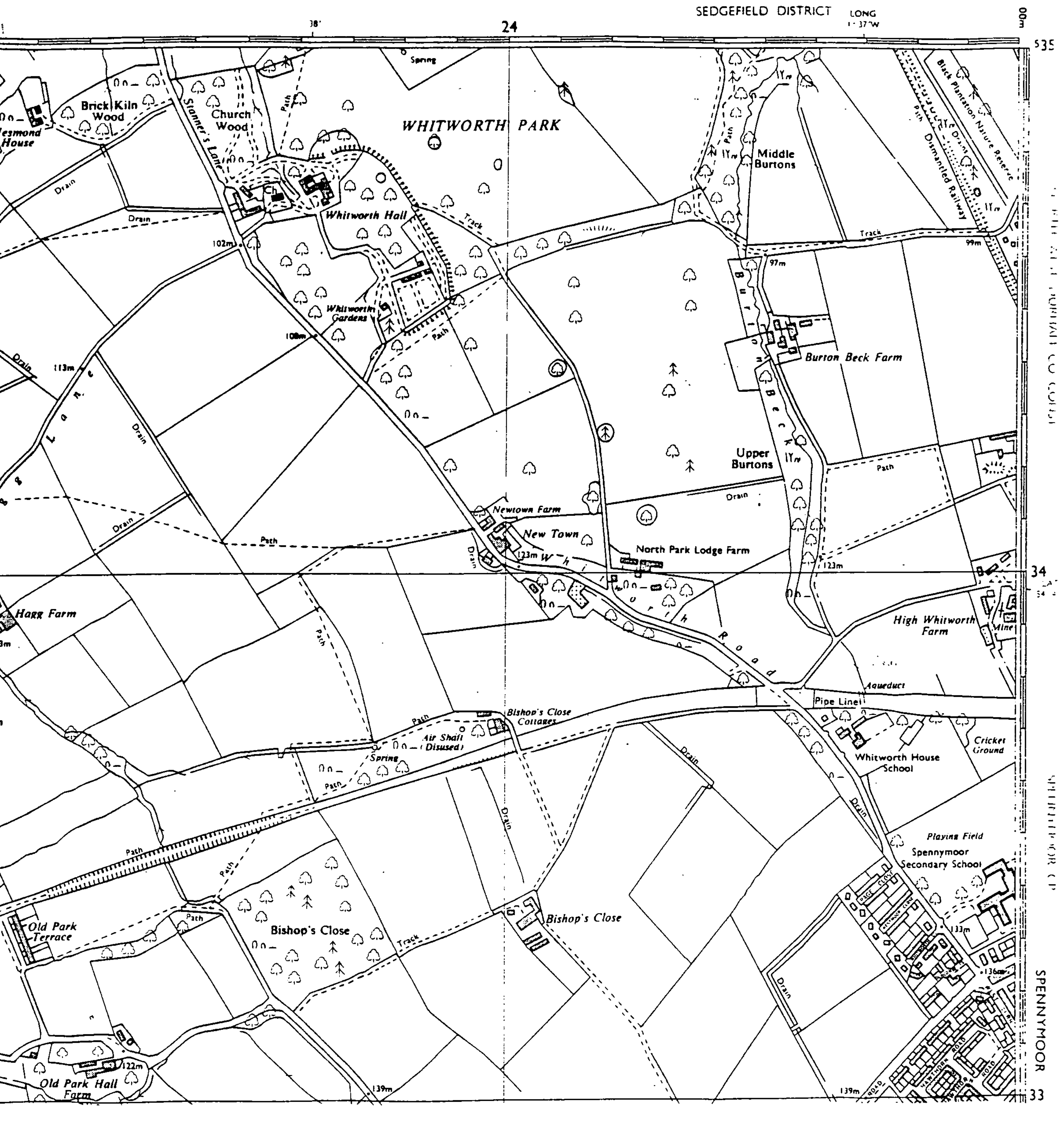
HEMIPTERA

Cymatia bonsdorffi
Gerris lacustris
Sigara fossarum
Sigara lateralis

COLEOPTERA

Haliplus fulvus
Haliplus lineolatus
Hygrotus inaequalis

ROSA SHAFTO
NZ 249347



ROSA SHAFTO

Situate in Rosa Shafto Nature Reserve amongst deciduous woodland, this pond has been subject to some management, having been dug out by volunteers on various occasions. It lies close to a well used footpath.

PLANTS

Alisma plantago-aquatica
Juncus effusus
Lemna minor
Menyanthes trifoliata
Phragmites australis
Sparganium erectum

HEMIPTERA

Cymatia bonsdorffi
Sigara scotti

COLEOPTERA

Haliplus fulvus
Hygrotis inaequalis
Laccophilus minutus

SEATON CAREW

This unusual but attractive pond is situated behind manmade dunes in damp grassland close to a golf course. It remains relatively undisturbed though, and supports an interesting flora and fauna.
It appears to be the most permanent body of water in this area of wetland patches and semi-permanent ponds.

PLANTS

Apium nodiflorum
Hippuris vulgaris
Juncus effusus
Juncus gerardi
Lemna minor
Potamogeton natans
Potentilla palustris
Ranunculus scleratus

HEMIPTERA

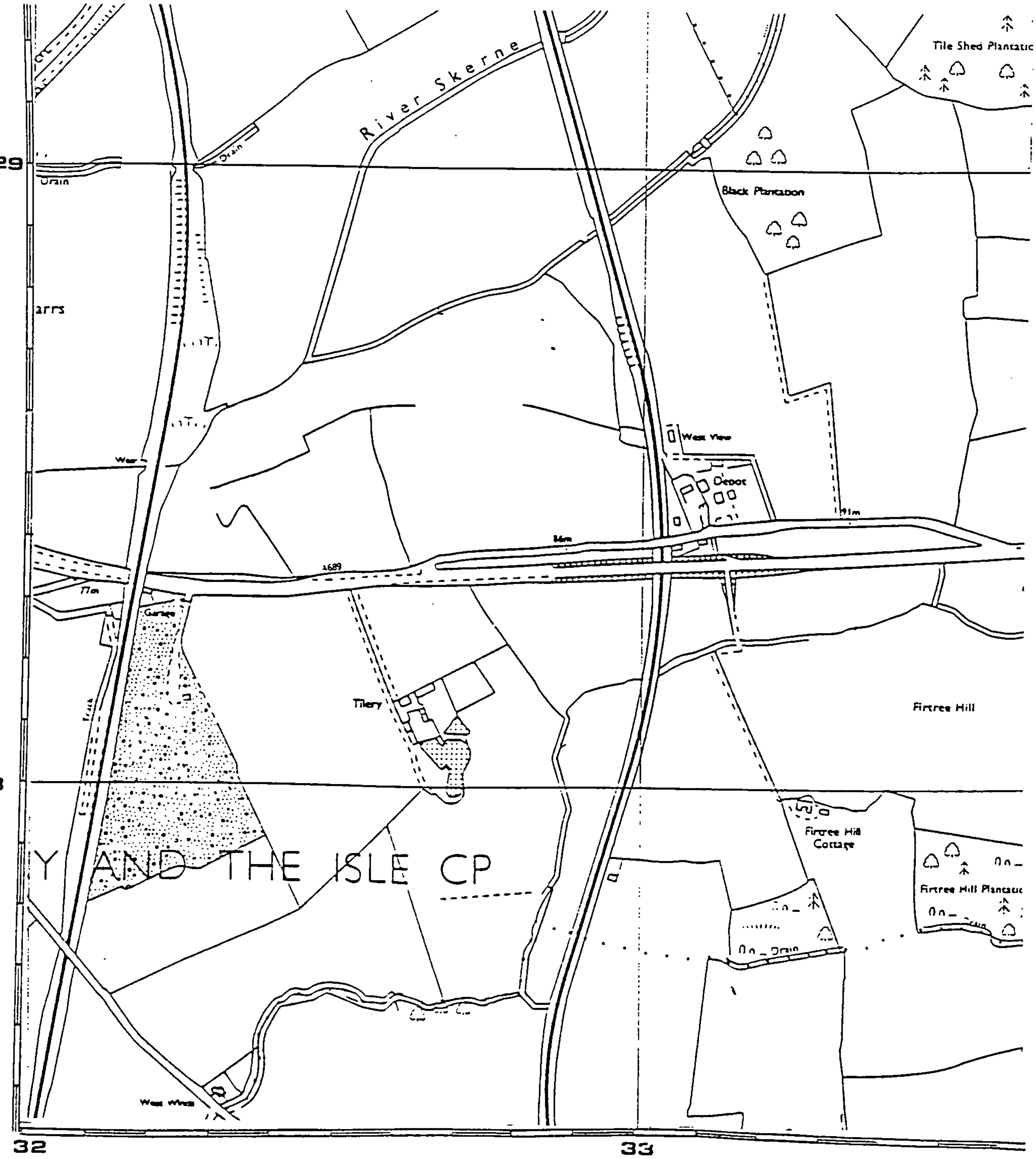
Callicorixa praeusta
Gerris thoracicus
Notonecta glauca
Sigara selecta

COLEOPTERA

Hydrobius fuscipes
Haliplus apicalis

TYLERY POND

NZ 326281



TYLERY

This flooded claypit is situated near arable land in a sheltered area close to a much larger pond.

PLANTS

Callitritche stagnalis
Eleocharis palustris
Equisetum fluviatile
Iris pseudacorus
Nymphae alba
Potamogeton natans
Phragmites australis
Typha latifolia

HEMIPTERA

Sigara lateralis
Notonecta glauca

COLEOPTERA

Haliplus apicalis

WINGATE

This pond is within an old Magnesian Limestone quarry surrounded by rough grassland and hawthorn scrub, there is pasture close by and a connecting pond.

PLANTS

Callitritche stagnalis
Caltha palustris
Hippurus vulgaris
Juncus effusus
Juncus inflexus
Mentha aquatica
Menyanthes trifoliata
Phragmites australis
Potamogeton pectinatus
Typha latifolia

HEMIPTERA

Sigara dorsalis
Sigara fossarum
Notonecta glauca

COLEOPTERA

Haliplus fluviatilis
Hydrobius fuscipes
Haliplus apicalis

WINGATE FAR POND

Situated within an old Magnesian Limestone quarry, like the previous pond it is surrounded by rough grassland and hawthorn scrub, it has an outflow into Wingate pond.

PLANTS

Callitritche stagnalis
Caltha palustris
Juncus inflexus
Hippuris vulgaris
Lemna minor
Mentha aquatica
Phragmites australis
Potamogeton natans
Typha latifolia

HEMIPTERA

Calicorixa praeusta
Sigara dorsalis

COLEOPTERA

Haliplus apicalis
Haliplus lineolatus
Haliplus ruficollis
Haliplus fluviatilis
Hydrobus fuscipes