Natural England Commissioned Report NECR005

Analysis and reporting of lowland freshwater ditches validation network monitoring data

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Introduction

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Background

The Validation Network Project aims to ensure that data on the condition of individual features on Sites of Special Scientific Interest are accurate, consistent and scientifically robust.

The specific aims of the lowland freshwater ditch data analysis project are:

- To validate the common standards monitoring condition assessment methodology for ditches.
- To establish a set of control sites to ensure that individual site assessments match regional or national changes over time.
- To contribute to a wider network of monitoring sites that will allow a better understanding of the drivers of change. Monitoring across a range of sites with similar habitats allows some determination of the condition of the resource as a whole, feeding into national and regional targets such as the UK Biodiversity Action Plan.

Natural England commissioned this work to review the methodologies and targets for Common Standards Monitoring for lowland freshwater ditches.

We plan to use the findings to improve Common Standards Monitoring for future assessments. It is important that condition assessment methodologies are regularly reviewed and quality assured and this report is part of that process for the ditches guidance.

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Further information
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Summary

In 1998, the statutory nature conservation agencies, including English Nature, presented a framework for monitoring on designated sites. The outline framework is published as *A Statement on Common Standards in Monitoring*. The aim for each site is to maintain it in favourable condition, and condition assessment is based on meeting a set of targets for each attribute contributing to the interest feature in the site. Common Standards Monitoring now forms the standard approach to monitoring statutorily designated sites.

Regular comparison against set targets enables site management to be appraised and revised if needed. Monitoring across a range of sites with similar habitats allows some determination of the condition of the resource as a whole, feeding into national and regional targets such as the UK Biodiversity Action Plan. This strategic monitoring forms the Validation Network Project, the aims of which are to validate condition monitoring, to establish control sites against which interest features can be assessed, and to contribute to understanding the drivers of change in individual habitat types.

This report presents the results and conclusions of the analyses of data collected for lowland freshwater ditches in England, undertaken as part of the Validation Network Project.

Ditches were selected from three SSSIs for inclusion in this validation study. These were King's Sedgemoor and Nailsea Moor in the Somerset Levels, Pevensey Levels in East Sussex and Berney Marshes in Norfolk.

Datasets, which were collected in 2005, included Common Standards Monitoring field assessment forms (qualitative data) composed of a 'structured walk' and 'fixed point sampling', and botanical and environmental data collected on the same ditches following more rigorous quantitative methods. All the ditches were individually assigned favourable or unfavourable condition. Analysis of these data took four approaches:

- Consideration of the quality and consistency of data collected.
- The comparability of qualitative and quantitative datasets.
- The factors influencing overall ditch condition.
- Multivariate analysis of botanical data.

This study revealed wide variability in the qualitative data recording (in methods and number of ditches recorded) while the quantitative data received was highly consistent and generally of good quality. This hampered direct comparison of the Common Standards Monitoring data (qualitative) with the validation dataset (quantitative).

The comparison of attribute passes and failures resulted in poor comparability of attributes between the assessment methods. Generally, qualitative assessments resulted in better pass-rates than quantitative assessments.

There was overall comparability between datasets in which factors were most influential in determining ditch condition. Water depth and native species richness were the key attributes causing failures in both qualitative and quantitative datasets. Macro-algae and 'negative' species also showed as important attributes causing fails for both datasets.

Multivariate analysis of the more detailed quantitative data suggested that the environmental variables already considered by the Common Standards Monitoring assessment remain the key factors although a significant amount of vegetation variation was unexplained by any of the environmental measurements. Therefore, this suggests that the Common Standards Monitoring is looking at the right factors.

The following improvements to the validation network project where it applies to ditches are suggested for future rounds of monitoring: initiate consistency training for field surveyors in applying the Common Standards Monitoring to ditches; amend Common Standards Monitoring proformas to be more consistent with targets, and to include more species recording space; ensure all field surveyors have appropriate equipment and botanical skills.

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1 Introduction

1.1 In January 2006, Penny Anderson Associates Ltd (PAA) was commissioned by English Nature to undertake a project to analyse and report on data collected as part of the Common Standard Monitoring Validation Network Project, in relation to lowland freshwater ditch systems at 4 different Sites of Special Scientific Interest (SSSI) in England, where the ditch systems are notified habitat features.

1.2 Ditches are artificial channels, many of which are centuries old and were originally excavated in ancient marshes and fens. They have also been used for transport, as 'wet fences' and more recently as irrigation reservoirs. Ditches are typically straight and uniform channels ranging in dimension from less than a metre wide and deep to over 10m wide and several metres deep. Ditches are stagnant or slow flowing and need to be kept open by frequent management such as cutting of aquatic and bankside vegetation and silt removal.

1.3 These varying physical conditions support a range of in-channel vegetation types, many of which are included in the National Vegetation Classification aquatic and swamp communities (Rodwell 1995). Many of these vegetation communities are now rare in the UK and are confined to ditch systems. These vegetation communities can also support rare species which are confined, or almost confined, to ditches such as some *Potamogeton* species and *Charophytes*.

1.4 The SSSIs from which ditches were selected for this validation study were King's Sedgemoor and Nailsea Moor in the Somerset Levels (which were looked at together), Pevensey Levels in East Sussex and Berney Marshes in the Norfolk Broadlands.

Background

1.5 In 1998, the statutory nature conservation agencies, including English Nature, presented a framework for monitoring on designated sites. The outline framework is published as A Statement on Common Standards in Monitoring (Joint Nature Conservation Committee 1998). The sites covered by this framework are Special Protection Areas (SPAs), candidate Special Areas of Conservation (cSACs), Ramsar Sites, Sites of Special Scientific Interest (SSSIs) and Areas of Special Scientific Interest (ASSIs).

1.6 The aim for each site is to maintain it in favourable condition, and condition assessment is based on meeting a set of targets for each attribute contributing to the interest feature in the SSSI. These attributes and targets (as well as the methods for monitoring them) are outlined in the Joint Nature Conservation Committee (1998) report and in the guidance on Common Standards Monitoring (Joint Nature Conservation Committee 2004). Monitoring across a range of sites with similar habitats allows some determination of the condition of the resource as a whole, feeding into national and regional targets such as the UK Biodiversity Action Plan.

1.7 The monitoring of key features allows each site to be categorised as *favourable maintained, favourable recovered, favourable recovering, unfavourable no change, unfavourable declining, partially destroyed* or *destroyed*.

1.8 The results of regular monitoring enable management practices on site to be appraised and changed where needed. Monitoring across a range of sites with similar habitats also allows some determination of the condition of the habitat resource as a whole, feeding into regional and national targets, including those identified within the UK Biodiversity Action Plan (UK Biodiversity Steering Group 1995).

1.9 The Validation Network Project also allows an evaluation of the effectiveness of the monitoring system, the comparability of the data collected and improvements upon monitoring methods to be enacted.

Overall aims

1.10 The overall aims of the Validation Network project are to ensure that data on the condition of individual features on SSSIs are accurate, consistent and scientifically robust. This has been achieved through undertaking parallel quantitative monitoring on selected SSSI ditch features at a number of sites in different parts of England. This project operates in concert with similar monitoring for other habitats across the SSSI network.

1.11 The specific aims of this lowland freshwater ditch data analysis project are as follows:

- To validate the condition assessment methodology in England through testing the suitability of attributes and associated targets in assessing quality and trends in condition.
- To establish a set of control sites to ensure that individual site assessments match regional or national changes in feature conditions over time.
- To contribute to a wider network of monitoring sites that will allow a better understanding of the drivers of change.

Report structure

1.12 This report presents the results and conclusions of the analyses of data collected for lowland freshwater ditch monitoring sites within England. The report briefly outlines the methods used to collect and analyse data, presents the analysis results in detail and discusses these results in relation to aims of the Validation Network project (as stated above).

1.13 Throughout the report, nomenclature follows Stace (1997) for all higher plants and Watson (1981) for bryophytes.

2 Methodology

Background

2.1 The methods used for habitat monitoring have been derived by English Nature from a combination of traditional quantitative methodologies, results from pilot studies and additional specialist advice. The basic strategy involves comparing sets of quantitative data on attributes from ditches which were also individually assessed as either favourable or unfavourable according to English Nature's condition monitoring criteria under Common Standards (JNCC 2004, 2005).

2.2 This study relied upon the following data collected in 2005:

- Qualitative data - Common Standards Monitoring field assessment forms completed for selected ditches by English Nature Conservation Officers during 2005.
- Quantitative botanical and environmental data collected on the same ditches (mostly), also in 2005 (Stewart 2005, in Appendix 1).

Selection of sample ditches

2.3 Ditches were pre-selected at a number of SSSI locations:

- King's Sedgemoor and Nailsea Moor in the Somerset Levels.
- Pevensey Levels in Kent.
- Berney Marshes in the Halvergate Marshes SSSI in the Norfolk/Suffolk Broadlands.

2.4 Ditches were assumed to be representative of 'favourable' and 'unfavourable' condition according to their habitat and water quality. Samples had been chosen according to the knowledge of local English Nature officers and RSPB staff, with the aim of including a range of ditch types as well as some geographic spread.

Somerset Levels

2.5 Data collected within the Somerset Levels came from 2 SSSIs, King's Sedgemoor and Nailsea Moor.

King's Sedgemoor

2.6 King's Sedgemoor is part of the extensive grazing marsh and ditch systems of the Somerset Levels and Moors. The site is at the centre of the larger Altcar series peat basin of King's Sedgemoor; lying between the Sowey River to the west, Cradle Bridge to the east and extending to the south over Beer Wall into part of Aller Moor.

2.7 The King's Sedgemoor Drain is the main drainage channel for a wide area and has a eutrophic deep-water flora typified by yellow water-lily *Nuphar lutea*. Larger 'rhynes' are generally maintained on an annual cycle, giving a flora dominated by rigid hornwort *Ceratophyllum demersum*; whereas many of the smaller field ditches are less frequently cleaned and are dominated by dense stands of reed sweet-grass *Glyceria maxima* and sea club-rush *Scirpus maritimus*. More regularly maintained field ditches may support a diverse flora, including frogbit *Hydrocharis morsus-ranae*, least duckweed *Wolffia arrhiza*, greater duckweed *Lemna polyrrhiza*, greater bladderwort *Ultricularia vulgaris*, stoneworts *Chara* spp. and occasionally flowering rush *Butomus umbellatus*. Ditch banks are often also herb-rich.

2.8 Two areas of King's Sedgemoor were included in this study, termed King's Sedgemoor East and King's Sedgemoor West. Maps showing the areas sampled are given at the end of Appendix 1 to this report.

Nailsea Moor

2.9 Tickenham, Nailsea and Kenn Moors form part of the Avon Levels and Moors, an extensive area of low-lying agricultural land situated to the north of the Mendip Hills. The soils of the area vary considerably. In the west, clays of the Allerton and Wentloog Series occur, whereas to the east, peat soils of the Sedgemoor and Godney Series predominate. The peat soils, however, are very shallow and in some areas have become mixed with underlying clays largely as a consequence of past cultivation. The Moors are drained by a network of large rhynes and smaller field ditches. These act as 'wet fences' and are important for watering the livestock, largely cattle, which graze the area during the summer months.

2.10 Many of the Internal Drainage Board maintained and regularly managed field ditches support exceptionally rich plant communities. Open water species include common and thread-leaved water-crowfoot *Ranunculus aquatilis* and *R. trichophyllus*, frogbit *Hydrocharis morsus-ranae*, horned pondweed *Zannichellia palustris*, unbranched bur-reed *Sparganium emersum* and small pondweed *Potamogeton berchtoldii*. Locally uncommon species include water-violet *Hottonia palustris*, greater bladderwort *Utricularia vulgaris* and the liverwort *Riccia fluitans*. The nationally scarce hairlike and fen pondweeds *Potamogeton trichoides* and *P. coloratus* and whorled water-milfoil *Myriophyllum verticillatum* also occur. Many emergent species are also present and some of the less frequently dredged field ditches are dominated by single-species emergent stands of reed sweet-grass *Glyceria maxima* and common reed *Phragmites australis*.

2.11 A map showing the area sampled is given at the end of Appendix 1 to this report.

Pevensey Levels

2.12 Pevensey Levels is a large area of low-lying grazing meadows intersected by a complex system of ditches which show a wide variety of form and species composition and support important communities of wetland flora and fauna. The site supports 1 nationally rare and several nationally scarce aquatic plants and many nationally rare invertebrates. Ornithologically, the site is of national importance for the number of wintering lapwings.

2.13 The ditch system facilitates removal of surface water to enable successful stock grazing, at the same time acting as a network of 'wet fences' and as a source of stock drinking water. Maintenance of the ditches is necessary to continue efficient execution of these functions and also creates a wide variety of ditch types from intensively or recently dredged ditches to neglected ones. In this way, a wide variety of floral conditions prevail and the specific requirements of certain invertebrates are always catered for. Following the dredging of a clogged ditch, a distinct successional pattern occurs: floating and submerged aquatic plants such as duckweeds *Lemna* sp, pondweeds *Potamogeton* sp or water fern *Azolla* sp colonise; next, floating or emergent plants take over, for example, frog-bit *Hydrocharis morsus-ranae*, bur-reed *Sparganium erectum* and arrow-head *Sagittaria sagittifolia*; finally, common reed *Phragmites australis* becomes dominant at the expense of most other species. Left unmanaged, ditches rapidly terrestrialise, with loss of plant and animal diversity.

2.14 The most species-rich ditches show a varied structure and a good mixture of both open water and emergent species including the nationally rare sharp-leaved pondweed *Potamogeton acutifolius*, the nationally scarce greater water-parsnip *Sium latifolium* and river water-dropwort *Oenanthe fluviatilis*.

2.15 A map showing the areas sampled is presented at the end of Appendix 1 to this report.

Berney Marshes

2.16 Halvergate Marshes (of which Berney Marshes are part) form Broadland's largest expanse of traditionally managed grazing marshes and intersecting network of drainage ditches. The soils are peaty along the upland margin, grading into clay alluvial soils toward the Breydon Estuary. A well-developed band of woodland occurs along the upland marsh margin and small areas of unimproved pasture, wet fen meadow, reedbed and alder carr add to the diversity of the habitat.

2.17 The ditches are of outstanding importance for nature conservation and show a transition from fresh to brackish conditions. They support the wide range of aquatic ditch community types for which Broadland is notable. These include acid and base-rich mesotrophic communities, meso-eutrophic communities, freshwater eutrophic types and truly brackish communities. The wide range of water conditions support an outstanding assemblage of plants and a rich invertebrate fauna. The freshwater ditches rich in pondweeds are recognised in the Broadland context as being of international importance. The freshwater ditch communities occur along the upland marsh margin in association with a flow of relatively nutrient-poor spring water.

2.18 Many of the ditches along the peaty margin contain a community typified by broad-leaved pondweed *Potamogeton natans*, water violet *Hottonia palustris* and the nationally scarce whorled water milfoil *Myriophyllum verticillatum*. Away from the margins, on the clay soils, the ditches tend to be dominated by the nationally scarce water soldier *Stratiotes aloides*. The freshwater ditches also support the nationally scarce fen pondweed *Potamogeton coloratus*, hairlike pondweed *Potamogeton trichoides* and greater water parsnip *Sium latifolium* and the regionally important lesser water plantain *Baldellia ranunculoides*, river water-dropwort *Oenanthe fluviatilis*, flat-stalked pondweed *Potamogeton friesii*, blunt-leaved pondweed *Potamogeton obtusifolius*, greater spearwort *Ranunculus lingua*, floating club-rush *Scirpus fluitans* and least bur-reed *Sparganium natans*.

2.19 The area close to the Breydon estuary possesses the best brackish ditch communities anywhere in Broadland. These support the regionally important soft hornwort *Ceratophyllum submersum* and brackish water crowfoot *Ranunculus baudotii*. The brackish ditch edges support the nationally scarce stiff saltmarsh grass *Puccinellia rupestris* and the regionally important marsh dock *Rumex palustris*.

2.20 A map showing the areas sampled is given at the end of Appendix 1 to this report.

Data collection

Qualitative (CSM) method

2.21 The CSM data collection method is based upon completing a standard procedure composed of a 'structured walk' and 'fixed point sampling'. Monitoring should be carried out between mid-June and late August, either before cutting takes place, or a few weeks after. Standard forms are provided in the guidance document (Appendices 4 & 5 in JNCC 2004).

2.22 The structured walk records onto a standard form, the extent of feature, water availability, water quality (clarity & algae), habitat structure (channel form, in-channel vegetation, bankside cover), negative trends (introduced plants), local distinctiveness (rare species presence and salinity). A fixed route is walked through the site recording these characteristics.

2.23 Fixed point sampling looks at a particular 20m section (the same as used for quantitative sampling), and records onto a standard form aquatic vegetation composition (to quantify species richness) and plants present indicating a salinity gradient (an aspect of local distinctiveness). Water depth, clarity, algal cover, conductivity, habitat structure and non-native plant abundance are also recorded as background information.

2.24 Each ditch that is monitored under CSM has been assigned a unique identifier based upon the site's initials and the ditch number, for example, NM2 at Nailsea Moor, BM1 at Berney Marshes. These are used throughout this study to identify individual ditches.

2.25 In the 2005 study period, monitoring was assigned to local area Conservation Officers, rather than being carried out by a dedicated national team as has happened previously with other habitat-type condition assessments.

Quantitative survey method

2.26 For the quantitative data collection, 20 ditches were sampled in each of the selected areas: the Somerset Levels (King's Sedgemoor, Nailsea Moors); Pevensey Levels in East Sussex; and Berney Marshes in the Norfolk/Suffolk Broadlands. Surveys targeted the same ditches as surveyed for the qualitative assessment (and some additional ditches). The survey work was undertaken between June and September 2005, by a freelance botanist, contracted to undertake the quantitative sampling across all the sites.

2.27 Twenty metre lengths were sampled at each ditch, corresponding to where condition was to be assessed independently. At each ditch sample location, the presence of all aquatic vascular plant species plus bryophytes was recorded. Sampling continued until no more new species were recorded.

2.28 Within the 20 m section, 10 sub-sample points were used at 2m intervals. At each sub-sample point, the following data were recorded:

- Biomass % of each submerged and floating macrophyte species based upon a grapnel trawl.
- Estimated % cover and DAFOR[1] rating of submerged and floating macrophytes and of macro-algae.
- Estimated % cover of each floating species in a 50cm wide strip across the ditch with floating duckweeds recorded collectively.
- Estimated % cover of each emergent species growing in the water in a c.50cm strip across the ditch.

2.29 An overall % cover and DAFOR rating for each submerged and floating macrophyte species was estimated for the whole 20m section.

2.30 In all cases, % were estimated to the nearest 10% or sometimes 5% except where the cover was very low (0-5%) or very high (95-100%). When estimating aquatic macrophyte biomass, the lesser components were usually assessed first and the dominant species adjusted up or down to ensure a total of 100%.

2.31 For the whole 20 m ditch section, additional variables (termed 'environmental' variables) were recorded. There was also an assessment of some features on a whole ditch basis such as bankside vegetation (degree of shading) and ditch profile. The following data were collected:

- GPS start and end point.
- Water clarity – Secchi depth (cm), turbidity (5-point scale).
- Water peatiness (5-point scale).
- Electrical Conductivity (microS/cm).
- Ditch width (m).

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[1] A relative abundance scale where D=dominant (71-100%), A=abundant (31-70%), F=frequent (11-30%), O=occasional (4-10%), R=rare (<3%)

- Ditch profile – water depth (cm) recorded at 50cm intervals from the water's edge to the midpoint or edge of reach, whichever was further.
- Successional stage - % of 20m length in each of early, mid and late categories, and the same for the ditch as a whole.
- Bankside % cover by vegetation – % covered by ground, shrub and tree-layer vegetation.
- Shading % cover – % of ditch overhung by ground layer and shrub/tree layer vegetation.

2.32 The detailed methods used are presented in Appendix 1, together with standard recording forms for environmental and botanical data. The Appendix 1 report (Stewart 2005) also discusses the methods and equipment used in more detail, as well as describing the effectiveness of the methodology in the field and any particular problems encountered.

Available data

2.33 The data available to this habitat validation monitoring project are summarised in Table 1, listing both qualitative and quantitative datasets. Table 2 lists all the ditches for which data, either qualitative or quantitative, was received. Unit 88 was surveyed for CSM monitoring but not included in the ditches receiving quantitative surveys in 2005, so has been excluded from further analyses.

2.34 The raw data is available as Microsoft Excel spreadsheets.

Table 1 Summary of the ditch sites included within the validation network

Site Name	Summary Ditch Description	National Grid Reference	Site Initials	No. ditches Qualitatively sampled	No. ditches Quantitatively sampled
Somerset Levels: King's Sedgemoor SSSI	Freshwater ditches within grazing marsh	ST 400 330	KSE	10	6
			KSW	10	6
Somerset Levels: Nailsea Moor (*part of* Tickenham, Nailsea and Kenn Moors SSSI)	Freshwater ditches within Avon Levels and Moors grazing marsh area	ST 440 700	NM	10	8
Pevensey Levels: Pevensey Levels SSSI	Freshwater ditches within grazing meadows	TQ 650 070	PL	2	20
Norfolk Broads: Berney Marshes (*part of* Halvergate Marshes SSSI)	Freshwater to brackish ditches within large area of grazing marsh	TG 450 050	BM	6	20
Totals				**38**	**60**

Table 2a Summary of the ditches included within the Lowland Freshwater Ditches Validation Network Project, a) Somerset Levels: (King's Sedgemoor East, West and Nailsea Moor)

SSSI Unit No. (& overall unit condition)	Ditch No.	Qualitative Survey?	Quantitative Survey?
99 (Favourable recovering)	**KSE1**	**Y**	**Y**
	KSE2	Y	N
	KSE3	**Y**	**Y**
	KSE4	Y	N
	KSE5	**Y**	**Y**
	KSE6	**Y**	**Y**
	KSE7	**Y**	**Y**
	KSE8	**Y**	**Y**
	KSE9	Y	N
	KSE10	Y	N
87 (Unfavourable no change)	**KSW1**	**Y**	**Y**
	KSW2	**Y**	**Y**
	KSW3	**Y**	**Y**
	KSW4	Y	N
	KSW5	**Y**	**Y**
	KSW6	Y	N
	KSW7	Y	N
	KSW8	**Y**	**Y**
	KSW9	**Y**	**Y**
	KSW10	Y	N
88 (Unfavourable no change)	1	Y	N
	2	Y	N
	3	Y	N
	4	Y	N
	5	Y	N

Table continued…

SSSI Unit No. (& overall unit condition)	Ditch No.	Qualitative Survey?	Quantitative Survey?
18 (Unfavourable no change[2])	NM1	Y	N
	NM2	**Y**	**Y**
	NM3	**Y**	**Y**
	NM4	**Y**	**Y**
	NM5	**Y**	**Y**
	NM6	**Y**	**Y**
	NM7	**Y**	**Y**
	NM8	Y	N
	NM9	**Y**	**Y**
	NM10	**Y**	**Y**

Table 2b Summary of the ditches included within the Lowland Freshwater Ditches Validation Network Project, b) Pevensey Levels

SSSI Unit No. (& unit condition)	Ditch No.	Qualitative Survey?	Quantitative Survey?
169 (Unfavourable recovering)	PL1	N	Y
172 (Favourable)	PL2	N	Y
169 (Unfavourable recovering)	PL3	N	Y
	PL4	N	Y
110 (Favourable)	**PL5**	**Y**	**Y**
	PL6	**Y**	**Y**
	PL7	N	Y
	PL8	N	Y
	PL9	N	Y
	PL10	N	Y
35 (Unfavourable recovering)	PL11	N	Y
	PL12	N	Y

Table continued...

[2] At NM, the ‘unfavourable – no change’ assessment is not a reflection of the quality of the collection of ditches but reflects the polluted water that inundates them at times. Only when the source of the water is eradicated can the units become ‘favourable’

SSSI Unit No. (& unit condition)	Ditch No.	Qualitative Survey?	Quantitative Survey?
74 (Unfavourable recovering)	PL13	N	Y
	PL14	N	Y
	PL15	N	Y
	PL16	N	Y
93 (Unfavourable recovering)	PL17	N	Y
	PL18	N	Y
96 (Unfavourable recovering)	PL19	N	Y
	PL20	N	Y

Table 2c Summary of the ditches included within the Lowland Freshwater Ditches Validation Network Project, c) Norfolk Broads: Berney Marshes (*part of* Halvergate Marshes SSSI), Norfolk

SSSI Unit No. (& unit condition)	Ditch No.	Qualitative Survey?	Quantitative Survey?
42 (Favourable)	BM1	**Y**	**Y**
	BM2	**Y**	**Y**
	BM3	**Y**	**Y**
	BM4	**Y**	**Y**
	BM5	**Y**	**Y**
	BM6	**Y**	**Y**
	BM7	N	Y
	BM8	N	Y
	BM9	N	Y
	BM10	N	Y
	BM11	N	Y
	BM12	N	Y
	BM13	N	Y
	BM14	N	Y
	BM15	N	Y
	BM16	N	Y
	BM17	N	Y
Outside SSSI	BM18	N	Y
	BM19	N	Y
	BM20	N	Y

Qualitative data

2.35 The qualitative (CSM) dataset was received as raw photocopied field sheets from the local area Conservation Officers who conducted the surveys, and required input to spreadsheets prior to analysis. In most cases a 'pass' or 'fail' had not been assigned for ditch attributes by the field surveyor, or for ditches as a whole. The surveys were carried out following the CSM Guidance issued by JNCC in February 2004. The most recent version of the guidance was issued in March 2005 (JNCC 2005) but was not used for this study. A summary of the survey data received for each site is presented below.

2.36 Ten ditches at King's Sedgemoor western section (KSW) were surveyed on 6th July 2005, well within the CSM guidance survey window. Both proformas for monitoring and assessing the structured walk and 20m sampling sites were used. Extent was partly recorded on the structured walk proforma; water depth was correctly recorded; water clarity was recorded with a comment on colour, while CSM asks for % in each of three categories; macro-algae was recorded by DAFOR[3]; conductivity was not recorded; channel form was recorded with a tick marking the appropriate trapezoidal or non-trapezoidal category; successional stage was correctly recorded as 'early', 'mid' or 'late'; shade was correctly recorded. Non-native species were recorded in the correct location on the proforma. The field proforma was not long enough for all the native species recorded, requiring further clarification from the CO who conducted the survey.

2.37 Ten ditches at Nailsea Moor (NM) were surveyed on 18th May 2005, slightly early compared with guidance dates of mid-June to late August. However, the list of botanical species was long and provided both genus and species names, indicating that vegetation was sufficiently advanced to be readily identifiable to a practised botanist. The proforma for monitoring and assessing 20m sampling sites was used. Extent was not recorded per se; water depth was correctly recorded; water clarity was correctly recorded; macro-algae was recorded mostly by % cover (correct method) or by DAFOR; conductivity was not recorded; channel form was correctly recorded; successional stage was correctly recorded; shade was correctly recorded. Non-native species were recorded in the correct location on the proforma. The field proforma was not long enough for all the native species recorded.

2.38 Only two ditches at Pevensey Levels (PL) were surveyed on 29th September 2005, late compared with guidance dates of mid-June to late August. This may be reflected in the short species lists that were collected, because many species would have died back underwater by this time of year. Several samples were collected along each ditch (results combined for this study). The recording form for 20m sampling sites was used. Water availability was correctly recorded; water clarity was correctly recorded by a tick in the appropriate category; macro-algae was not recorded so assumed absent; conductivity was 'not recorded'; channel form was correctly recorded with a tick in the appropriate category; successional stage was recorded as a tick for 'early', 'mid' or 'late'; shade was recorded by a tick for the category. Non-native species were 'not recorded' – assumed not present; native species were recorded (only 5), but the surveyor assigned 'favourable' status to ditch PL5 for this attribute. No condition was assigned to PL6, although only two species were recorded and comments suggest that the ditch is in late succession and urgently requires cleaning out.

2.39 Six ditches at Berney Marshes (BM) were surveyed on 11th November 2005, well outside the optimal survey window of mid-June to late August (JNCC 2004). The recording form for the structured walk was used, not that for 20m sampling sites, as at the other sites. Extent was correctly recorded; water depth was not recorded, simply a tick to indicate the target had been met; water clarity was correctly recorded by % in each of three categories; macro-algae was correctly recorded by % cover; conductivity was correctly recorded; channel form was correctly recorded; successional stage was correctly recorded as 'early', 'mid' or 'late'; shade was correctly recorded. Non-native species were correctly noted in the proforma; indicator species of local

[3] Where DAFOR categories have been recorded, they can be translated to value ranges (D= 71-100%, A= 31-70%, F= 11-30%, O= 4-10, R= <3%), but this does not provide accuracy to nearest 5% as in the guidance (JNCC 2004)

distinctiveness were recorded, but no overall species list was prepared as at the other sites, and many species would not be visible in November.

2.40 Overall, there was some variability in the dates and proformas used to conduct the CSM surveys. Attributes and methods for recording them vary between the 'structured walk' and the '20m sampling sections' resulting in non-comparable data. The survey recording forms do not contain enough space for detailed species recording where vegetation is diverse. There is discrepancy between what the proformas ask for in terms of each attributed and how the target is assessed. For example, in some cases, the form asks for ticks, and the targets require %cover information.

Quantitative data

2.41 Quantitative data was received in digital format, but this was set out as individual proformas and therefore not compatible with the proposed statistical analyses and required re-entry. The data was accompanied by a short report detailing the field methods used, the definitions and the problem areas (Stewart 2005). This is presented in Appendix 1.

2.42 Survey work was undertaken between June and September 2005, extending beyond the recommended survey period of mid-June to late August (JNCC 2004).

2.43 The environmental variables recorded were summarised as shown in Table 3 for use in the statistical analysis.

2.44 Turbidity scale and peatiness were recorded in categories so were not measured data. The categories were defined (as in Appendix I) but these definitions were considered to be qualitative rather than quantitative, for example, peatiness categories were defined as 'gin', 'lemon juice', 'white wine', 'tea' and 'black coffee'. Thus, they were not used in the analysis of environmental variables. The Secchi depth measurement was considered a more robust representation of the euphotic zone although it does not reflect peaty influences. There may be better ways to measure peat staining in water, such as pH (acidity/alkalinity) or hazen (mg/l of Pt/Co).

2.45 Two ditch profile models were included to see which better represented this variable in the analysis – this could be selected/improved upon for future studies. These models are explained in more detail in Appendix 2. The models represent an initial attempt to quantify the relationship between measured depths and habitat quality.

2.46 Successional stage was related to the vegetation recorded in each ditch so not an independent environmental variable.

Table 3 How quantitative environmental data was summarised for use in the condition assessments and statistical analyses

Feature (label)	Field survey measure	Measure used for analysis	Comment
Secchi depth (Secc)	Measured in cm	Secchi depth/ maximum depth*100	% of water column with light penetration
Turbidity Scale	Scale of 1-5	Not used	Not used, because this should be reflected in the Secchi depth
Peatiness	Scale of 1-5	Not used	Not used because this is not a measurement
Conductivity (Cond)	Micro S/cm	Micro S/cm	
Ditch width (Width)	Width in metres	Width in metres	
Ditch depth (Mdep)	Depth (cm) at 50cm intervals	Mean depth (cm)	
Ditch profile model (Prof3)	Depth (cm) at 50cm intervals	Ditch Profile Model 3 (Appendix 2)	Model 3 gave a value for deviation from a standard v-shaped ditch
Ditch profile model (Prof4)	Depth (cm) at 50cm intervals	Ditch Profile Model 4 (Appendix 2)	Model 4 gave a ratio which was for steep-sided ditches and lower for more sloping ones
Successional stage	a) % of ditch section in Early, Mid and Late stages b) % of whole ditch in each stage	Dominant stage assigned to each ditch sample	Used for condition assessment only
Bankside vegetation (Grou, Shru, Tree)	% cover of ground, shrub and tree layers	% cover	
Shading (Shad) (Over)	a) % of ditch overhung by ground layer vegetation b) % shaded by shrubs and trees	% shaded % shaded	
Algae (Alga)	% cover of macro-algae	Overall % cover of macro-algae	

Table 4 Condition assessment criteria for qualitatively-sampled 20 m ditch sections, on a ditch-by-ditch basis, following guidance in JNCC 2004

Attribute	Target (after Table 1, JNCC 2004)	Criteria for 'Pass'	Criteria for 'Fail'	Comments on Robustness of Assessment
Extent of ditch feature	No reduction in channel length	no loss	some loss	Easy to decide based upon information provided
Habitat functioning: water availability	Characteristic water levels to be maintained. Generally in wet ditches summer water depth at least 0.5m in minor ditches and 1m in major drains. 90% of channel length should reach this target.	more than 50cm	less than 50cm	Generally easy to decide based upon information provided
Habitat functioning: water quality - clarity	Water clear or only slightly turbid/discoloured in at least 90% of channel length	clear or slight/limited turbidity/colour	marked/extensive turbidity/colour	Easy to decide based upon information provided
Habitat functioning: water quality - algae	Mean cover of filamentous macro-algae and *Enteromorpha* not more than 10% (mid June to end August)	<10% cover, that is, O or R in DAFOR scale	>10% cover, that is, F, A or D in DAFOR scale	Easy to decide based upon information provided
*Habitat functioning: water quality - chemistry	Optional criteria	Not used	Not used	
Habitat structure: channel form	A range of variation in ditch profiles. If ditches are the only wetland feature, no more than 75% of ditch length with a trapezoidal cross-section. (This target may be adjusted according to the characteristics of the site).	Trapezoidal section, ie managed profile with vertical or sloping sides	Non-trapezoidal section, for example, where banks are stock-trampled, ditch is silted but still wet, or contains berms	Surveyors ticked 1 of the 2 categories offered so not possible to work out %. Also, whole 20m section likely to received same management. Thus assigning pass or fail is based upon limited information. Surveyors interpreted criteria differently, and where trapezoidal ditches have been described as 'good' it is assumed that they pass the assessment.

Table continued…

Attribute	Target (after Table 1, JNCC 2004)	Criteria for 'Pass'	Criteria for 'Fail'	Comments on Robustness of Assessment
Habitat structure: successional stage	Mix of early, mid and late succession ditches: 10-25% early, 35-75% mid, 10-25% late	Mid or late successional stage	Early successional stage	Pass or fail criteria set because the guidance also suggests that 20m survey sections should only fall into mid or late succession stage ditches. Easy to decide, but may be arbitrary as all ditches need to go through the early phase to reach later ones, so stage may not reflect condition at all.
Habitat structure: extent of shading	Where aquatic vegetation is a key feature of the site, no more than 10% of the channel length should be heavily shaded.	none or <10% in heavy shade	>10% in heavy shade	Easy to decide based upon information provided
Aquatic vegetation composition: native species richness	Native aquatic flora of ditches species=rich: freshwater ditches - mean at least 7 species per 20m; brackish ditches - mean at least 5.	≥7 (freshwater) or ≥5 (brackish) species from Appendix 2.	<7 (freshwater) or <5 (brackish) species from Appendix 2.	Easy to decide based upon information provided, but in some cases this was the only feature which failed and in others very few species were actually recorded.
Indicators of negative change: non-native plants	Mean cover of each very aggressive non-native plant not exceeding 1%. Mean total combined cover of all non-native species and introduced species less than 30%.	Meets target	Fails target	Easy to decide based upon information provided
*Local distinctiveness: rare species/quality indicators	Optional criteria	Not used	Not used	
*Local distinctiveness: salinity gradient	Optional criteria	Not used	Not used	

Condition assessments

2.47 The condition assessments for both qualitative and quantitative data adhered rigidly to the interpretations of the guidance detailed below, even where Conservation Officers had assigned a pass or fail to a ditch or attribute in the field. This is because not all attributes or ditches had had condition assigned so the methods used to assign this for this study needed to be consistent.

Condition assessments for individual ditches (Qualitative)

2.48 The data described above was compared with the JNCC guidance (2004) on a ditch by ditch basis to ascertain whether each attribute passed or failed. Because the guidance on conservation objectives for ditches was devised for assessing a number of different ditches forming an SSSI feature, the targets and methods of assessment have had to be adapted slightly to allow individual ditches to be 'passed' or 'failed'. For the most part, 'pass' or 'fail' for each attribute had not been assigned by the surveyors in the field. This needed to be completed in a consistent way as part of this analysis. Therefore, the rules used to make the decisions as part of this study are detailed in Table 4. Because not many passes were achieved (that is, favourable condition), samples were given ranks based upon the number of attributes that passed. Nine attributes were used to assign condition.

2.49 There were some inconsistencies in the data collection, as is often the case when different individuals collect data of a range of different sites. Parts of forms had not been filled in or the same information was provided on different forms, as different data or even the methods varied in small ways. Some assumptions had to be made to allow analysis. These are as follows:

- Where 'DAFOR' categories have been interpreted into %cover, the minimum value has been used.
- At KSE, channel form was noted as 'vg', 'good' and 'excel' in the trapezoidal row – it was assumed that this constituted a pass.
- At KSW, field survey forms were hard to read and the CO supplied an accompanying table with the species list, on request.
- At NM, both structured walk and 20m sampling forms were completed for each ditch. Only 20m sampling data was used. When interpreting the field data, the following assumptions were made: % cover for macro-algae were assigned a 'DAFOR', where successional stage was given as '100% mid-late' this was categorised as 'mid'.
- At PL, several samples were taken for each ditch. These were averaged to provide a single set of figures for analysis. Macro-algae were assumed not present. Indicators of negative trends: non-native/introduced plants were 'not recorded'- assumed not present.
- At BM, the structured walk proforma was used only. No ditches were marked as lost, but actual depths were not noted. Although all depth targets were achieved according to the surveyor, the lack of data constitutes a 'fail' in the context of this assessment. DAFOR categories were assigned to macro-algae from the % covers noted. Species lists were compiled from the indicators of local distinctiveness rare/quality species listed. These ditches were noted as species-poor brackish water.

Condition assessments for individual ditches (quantitative)

2.50 Condition assessments for the quantitative data also required an adaptation of the JNCC (2004) guidance in order to allow the assessment of individual ditch attributes. The criteria devised are set out and explained in Table 5. Generally, it was fairly straight-forward to assign a 'pass' or 'fail' to the data, although channel form and successional stage proved more difficult due to the way data was collected. The criteria were applied to all the quantitative data, with selected ditches being used for qualitative comparisons (see Table 2) and all for the multivariate study. Nine attributes were used for the condition assessment.

Comparing qualitative and quantitative species datasets

2.51 Species lists for qualitative and quantitative samples were compared to examine comparability of data collection methods. Qualitative data was in presence-absence format already, so % cover values from the quantitative data needed to be turned into presence-absence. Species lists were compared and amended so that the 2 datasets could be merged into one. Species data for all sites surveyed using both methods was put through a detrended correspondence analysis (DCA) using the Canoco statistical package (Microcomputer Power) with rare species down-weighted. The samples used were:

- King's Sedgemoor East (KSE): 1, 3, 5, 6, 7, 8.
- King's Sedgemoor West (KSW): 1, 2, 3, 5, 8, 9.
- Nailsea Moor (NM): 2, 3, 4, 5, 6, 7, 9, 10.
- Pevensey Levels (PL): 5, 6.
- Berney Marshes (BM): 1, 2, 3, 4, 5, 6.

2.52 The resulting ordination diagram was used to assess the comparability between species lists collected at all the sites.

Overall ditch condition

2.53 Multivariate statistical examination of ditch condition was confined to the quantitatively collected data. This comprised both species data with %cover values, and environmental data covering a range of variables which were measured in various ways. This part of the study aimed to look at species lists and environmental variables recorded for each sample site (a total of 60 ditches) to see which environmental variables accounted most for differences in botanical species composition.

2.54 All the ditches were individually assigned favourable or unfavourable condition based upon the criteria outlined in Table 5.

2.55 Species data were entered from the data sheets provided by the botanical surveyor, using overall % cover for submerged/floating species, and average % cover for floating and emergent species. Where species were present as submerged, floating and/or emergent species, they were distinguished in the ordination process by the species abbreviations in Table 6 followed by 's' for submerged, 'f' for floating or 'e' for emergent. At Berney Marshes, 2 samples were taken at ditch BM4, termed BM4s and BM4n. These have been included separately using the same environmental data for each sample.

Table 5 Condition assessment criteria for quantitatively-sampled 20m ditch sections, on a ditch-by-ditch basis, following guidance in JNCC 2004

Attribute	Target (after Table 1, JNCC 2004)	Criteria for 'Pass'	Criteria for 'Fail'	Comments on Robustness of Assessment
Extent of ditch feature	No reduction in channel length	no loss	some loss	Easy to decide based upon information provided.
Habitat functioning: water availability	Characteristic water levels to be maintained. Generally in wet ditches summer water depth at least 0.5m in minor ditches and 1m in major drains. 90% of channel length should reach this target.	more than 50cm	less than 50cm	Generally easy to decide based upon information provided.
Habitat functioning: water quality - clarity	Water clear or only slightly turbid/discoloured in at least 90% of channel length	Secchi depth more than 50% of maximum depth	Secchi depth less than 50% of maximum depth	Easy to decide based upon information provided.
Habitat functioning: water quality - algae	Mean cover of filamentous macro-algae and *Enteromorpha* not more than 10% (mid June to end August)	Less than 10% cover	10% cover or more	Easy to decide based upon information provided.
*Habitat functioning: water quality - chemistry	Optional criteria	Not used	Not used	

Table continued…

Attribute	Target (after Table 1, JNCC 2004)	Criteria for 'Pass'	Criteria for 'Fail'	Comments on Robustness of Assessment
Habitat structure: channel form	A range of variation in ditch profiles. If ditches are the only wetland feature, no more than 75% of ditch length with a trapezoidal cross-section. (This target may be adjusted according to the characteristics of the site).	Ditch model value less than 4000 (where lower values mean ditch profile is more sloping)	Ditch model values more than 4000 (that is, ditch profile has more vertical sides)	The equation for a straight line **Y = m*X + c** was used to estimate the gradient (m) and intercept (c) if the ditch has a straight profile from 0.5cm to a later measurement. [Depth at 0.5m and the maximum depth were used]. The depths at each distance from the edge that would be expected if the ditch had a straight line (or 'V') profile can be calculated. Using a chi-squared type approach, the difference between the observed depth and expected depth at each 'X' value (distance from ditch edge) can be calculated. These values are squared and then the squares summed to give a final value reflecting how different the observed profile is from the expected.
Habitat structure: successional stage	Mix of early, mid and late succession ditches: 10-25% early, 35-75% mid, 10-25% late	Ditch Phase Value more than 1.5	Ditch Phase Value less than 1.5	The guidance states that 20m survey sections should only fall into mid or late succession stage ditches. As all ditches need to go through the early phase to reach later ones, stage of a certain 20m section is unlikely to reflect overall ditch condition well. Still, as formula was devised to reflect the stage of the ditch: **Ditch Phase Value = [(%early)+(%mid)*2+(%late)*3] /100** which gives an integer of 1 for early, 2 for mid and 3 for late succession.
Habitat structure: extent of shading	Where aquatic vegetation is a key feature of the site, no more than 10% of the channel length should be heavily shaded.	Less than 10% in heavy shade	>10% in heavy shade	Easy to decide based upon information provided.

Table continued…

Attribute	Target (after Table 1, JNCC 2004)	Criteria for 'Pass'	Criteria for 'Fail'	Comments on Robustness of Assessment
Aquatic vegetation composition: native species richness	Native aquatic flora of ditches species rich: freshwater ditches - mean at least 7 species per 20m; brackish ditches - mean at least 5.	≥7 (freshwater) or ≥5 (brackish) species from Appendix 2.	<7 (freshwater) or <5 (brackish) species from Appendix 2.	Easy to decide based upon information provided.
Indicators of negative change: non-native plants	Mean cover of each very aggressive non-native plant not exceeding 1%. Mean total combined cover of all non-native species and introduced species less than 30%.	Meets target	Fails target	Easy to decide based upon information provided.
*Local distinctiveness: rare species/quality indicators	Optional criteria	Not used	Not used	
*Local distinctiveness: salinity gradient	Optional criteria	Not used	Not used	

Table 6 Species list for samples in quantitative analysis

Code	Scientific Name	Common Name
Ali lan	*Alisma lanceolatum*	Narrow-leaved water-plantain*
Ali pla	*Alisma plantago-aquatica*	Water plantain*
Alo gen	*Alopecurus geniculatus*	Marsh foxtail
Agr sto	*Agrostis stolonifera*	Creeping bent
Ang syl	*Angelica sylvestris*	Wild angelica
Api nod	*Apium nodiflorum*	Fool's water-cress*
Azol sp	*Azolla sp*	Water fern species#
Ber ere	*Berula erecta*	Narrow-leaved water-parsnip*
Bid cer	*Bidens cernua*	Nodding bur-marigold
Bol m e	*Bolboschoenus maritimus emergent*	Sea club-rush*
Bol m s	*Bolboschoenus maritimus submerged*	
Cal bru	*Callitriche brutia*	Pedunculate water-starwort*
Cal cus	*Calliergonella cuspidata*	A moss
Cal pla	*Callitriche platycarpa*	Various-leaved water-starwort*
Cal obt	*Callitriche obtusangula*	Blunt-fruited water starwort*
Cal sep	*Calystegia sepium*	Hedge bindweed
Car otr	*Carex otrubae*	False fox-sedge
Car pse	*Carex pseudocyperus*	Cyperus sedge*
Car rip	*Carex riparia*	Great pond-sedge*
Cer dem	*Ceratophyllum demersum*	Hornwort*
Cer sub	*Ceratophyllum submersum*	Soft hornwort*
Cha glo	*Chara globularis*	Fragile stonewort*
Cha his	*Chara hispida*	Bristly stonewort*
Cha vir	*Chara virgata*	Delicate stonewort*
Cha vul	*Chara vulgaris*	Common stonewort*
Cra h s	*Crassula helmsii submerged*	New Zealand pygmy-weed#
Cra h e	*Crassula helmsii emergent*	
Des ces	*Deschampsia cespitosa*	Tufted hair-grass
Dre adu	*Drepanocladus aduncus*	A moss*
Dre sp.	*Drepanocladus sp*	A moss*
Eleoc pal	*Eleocharis palustris*	Common spike-rush*

Table continued…

Code	Scientific Name	Common Name
Eleoc uni	*Eleocharis cf. uniglumis*	Slender spike-rush*
Elo can	*Elodea canadensis*	Canadian pondweed^
Elo nut	*Elodea nuttallii*	Nuttall's pondweed^
Epi hir	*Epilobium hirsutum*	Great willowherb
Epi par	*Epilobium parviflorum*	Hoary willowherb
Equ arv	*Equisetum arvense*	Field horsetail
Equ flu	*Equisetum fluviatile*	Water horsetail*
Equ pal	*Equisetum palustre*	Marsh horsetail
Fil ulm	*Filipendula ulmaria*	Meadowsweet
Gal pal	*Galium palustre*	Common marsh bedstraw
Gly flu	*Glyceria fluitans*	Flote-grass*
Gly max	*Glyceria maxima*	Reed sweet-grass*
Hip v s	*Hippuris vulgaris* submerged	Mare's tail*
Hip v e	*Hippuris vulgaris* emergent	
Hot p s	*Hottonia palustris* submerged	Water violet*
Hot p f	*Hottonia palustris* floating	
Hyd m s	*Hydrocharis morsus-ranae* submerged	Frogbit*
Hyd m f	*Hydrocharis morsus-ranae* floating	
Hyd r s	*Hydrocotyle ranunculoides* submerged	Floating Pennywort#
Hyd r f	*Hydrocotyle ranunculoides* floating	
Iri pse	*Iris pseudacorus*	Yellow flag*
Jun art	*Juncus articulatus*	Jointed rush
Jun inf	*Juncus inflexus*	Hard rush
Jun eff	*Juncus effusus*	Soft-rush
Jun ger	*Juncus gerardii*	Saltmarsh rush
Jun sub	*Juncus subnodulosus*	Blunt-flowered rush
Lem gib	*Lemna gibba*	Fat duckweed*
Lem mino	*Lemna minor*	Common duckweed*
Lem minu	*Lemna minuta*	Least duckweed^
Lem tri	*Lemna trisulca*	Ivy-leaved duckweed*
Lemnaceae	*Lemnaceae*	Duckweed species

Table continued…

Code	Scientific Name	Common Name
Lyc eur	*Lycopus europaeus*	Gypsywort
Lys num	*Lysimachia nummularia*	Yellow pimpernel
Men aqu	*Mentha aquatica*	Water mint
Myo lax	*Myosotis laxa*	Tufted forget-me-not
Myo sco	*Myosotis scorpioides*	Water forget-me-not*
Myr spi	*Myriophyllum spicatum*	Spiked water milfoil*
Nit muc	*Nitella mucronata*	Pointed stonewort*
Nup l s	*Nuphar lutea* submerged	Yellow water-lily*
Nup l f	*Nuphar lutea* floating	
Oen aqu	*Oenanthe aquatica*	Fine-leaved water dropwort*
Oen cro	*Oenanthe crocata*	Hemlock water dropwort*
Oen fis	*Oenanthe fistulosa*	Tubular water-dropwort*
Per amp	*Persicaria amphibia*	Amphibious bistort*
Per hyd	*Persicaria hydropiper*	Redshank
Pha aru	*Phalaris arundinacea*	Reed canary-grass*
Phr aus	*Phragmites australis*	Common reed*
Pot acu	*Potamogeton acutifolius*	Sharp-leaved pondweed*
Pot cri	*Potamogeton crispus*	Curled pondweed*
Pot luc	*Potamogeton lucens*	Shining pondweed*
Pot n s	*Potamogeton natans* submerged	Broad-leaved pondweed*
Pot n f	*Potamogeton natans* floating	
Pot obt	*Potamogeton obtusifolius*	Blunt-leaved pondweed*
Pot pec	*Potamogeton pectinatus*	Fennel-leaved pondweed*
Pot pus	*Potamogeton pusillus*	Lesser pondweed*
Pot tri	*Potamogeton trichoides*	Hairlike pondweed*
Pul dys	*Pulicaria dysenterica*	Common fleabane
Ran bau	*Ranunculus baudotii*	Brackish water-crowfoot*
Ran cir	*Ranunculus circinatus*	Fan-leaved water-crowfoot*
Ran fla	*Ranunculus flammula*	Lesser spearwort*
Ran rep	*Ranunculus repens*	Creeping buttercup
Ran sce	*Ranunculus sceleratus*	Celery-leaved buttercup
Ran sp	*Ranunculus sp*	Water-crowfoot species*

Table continued…

Code	Scientific Name	Common Name
Ric flu	*Riccia fluitans*	A liverwort*
Ror nas	*Rorippa nasturtium-aquaticum*	Water-cress*
Rum con	*Rumex conglomeratus*	Clustered dock
Rum hyd	*Rumex hydrolapathum*	Great water-dock*
Sag s s	*Sagittaria sagittifolia* submerged	Arrow-head*
Sag s f	*Sagittaria sagittifolia* floating	
Sag s e	*Sagittaria sagittifolia* emergent	
Scu gal	*Scutellaria galericulata*	Skullcap
Sch tab	*Schoenoplectus tabernaemontani*	Common bulrush*
Sol dul	*Solanum dulcamara*	Bittersweet
Spa e s	*Sparganium erectum* submerged	Branched bur-reed*
Spa e e	*Sparganium erectum* emergent	
Spi pol	*Spirodela polyrhiza*	Greater duckweed*
Stac pal	*Stachys palustris*	Marsh woundwort
Str alo	*Stratiotes aloides*	Water-solder*
Str a f	*Stratiotes aloides* floating	
Typ ang	*Typha angustifolia*	Lesser reedmace/lesser bulrush*
Typ lat	*Typha latifolia*	Great reedmace/great bulrush*
Urt dio	*Urtica dioica*	Common nettle
Utr vul	*Utricularia vulgaris*	Greater bladderwort*
Ver lat	*Veronica beccabunga*	Brook-lime*
Wol arr	*Wolffia arrhiza*	Rootless duckweed*
Zan pal	*Zannichellia palustris*	Horned pondweed*

* = in Appendix 1 (JNCC 2004), # = most invasive species in Appendix 2 (JNCC 2004), ^ = non-native species

2.56 The environmental data which was selected for use in the analysis comprised the variables listed in Table 7.

2.57 Environmental and species data was analysed using a Canonical Correspondence Analysis (CCA). Canonical ordination is designed to detect patterns of variation in the species data that are best explained by the observed environmental variables. A joint plot of species points and environmental arrows approximates the weighted averages of the species with respect to each of the environmental variables. If the species point lies between the origin and an arrow head, then the variable has a strong positive correlation to the species position. If the origin is between the species point and the arrow head, then the correlation is negative.

2.58 Data was transformed using Canoco's default log transformation. Rare species were down-weighted.

Table 7 Environmental variables used in multivariate analysis

Environmental Variable Name	Definition	Method of measurement
Secc	Secchi Depth	cm
Cond	Conductivity	microS/cm
Widt	Width	m
Mdep	Mean Depth	cm
Prof2	Profile Model 2	d/w
Prof3	Profile Model 3	Value related to deviation from a standard v-shaped ditch
Prof4	Profile Model 4	Ratio of a:b where a = deviation from an expected v-shaped ditch profile, b = deviation from a u-shaped ditch profile
Grou	Ground layer on bankside	% cover
Shru	Shrub layer on bankside	% cover
Tree	Tree layer on bankside	% cover
Over	Overhung by ground vegetation	% cover
Shad	Shaded by shrubs/trees	% cover
Alga	Marco-algae	% cover

3 Results

Condition assessments

Condition assessments for individual ditches (qualitative)

3.1 The results of the condition assessment are presented in Table 8 for a total of 38 ditches surveyed under the qualitative condition assessment methodology. This table describes each attribute recorded in the qualitative surveys, and assigns a pass or fail based upon the criteria set out in Table 4. Ditches were assigned an overall fail if any of the attributes did not pass the criteria set. There were 9 attributes used in all cases, and most ditches failed the assessment. Because of this, the number of passes was also considered important, with 7 or 8 passes being a good fail (Fail 1), 5 or 6 passes being a mediocre fail (Fail 2) and less than 5 passes constituting a poor fail (Fail 3).

3.2 Where a ditch failed on 1 or 2 attributes, the reason(s) for the fail was noted in the final column of the table, so that patterns in failures could be more easily identified. In the qualitative dataset, a wide range of causes for ditch failures to achieve favourable condition were evident. Too few native species and poor channel form were the most abundant reasons, but Pevensey Levels and Berney Marshes were surveyed too late in the year to get a good array of aquatic species (late September & November respectively), which may have negatively influenced results on otherwise favourable ditches. Channel form is not easily measured and, as Table 4 explains, does not provide a good measure of habitat quality as a range of ditch shapes provide the diverse habitats needed by a site supporting high biological interest for this feature. Equally, successional stage is a poor measure of individual ditch condition as early successional stages are a necessary part of good ditch management at a site. Failures also occurred in water depth, macro-algae and shade targets.

3.3 Table 8 also totals the number of failures for each condition attribute at each site. Obviously, because there were 30 samples taken at KSE, KSW and NM, this will give a more robust indication of the key conditions issues for the site than for PL where only 2 ditches were surveyed and BM where only 6 were surveyed.

3.4 At the Somerset Levels, 2 samples passed on all 9 attributes at King's Sedgemoor East, none passed at King's Sedgemoor West and 4 passed at Nailsea Moors. This amounts to a total of 6 sample sites passing on the criteria set out of a total of 30 ditches sampled during the qualitative analysis. At King's Sedgemoor and Nailsea Moors, water depth, successional stage and native species richness clearly stood out of the qualitative condition assessments as the key overall aspects featuring in failures to achieve favourable condition. These aspects failed in 13, 11 and 10 samples respectively, out of the total of 30 samples. Macro-algae and negative indicator species were responsible for 5 attribute failures each and shade was a factor in failures at 4 sample sites. Water clarity was generally good and only caused a single failure. The data collected indicates that water levels below summer minimums in the early summer (for example, 18/5 (NM), 26/5(KSE) and 6/7(KSW), when surveys were undertaken) are potentially a matter for concern at this site.

3.5 At Pevensey Levels, only 2 samples were taken, and neither passed the qualitative assessment. Channel form and native species richness failed on both samples, and water depth was also too low at 1 of the ditches. Native species richness depends upon surveyors being able to see and identify all plant species present. This would be becoming more difficult in late September when the surveys were undertaken (29/9/05), as many water plants die back underwater as autumn progresses toward winter. Water levels were below the minimum recommended summer levels in 1 ditch even into the autumn period when they should be beginning to rise after the summer.

3.6 At Berney Marshes, 6 samples were taken and none passed the qualitative assessment. Channel form and native species richness were the key attributes which failed, although turbidity was also a problem at 1 site. Channel form has proved difficult to assign pass or fail on the information given in the form as the JNCC (2004) guidance is unclear on what shape is ideal and it would seem that a range of channel shapes would be optimal to offer the range of habitat conditions required by a diverse botanical flora. Native species richness recorded for this site is likely to have been influenced by the late timing of the survey (11/11) when few aquatic plants would be visible, especially those that die back beneath the water surface in the winter. Added to this is the lower diversity expected in brackish ditches, although the targets in JNCC 2004 are lower for brackish ditches to reflect this.

3.7 In summary, poor overall results were received for condition assessments at the sites where botanical data was poor, namely Pevensey Levels and Berney Marshes. At Somerset Levels, better pass rates were achieved, although many samples still failed to achieve botanical targets despite detailed recording. Indeed, at Pevensey Levels there was 1 fail in the 'Fail 1' category (that is, 7 or 8 attributes passed), and at Berney Marshes, there were 5. The remaining samples all fell into 'Fail 2' (that is, 5 or 6 passes).

Table 8 Results of condition assessment for qualitative data, following the rules set out in Table 3

Ditch No.	Extent (loss/no loss)	Water Depth (value/ no loss)	Water Clarity (all clear/slight/ marked colour)	Macro- algae (dafor/ %cover)	Electrical Conductivity (value)	Channel Form (t=trapezoidal/ nont=non-trapezoidal)	Successional Stage (dominant type: e/m/l)	Shade (% cover)	Negative Indicator spp. (%cover a. invasive b. non-native)	Native Spp. Richness (#spp. on Appendix 1)	Notes	Number of Passes	Overall Assess-ment	Reason for Borderline Failures (that is, 1xF)
KSE1	no loss P	55 P	all clear P	r P	-	t (very good) P	m P	0 P	0 1 P	8 P	Freshwater	9	Pass	
KSE2	no loss P	70 P	all clear P	r P	-	t (very good) P	m P	25 F	0 1 P	6 F	Freshwater	7	Fail	native spp., shade
KSE3	no loss P	70 P	all clear P	f F	-	t (very good) P	e F	0 P	0 1 P	12 P	Freshwater	7	Fail	successional stage, algae
KSE4	no loss P	20 F	all clear P	r P	-	t (good) P	l P	90 F	0 1 P	5 F	Freshwater	6	Fail	
KSE5	no loss P	70 P	all clear P	o P	-	t (excellent) P	m P	0 P	0 0 P	9 P	Freshwater	9	Pass	
KSE6	no loss P	40 F	all clear P	d F	-	t (excellent) P	m P	6 P	0 1 P	11 P	Freshwater	7	Fail	algae, water depth
KSE7	no loss P	50 P	all clear P	a F	-	t (very good) P	m P	0 P	0 1 P	8 P	Freshwater	8	Fail	macro-algae
KSE8	no loss P	60 P	all clear P	r P	-	t (very good) P	l P	0 P	0 0 P	6 F	Freshwater	8	Fail	native spp.

Table continued...

Ditch No.	Extent (loss/no loss)		Water Depth (value/ no loss)		Water Clarity (all clear/slight/ marked colour)		Macro- algae (dafor/ %cover)		Electrical Conductivity (value)	Channel Form (t=trapezoidal/ nont=non-trapezoidal)		Successional Stage (dominant type: e/m/l)		Shade (% cover)		Negative Indicator spp. (%cover a. invasive b. non-native)			Native Spp. Richness (#spp. on Appendix 1)		Notes	Number of Passes	Overall Assess-ment	Reason for Borderline Failures (that is, 1xF)
KSE9	no loss	P	90	P	slight colour	P	r	P	-	t (good, IDB managed)	P	e	F	0	P	0	1	P	11	P	Freshwater	8	Fail	successional stage
KSE10	no loss	P	120	P	slight colour	P	r	P	-	t (good)	P	e	F	1	P	0	1	P	15	P	Freshwater	8	Fail	successional stage
KSW1	no loss	P	100	P	clear	P	r	P	-	nont	F	e	F	0	P	0	0	P	14	P	Freshwater	7	Fail	successional stage, channel form
KSW2	no loss	P	25	F	clear	P	o	P	-	t	P	e	F	0	P	71	0	F	5	F	Freshwater	5	Fail	
KSW3	no loss	P	40	F	clear	P	-	P	-	t	P	m	P	0	P	0	0	P	14	P	Freshwater	8	Fail	depth
KSW4	no loss	P	30	F	clear	P	f	F	-	t	P	m	P	0	P	0	0	P	11	P	Freshwater	7	Fail	algae, water depth
KSW5	no loss	P	10	F	slight colour	P	-	P	-	t	F	m	P	70	F	0	80	F	5	F	Freshwater	4	Fail	
KSW6	no loss	P	30	F	clear	P	-	P	-	t	P	l	P	0	P	0	0	P	8	P	Freshwater	8	Fail	depth
KSW7	no loss	P	20	F	clear	P	-	P	-	nont	F	e	F	0	P	0	0	P	8	P	Freshwater	6	Fail	

Table continued…

Ditch No.	Extent (loss/no loss)		Water Depth (value/ no loss)		Water Clarity (all clear/slight/ marked colour)		Macro- algae (dafor/ %cover)		Electrical Conductivity (value)	Channel Form (t=trapezoidal/ nont=non-trapezoidal)		Successional Stage (dominant type: e/m/l)		Shade (% cover)		Negative Indicator spp. (%cover a. invasive b. non-native)			Native Spp. Richness (#spp. on Appendix 1)		Notes	Number of Passes	Overall Assess-ment	Reason for Borderline Failures (that is, 1xF)
KSW8	no loss	P	40	F	clear	P	o	P	-	t	P	e	F	0	P	0	0	P	9	P	Freshwater	7	Fail	successional stage, water depth
KSW9	no loss	P	100	P	clear	P	o	P	-	nont	F	e	F	0	P	0	0	P	3	F	Freshwater	6	Fail	
KSW10	no loss	P	40	F	clear	P	o	P	-	t	P	e	F	5	P	0	1	F	7	P	Freshwater	6	Fail	
NM1	no loss	P	60	P	clear	P	r	P	-	t	P	m	P	0	P	0	1	P	12	P	Freshwater	9	Pass	
NM2	no loss	P	50	P	clear	P	r	P	-	t	P	m	P	50	F	0	1	P	10	P	Freshwater	8	Fail	shade
NM3	no loss	P	50	P	clear	P	r	P	-	t + berm	P	m	P	0	P	0	1	P	9	P	Freshwater	9	Pass	
NM4	no loss	P	45	F	clear	P	r	P	-	t	P	m	P	0	P	1	51	F	5	F	Freshwater	6	Fail	
NM5	no loss	P	35	F	clear	P	r	P	-	t + too steep	F	e	F	0	P	0	91	F	6	F	Freshwater	4	Fail	
NM6	no loss	P	65	P	clear	P	r	P	-	t	P	m	P	0	P	0	0	P	6	F	Freshwater	8	Fail	native spp.

Table continued…

Ditch No.	Extent (loss/no loss)		Water Depth (value/ no loss)		Water Clarity (all clear/slight/ marked colour)		Macro- algae (dafor/ %cover)		Electrical Conductivity (value)		Channel Form (t=trapezoidal/ nont=non-trapezoidal)		Successional Stage (dominant type: e/m/l)		Shade (% cover)		Negative Indicator spp. (%cover a. invasive b. non-native)			Native Spp. Richness (#spp. on Appendix 1)		Notes	Number of Passes	Overall Assess-ment	Reason for Borderline Failures (that is, 1xF)
NM7	no loss	P	50	P	clear	P	r	P	-		t	P	m	P	0	P	0	0	P	9	P	Freshwater	9	Pass	
NM8	no loss	P	40	F	clear	P	r	P	-		t (good)	P	m	P	0	P	0	0	P	5	F	Freshwater	7	Fail	native spp., depth
NM9	no loss	P	50	P	clear	P	o	P	-		t	P	m	P	0	P	0	1	P	9	P	Freshwater	9	Pass	
NM10	no loss	P	90	P	marked colour	F	a	F	-		t + berm	P	e	F	0	P	0	0	P	10	P	Freshwater	6	Fail	
Total Fails:		**0**		**13**		**1**		**5**				**5**		**11**		**4**			**5**		**10**				
PL5	no loss	P	75	P	clear	P	-	P	-		nont	F	m	P	0	P	0	0	P	5	F	Freshwater	7	Fail	native spp., channel form
PL6	no loss	P	8.3	F	clear	P	-	P	-		nont	F	l	P	0	P	0	0	P	2	F	Freshwater	6	Fail	
Total Fails:		**0**		**1**		**0**		**0**				**2**		**0**		**0**			**0**		**2**				
BM1	no loss	P	-		clear	P	-	P	4150	P	nont	F	m	P	0	P	0	0	P	3	F	Brackish	7	Fail	native spp., channel form

Table continued…

Ditch No.	Extent (loss/no loss)		Water Depth (value/ no loss)	Water Clarity (all clear/slight/ marked colour)		Macro- algae (dafor/ %cover)		Electrical Conductivity (value)		Channel Form (t=trapezoidal/ nont=non-trapezoidal)		Successional Stage (dominant type: e/m/l)		Shade (% cover)		Negative Indicator spp. (%cover a. invasive b. non-native)			Native Spp. Richness (#spp. on Appendix 1)		Notes	Number of Passes	Overall Assess-ment	Reason for Borderline Failures (that is, 1xF)
BM2	no loss	P	-	marked colour	F	-	P	3100	P	nont	F	m	P	0	P	0	0	P	3	F	Brackish	6	Fail	
BM3	no loss	P	-	clear	P	o	P	3190	P	nont	F	m	P	0	P	1	0	P	4	F	Brackish	7	Fail	native spp., channel form
BM4	no loss	P	-	clear	P	o	P	3590	P	nont	F	m	P	0	P	0	0	P	2	F	Brackish	7	Fail	native spp., channel form
BM5	no loss	P	-	clear	P	-	P	3230	P	nont	F	m	P	0	P	0	0	P	2	F	Brackish	7	Fail	native spp., channel form
BM6	no loss	P	-	clear	P	o	P	5750	P	nont	F	m	P	0	P	0	0	P	3	F	Brackish	7	Fail	native spp., channel form
Total Fails:		**0**			**1**		**0**		**0**		**6**		**0**		**0**			**0**		**6**				

Pass or failure of each attribute is shown to the right of each column as 'P' or 'F'. A blank means no data collected, '-' signifies that attribute not present.

Condition assessments for individual ditches (quantitative)

3.8 The results of the condition assessment for the quantitatively-sampled ditches are presented in Table 9. The table describes each attribute recorded in the quantitative survey and assigns a pass or fail based upon the criteria set out in Table 5. A total of 60 ditches were sampled under this method. Ditches were assigned an overall fail if any one of the attributes did not pass the criteria set. There were 9 attributes used in all cases, and most ditches failed the assessment. Because of this, the number of passes was considered important, as before, with 7 or 8 passes being a good fail (Fail 1), 5 or 6 passes being a mediocre fail (Fail 2) and 4 or fewer passes constituting a poor fail (Fail 3).

3.9 For ditches falling into the ‘Fail 1’ category, that is, failing by 1 or 2 attributes, the reason for the fail was noted in the final column of the table, so that any patterns in failures could be identified.

3.10 Table 9 totals the number of failures for each attribute at each of the 3 sites. For a total of 60 sites, this provides a reasonable robust measure of the key factors influencing unfavourable condition at each site. The attributes causing the most failures were also those which occurred most frequently among the near-passes (Fail 1) too.

3.11 At King’s Sedgemoor and Nailsea Moors, only 1 ditch passed on the criteria set in this study. 17 out of 20 samples failed on water depth (see Table 9a). Surveys were undertaken on 19th July, 26th and 27th September. Water levels are evidently below target levels at this site during the summer months and leading into the autumn. (Indeed, indications from the qualitative data suggest they are too low in early summer too). Fourteen out of 20 sites failed on shading indicating that lack of ditch management may be an issue at the SSSI. Other frequently failing attributes were negative species (8 samples failed) and macro-algae (7 failed). High abundance of negative species can suggest disturbance, public pressure and a lack of management of the issue – in this case, *Azolla* was present at 1 site, but fails were mainly due to high abundance of *Lemna minuta* which is not considered among the ‘most invasive’ species (JNCC 2004). High %cover of macro-algae in freshwater ditches means eutrophication is a problem. Native species richness failed in 5 samples although all sites contained 3 or more of the important species listed in Appendix 1 of JNCC 2004 (7 are needed to pass this attribute for freshwater ditches). All other attributes except extent failed a few times but showed no particular significance.

3.12 At Pevensey Levels (see Table 9b), only 2 ditches passed the condition assessment based upon the criteria set in this study. Eleven out of 20 samples failed on negative species, including a number of the ‘most invasive’ aliens (JNCC 2004), *Crassula helmsii* and *Hydrocotyle ranunculoides*. Mean water depth failed target in 8 samples; surveys were undertaken on 2nd and 3rd September. Shade caused failures in 6 samples, while 4 samples failed on successional stage and 3 on channel form and native species richness. Macro-algae were generally not a problem at this site, with only 1 ditch experiencing cover above 10%, while water clarity caused no failures at all.

3.13 At Berney Marshes (see Table 9c), a total of 7 ditches passed the assessment, based upon the criteria set by this study. Ten out of the 20 samples failed on macro-algae, possibly suggesting nutrient enrichment problems at the site may be the dominant factor in affecting condition. Five samples failed on successional stage and 3 on water depth (surveys were undertaken on 31st August, 1st and 2nd September when levels would be low especially after a dry summer). Single failures were observed for water clarity, channel form, shade, negative species and native species, indicating that these attributes were generally in acceptable condition across the site.

3.14 In summary, at Somerset Levels, the attributes responsible for the most fails were water availability and shading, with negative species and macro-algal presence also frequently occurring above target levels. At Pevensey Levels, the 4 most significant failing attributes, in order of importance, were negative species, mean water depth, shading and successional stage. Berney Marshes ditches suffered failures because of macro-algae, with successional stage and water depth also featuring in the failed attributes.

Table 9a King's Sedgemoor & Nailsea Moor quantitative data

Ditch No.	Extent lost (m)		Mean water depth (cm)		Water clarity (Secchi depth as % of max depth, *P* if >50%)		Macro-algae (% cover)		* Electrical Conductivity (>2000= brackish)	Channel form (Profile Model 4 output value *P* if <0.5 ie closer to a V-shape)		Successional stage (dominant type: <1.4(e), 1.5-2.4(m), 2.5-3(l))		Shade (% cover overhanging ground layer and shrubs/ trees)		Negative indicator species (%cover a. invasive & b. non-native)			Native spp. richness (#spp. on Appendix 1)		Notes	Number of Attribute passes	Overall Assess-ment	Reason for borderline failures (that is, 1xF)
KSE1	0	P	0	F	dry	N/A	0	P	730	dry	N/A	2	P	25	F	0	40	F	5	F	Freshwater	3	Fail	
KSE3	0	P	41.25	F	40	F	50	F	765	0.08	P	2	P	5	P	0	1	P	10	P	Freshwater	6	Fail	
KSE5	0	P	32.5	F	67	P	5	P	905	0.01	P	2	P	5	P	0	0	P	15	P	Freshwater	8	Fail	depth
KSE6	0	P	36.67	F	91	P	2	P	860	0.21	P	3	P	25	F	0	70	F	12	P	Freshwater	6	Fail	
KSE7	0	P	37.5	F	100	P	60	F	765	small v	P	1	F	40	F	0	5	P	9	P	Freshwater	5	Fail	
KSE8	0	P	15.5	F	100	P	1	P	755	0.11	P	3	P	60	F	0	0	P	10	P	Freshwater	7	Fail	shade, water depth
KSW1	0	P	93.75	P	95	P	5	P	730	0.48	P	1.5	P	2	P	1	1	P	11	P	Freshwater	9	Pass	
KSW2	0	P	60	P	100	P	0	P	620	0.18	P	2	P	20	F	80	25	F	10	P	Freshwater	7	Fail	negative species, shade
KSW3	0	P	45	F	100	P	70	F	610	0.36	P	2	P	5	P	0	1	P	18	P	Freshwater	7	Fail	macro-algae, depth
KSW5	0	P	32.5	F	100	P	0	P	680	0.25	P	2	P	90	F	0	95	F	4	F	Freshwater	5	Fail	

Table continued...

Ditch No.	Extent lost (m)		Mean water depth (cm)		Water clarity (Secchi depth as % of max depth, *P* if >50%)		Macro-algae (% cover)		* Electrical Conductivity (>2000= brackish)		Channel form (Profile Model 4 output value *P* if <0.5 ie closer to a V-shape)		Successional stage (dominant type: <1.4(e), 1.5-2.4(m), 2.5-3(l))		Shade (% cover overhanging ground layer and shrubs/ trees)		Negative indicator species (%cover a. invasive & b. non-native)			Native spp. richness (#spp. on Appendix 1)		Notes	Number of Attribute passes	Overall Assess-ment	Reason for borderline failures (that is, 1xF)
KSW8	0	P	35	F	100	P	1	P	670		0.01	P	3	P	50	F	0	90	F	8	P	Freshwater	6	Fail	
KSW9	0	P	35.71	F	93	P	80	F	760		0.16	P	1.3	F	1	P	1	5	P	13	P	Freshwater	6	Fail	
NM2	0	P	47.5	F	100	P	0	P	580		0.21	P	3	P	90	F	0	40	F	5	F	Freshwater	5	Fail	
NM3	0	P	45	F	100	P	0	P	610		1.00	F	3	P	61	F	0	0	P	10	P	Freshwater	6	Fail	
NM4	0	P	37.5	F	100	P	40	F	660		0.56	F	2	P	50	F	0	0	P	6	F	Freshwater	4	Fail	
NM5	0	P	35	F	100	P	0	P	600		small v	P	2	P	80	F	0	95	F	3	F	Freshwater	5	Fail	
NM6	0	P	35	F	100	P	0	P	745		small v	P	2	P	120	F	0	10	P	8	P	Freshwater	7	Fail	shade, depth
NM7	0	P	40	F	100	P	5	P	810		small v	P	3	P	75	F	0	0	P	11	P	Freshwater	7	Fail	shade, depth
NM9	0	P	45	F	100	P	30	F	1050		small v	P	2	P	60	F	0	0	P	14	P	Freshwater	6	Fail	
NM10	0	P	71	P	100	P	70	F	570		0.49	P	1	F	7	P	10	1	F	19	P	Freshwater	6	Fail	
Total Fails:		**0**		**17**		**1**		**7**				**2**		**3**		**14**			**8**	**mean10.05**	**5**	**Total Passes:**		**1**	

Pass & Fail for each criterion and overall ditch condition based upon JNCC 2004. (* denotes non-mandatory attribute excluded from assessment).

Table 9b Pevensey Levels quantitative data

Ditch No.	Extent lost (length, m)		Mean water depth (cm)		Water clarity (Secchi depth as % of max depth, *P* if >50%)		Macro-algae (% cover)		* Electrical Conductivity (>2000= brackish)	Channel form (Profile Model 4 output value *P* if <0.5 ie closer to a V-shape)		Successional stage (dominant type: <1.4(e), 1.5-2.4(m), 2.5-3(l))		Shade (% cover over-hanging ground layer and shrubs/ trees)		Negative indicator species (%cover a. invasive & b. non-native)			Native spp. richness (#spp. on Appendix 1)		Notes	Number of Attribute Passes	Overall Assess-ment	Reason for borderline failures
PL1	0	P	60	P	100	P	60	F	1450	0.01	P	2	P	2	P	35	0	F	16	P	Freshwater	7	Fail	negative spp., algae
PL2	0	P	77.5	P	100	P	1	P	1350	0.20	P	2	P	30	F	15	0	F	10	P	Freshwater	7	Fail	negative spp., shade
PL3	0	P	50	P	100	P	0	P	975	0.07	P	2	P	10	P	1	0	P	11	P	Freshwater	9	Pass	
PL4	0	P	50	P	100	P	3	P	1100	0.15	P	2	P	2	P	5	0	F	9	P	Freshwater	8	Fail	negative spp.
PL5	0	P	72.5	P	clear	P	4	P	515	1.02	F	2	P	3	P	20	0	F	10	P	Freshwater	7	Fail	negative spp., channel form
PL6	0	P	16.7	F	100	P	5	P	705	0.38	P	3	P	2	P	0	0	P	15	P	Freshwater	8	Fail	water depth
PL7	0	P	61.3	P	100	P	1	P	910	0.43	P	2	P	5	P	1	0	P	13	P	Freshwater	9	Pass	
PL8	0	P	7.5	F	100	P	0	P	610	0.00	P	3	P	10	P	0	0	P	13	P	Freshwater	8	Fail	water depth
PL9	0	P	41.7	F	100	P	1	P	545	0.01	P	2	P	1	P	0	0	P	16	P	Freshwater	8	Fail	water depth

Table continued…

Ditch No.	Extent lost (length, m)		Mean water depth (cm)		Water clarity (Secchi depth as % of max depth, *P* if >50%)		Macro-algae (% cover)		* Electrical Conductivity (>2000= brackish)		Channel form (Profile Model 4 output value *P* if <0.5 ie closer to a V-shape)		Successional stage (dominant type: <1.4(e), 1.5-2.4(m), 2.5-3(l))		Shade (% cover over-hanging ground layer and shrubs/ trees)		Negative indicator species (%cover a. invasive & b. non-native)			Native spp. richness (#spp. on Appendix 1)		Notes	Number of Attribute Passes	Overall Assess-ment	Reason for borderline failures
PL10	0	P	10	F	slight turbidity	P	1	P	770		1.60	F	3	P	10	P	0	0	P	11	P	Freshwater	7	Fail	water depth
PL11	0	P	95	P	80	P	0	P	665		0.68	F	2	P	2	P	95	35	F	5	F	Freshwater	6	Fail	
PL12	0	P	97	P	70	P	0	P	705		0.08	P	1	F	5	P	3	20	F	9	P	Freshwater	7	Fail	negative spp., successional stage
PL13	0	P	0	F	dry	N/A	0	P	dry		dry	N/A	3	P	70	F	0	0	P	5	F	Freshwater	4	Fail	
PL14	0	P	76	P	94	P	0	P	440		0.52	F	1	F	42	F	51	0	F	12	P	Freshwater	5	Fail	
PL15	0	P	113.8	P	80	P	1	P	625		0.56	F	1	F	3	P	20	60	F	10	P	Freshwater	6	Fail	
PL16	0	P	37.5	F	100	P	1	P	825		small v	P	2	P	20	F	0	0	P	16	P	Freshwater	7	Fail	shade, water depth
PL17	0	P	62.5	P	67	P	0	P	690		0.07	P	2	P	5	P	96	50	F	10	P	Freshwater	8	Fail	negative spp.
PL18	0	P	40	F	100	P	1	P	815		0.21	P	2	P	5	P	90	3	F	14	P	Freshwater	7	Fail	negative spp., water depth
PL19	0	P	36.7	F	111	P	0	P	520		0.18	P	3	P	82	F	0	1	P	6	F	Freshwater	6	Fail	
PL20	0	P	71.3	P	82	P	3	P	960		0.29	P	1	F	15	F	30	0	F	10	P	Freshwater	6	Fail	
Total Fails:		**0**		**8**		**0**		**1**		**N/A**		**5**		**4**		**6**			**11**	**mean11.05**	**3**	**Total Passes:**		**2**	

Pass & Fail for each criterion and overall ditch condition based upon JNCC 2004. (* denotes non-mandatory attribute excluded from assessment).

Table 9c Berney Marshes quantitative data

Ditch No.	Extent lost (length, m)		Mean water depth (cm)		Water clarity (Secchi depth as % of max depth, *P* if >50%)		Macro-algae (% cover)		*Electrical Conductivity (>2000= brackish)		Channel form (Profile Model 4 output value *P* if <0.5 ie closer to a V-shape)		Successional stage (dominant type: <1.4(e), 1.5-2.4(m), 2.5-3(l))		Shade (%cover over-hanging, ground layer & shrubs/ trees)		Negative indicator species (%cover a. invasive & b. non-native)			Native spp. richness (#spp. on Appendix 1)		Notes	Number of attribute passes	Overall assess-ment	Reason for borderline failures (that is, 1xF)
BM1	0	P	57.5	P	100	P	3	P	2050	N/A	0.02	P	2	P	5	P	1	1	P	7	P	Brackish	9	Pass	
BM2	0	P	50	P	100	P	10	P	3700	N/A	0.13	P	2	P	2	P	30	2	F	5	P	Brackish	8	Fail	negative spp.
BM3	0	P	59	P	100	P	70	F	1950	N/A	0.29	P	2	P	4	P	0	2	P	7	P	Brackish	8	Fail	low conductivity, algae
BM4	0	P	52.86	P	93	P	50	F	1900	N/A	0.13	P	2	P	0	P	0	1	P	10	P	Brackish	8	Fail	low conductivity, algae
BM5	0	P	62.86	P	57	P	1	P	3200	N/A	0.02	P	2	P	1	P	0	0	P	9	P	Brackish	9	Pass	
BM6	0	P	59.29	P	78	P	20	F	6200	N/A	0.04	P	2	P	2	P	0	0	P	5	P	Brackish	8	Fail	algae
BM7	1	P	66.25	P	94	P	65	F	2800	N/A	0.21	P	1	F	1	P	1	0	P	11	P	Brackish	7	Fail	successional stage, algae
BM8	2	P	85	P	90	P	10	P	3300	N/A	0.22	P	2	P	3	P	0	0	P	8	P	Brackish	9	Pass	
BM9	3	P	46.67	F	100	P	30	F	3550	N/A	0.10	P	2	P	30	F	0	0	P	8	P	Brackish	6	Fail	
BM10	4	P	35	F	114	P	5	P	2600	N/A	0.60	F	2	P	5	P	0	0	P	7	P	Brackish	7	Fail	water depth

Table continued…

Ditch No.	Extent lost (length, m)		Mean water depth (cm)		Water clarity (Secchi depth as % of max depth, *P* if >50%)		Macro-algae (% cover)		*Electrical Conductivity (>2000= brackish)		Channel form (Profile Model 4 output value *P* if <0.5 ie closer to a V-shape)		Successional stage (dominant type: <1.4(e), 1.5-2.4(m), 2.5-3(l))		Shade (%cover over-hanging, ground layer & shrubs/ trees)		Negative indicator species (%cover a. invasive & b. non-native)			Native spp. richness (#spp. on Appendix 1)		Notes	Number of attribute passes	Overall assess-ment	Reason for borderline failures (that is, 1xF)
BM11	5	P	77.5	P	40	F	15	F	2750	N/A	0.33	P	2	P	5	P	0	0	P	7	P	Brackish	7	Fail	algae, water clarity
BM12	6	P	77.5	P	100	P	10	P	2650	N/A	0.35	P	2	P	3	P	0	0	P	12	P	Brackish	9	Pass	
BM13	7	P	85	P	70	P	0	P	2100	N/A	0.35	P	2	P	5	P	0	0	P	11	P	Brackish	9	Pass	
BM14	8	P	68.75	P	100	P	20	F	2550	N/A	0.12	P	2	P	5	P	0	0	P	7	P	Brackish	8	Fail	algae
BM15	9	P	73.75	P	94	P	99	F	2650	N/A	0.25	P	1	F	5	P	0	0	P	13	P	Brackish	7	Fail	successional stage, algae
BM16	10	P	74.17	P	100	P	40	F	2600	N/A	0.28	P	1	F	2	P	0	0	P	13	P	Brackish	7	Fail	
BM17	11	P	80	P	95	P	5	P	3800	N/A	0.23	P	2	P	3	P	0	0	P	9	P	Brackish	9	Pass	
BM18	12	P	32.5	F	63	P	0	P	3300	N/A	0.06	P	1	F	0	P	0	0	P	1	F	Brackish	6	Fail	
BM19	13	P	75	P	100	P	1	P	3350	N/A	0.29	P	2	P	5	P	0	0	P	8	P	Brackish	9	Pass	
BM20	14	P	63.33	P	100	P	25	F	2900	N/A	0.13	P	1	F	5	P	0	0	P	10	P	Brackish	7	Fail	successional stage, algae
Total Fails:		**0**		**3**		**1**		**10**		**N/A**		**1**		**5**		**1**			**1**	**mean 8.4**	**1**	**Total Passes:**		**7**	

Pass & Fail for each criterion and overall ditch condition based upon JNCC 2004. (* denotes non-mandatory attribute excluded from assessment).

Comparing qualitative and quantitative condition

3.15 The comparison of qualitative and quantitative data was confined to samples for which both datasets were available. This comprised 20 sample sites in the King's Sedgemoor and Nailsea Moor complex, 2 sites at Pevensey Levels and 6 sites at Berney Marshes. A detailed site-by-site comparison of condition assessment of each attribute is presented in Table 10.

Overall condition

3.16 Comparability of qualitative and quantitative condition assessment results was based upon each sample achieving the same number of passes for attributes according to the criteria set. Comparability was achieved even when passes were for different attributes, as long as the same number overall was obtained.

3.17 Overall, only 5 of the assessments of qualitative and quantitative data resulted in comparable evaluation of ditch condition. In 14 cases, the qualitative assessment resulted in more favourable condition than the quantitative surveys did. In the remaining 9, qualitative surveys were less favourable than quantitative.

3.18 On the Somerset Levels, 2 of the 20 paired samples produced a comparable result. Of the remaining not-comparable findings, 14 were more favourably recorded in the qualitative dataset, while 4 were not. Ditches KSE1, KSE5, NM3, NM7 and NM9 passed the qualitative assessment but failed the quantitative one. This suggests that, where species data collecting is comparable, the quantitative assessment is more rigorous than the qualitative method.

3.19 At Pevensey Levels, only 2 paired samples were available. Of these 1 produced a comparable result for both qualitative and quantitative data. The other sample was more favourably recorded in the quantitative data, because a) native species were more fully recorded in the quantitative survey, and b) channel form passed using the quantitative model where it had failed the qualitative assessment. Neither ditch passed the qualitative or quantitative assessment, but conclusions are hard to draw from so few samples.

3.20 At Berney Marshes, 6 paired samples were available for the comparison. Two of these produced a comparable result. The remaining 4 were more favourably represented in the quantitative dataset, all because native species were more fully recorded in the quantitative survey and because the qualitative assessment resulted in failures in channel form. One site also failed on water clarity. Ditches BM1 and BM5 failed the qualitative assessment but passed the quantitative one, suggesting that obtaining good quality species data is important in assessing condition, or at least in achieving species targets of 7 species for freshwater 20m samples and 5 for brackish. Fails in channel form are considered to be somewhat arbitrary for the reasons discussed above.

Table 10a Summary comparison of attribute passes for qualitative and quantitative ditch assessments - King's Sedgemoor (East and West sections) and Nailsea Moor (20 Samples)

(***** = optional attribute; F = attribute fails assessment; P = attribute passes assessment; N/A = assessed due to incomplete data)

Attribute	Qualitative	Quantitative	Comparable?
KSE1			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	P	F	No
Habitat functioning: water quality - clarity	P	N/A	No
Habitat functioning: water quality - algae	P	P	Yes
Habitat structure: channel form	P	N/A	No
Habitat structure: successional stage	P	P	Yes
Habitat structure: extent of shading	P	F	No
Indicators of negative change: non-native plants	P	F	No
Aquatic vegetation composition: native species richness	P	F	No
Total Passes:	9	3	No
KSE3			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	P	F	No
Habitat functioning: water quality - clarity	P	F	No
Habitat functioning: water quality - algae	F	F	Yes
Habitat structure: channel form	P	P	Yes
Habitat structure: successional stage	F	P	No
Habitat structure: extent of shading	P	P	Yes
Indicators of negative change: non-native plants	P	P	Yes
Aquatic vegetation composition: native species richness	P	P	Yes
Total Passes:	7	6	No

Table continued…

Attribute	Qualitative	Quantitative	Comparable?
KSE5			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	P	F	No
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	P	P	Yes
Habitat structure: channel form	P	P	Yes
Habitat structure: successional stage	P	P	Yes
Habitat structure: extent of shading	P	P	Yes
Indicators of negative change: non-native plants	P	P	Yes
Aquatic vegetation composition: native species richness	P	P	Yes
Total Passes:	9	8	No
KSE6			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	F	F	Yes
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	F	P	No
Habitat structure: channel form	P	F	No
Habitat structure: successional stage	P	P	Yes
Habitat structure: extent of shading	P	F	No
Indicators of negative change: non-native plants	P	F	No
Aquatic vegetation composition: native species richness	P	P	Yes
Total Passes:	7	5	No

Table continued…

Attribute	Qualitative	Quantitative	Comparable?
KSE7			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	O	F	No
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	F	F	Yes
Habitat structure: channel form	P	P	Yes
Habitat structure: successional stage	P	F	No
Habitat structure: extent of shading	P	F	No
Indicators of negative change: non-native plants	P	P	Yes
Aquatic vegetation composition: native species richness	P	P	Yes
Total Passes:	8	5	No
KSE8			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	P	F	No
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	P	P	Yes
Habitat structure: channel form	P	P	Yes
Habitat structure: successional stage	P	P	Yes
Habitat structure: extent of shading	P	F	No
Indicators of negative change: non-native plants	P	P	Yes
Aquatic vegetation composition: native species richness	F	P	No
Total Passes:	8	7	No

Table continued…

Attribute	Qualitative	Quantitative	Comparable?
KSW1			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	P	P	Yes
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	P	P	Yes
Habitat structure: channel form	F	F	Yes
Habitat structure: successional stage	F	P	No
Habitat structure: extent of shading	P	P	Yes
Indicators of negative change: non-native plants	P	P	Yes
Aquatic vegetation composition: native species richness	P	P	Yes
Total Passes:	7	8	No
KSW2			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	F	P	No
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	P	P	Yes
Habitat structure: channel form	P	P	Yes
Habitat structure: successional stage	F	P	No
Habitat structure: extent of shading	P	F	No
Indicators of negative change: non-native plants	F	F	Yes
Aquatic vegetation composition: native species richness	F	P	No
Total Passes:	5	7	No

Table continued…

Attribute	Qualitative	Quantitative	Comparable?
KSW3			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	F	F	Yes
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	P	F	No
Habitat structure: channel form	P	P	Yes
Habitat structure: successional stage	P	P	Yes
Habitat structure: extent of shading	P	P	Yes
Indicators of negative change: non-native plants	P	P	Yes
Aquatic vegetation composition: native species richness	P	P	Yes
Total Passes:	8	7	No
KSW5			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	F	F	Yes
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	P	P	Yes
Habitat structure: channel form	F	P	No
Habitat structure: successional stage	P	P	Yes
Habitat structure: extent of shading	F	F	Yes
Indicators of negative change: non-native plants	F	F	Yes
Aquatic vegetation composition: native species richness	F	F	Yes
Total Passes:	4	5	No

Table continued…

Attribute	Qualitative	Quantitative	Comparable?
KSW8			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	F	F	Yes
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	P	P	Yes
Habitat structure: channel form	P	P	Yes
Habitat structure: successional stage	F	P	No
Habitat structure: extent of shading	P	F	No
Indicators of negative change: non-native plants	P	F	No
Aquatic vegetation composition: native species richness	P	P	Yes
Total Passes:	7	6	No
KSW9			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	P	F	No
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	P	P	Yes
Habitat structure: channel form	F	P	No
Habitat structure: successional stage	F	P	No
Habitat structure: extent of shading	P	F	No
Indicators of negative change: non-native plants	P	F	No
Aquatic vegetation composition: native species richness	F	P	No
Total Passes:	6	6	Yes

Table continued…

Attribute	Qualitative	Quantitative	Comparable?
NM2			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	P	F	No
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	P	P	Yes
Habitat structure: channel form	P	P	Yes
Habitat structure: successional stage	P	P	Yes
Habitat structure: extent of shading	F	F	Yes
Indicators of negative change: non-native plants	P	F	No
Aquatic vegetation composition: native species richness	P	F	No
Total Passes:	8	5	No
NM3			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	P	F	No
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	P	P	Yes
Habitat structure: channel form	P	P	Yes
Habitat structure: successional stage	P	P	Yes
Habitat structure: extent of shading	P	F	No
Indicators of negative change: non-native plants	P	P	Yes
Aquatic vegetation composition: native species richness	P	P	Yes
Total Passes:	9	7	No

Table continued…

Attribute	Qualitative	Quantitative	Comparable?
NM4			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	F	F	Yes
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	P	F	No
Habitat structure: channel form	P	P	Yes
Habitat structure: successional stage	P	P	Yes
Habitat structure: extent of shading	P	F	No
Indicators of negative change: non-native plants	F	P	No
Aquatic vegetation composition: native species richness	F	F	Yes
Total Passes:	6	5	No
NM5			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	F	F	Yes
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	P	P	Yes
Habitat structure: channel form	F	P	Yes
Habitat structure: successional stage	F	P	No
Habitat structure: extent of shading	P	F	No
Indicators of negative change: non-native plants	F	F	Yes
Aquatic vegetation composition: native species richness	F	F	Yes
Total Passes:	4	5	No

Table continued…

Attribute	Qualitative	Quantitative	Comparable?
NM6			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	P	F	No
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	P	P	Yes
Habitat structure: channel form	P	P	Yes
Habitat structure: successional stage	P	P	Yes
Habitat structure: extent of shading	P	F	No
Indicators of negative change: non-native plants	P	P	Yes
Aquatic vegetation composition: native species richness	F	P	No
Total Passes:	8	7	No
NM7			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	P	F	No
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	P	P	Yes
Habitat structure: channel form	P	P	Yes
Habitat structure: successional stage	P	P	Yes
Habitat structure: extent of shading	P	F	No
Indicators of negative change: non-native plants	P	P	Yes
Aquatic vegetation composition: native species richness	P	P	Yes
Total Passes:	9	7	No

Table continued…

Attribute	Qualitative	Quantitative	Comparable?
NM9			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	P	F	No
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	P	F	No
Habitat structure: channel form	P	P	Yes
Habitat structure: successional stage	P	P	Yes
Habitat structure: extent of shading	P	F	No
Indicators of negative change: non-native plants	P	P	Yes
Aquatic vegetation composition: native species richness	P	P	Yes
Total Passes:	9	6	No
NM10			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	P	P	Yes
Habitat functioning: water quality - clarity	F	P	No
Habitat functioning: water quality - algae	F	F	Yes
Habitat structure: channel form	P	P	Yes
Habitat structure: successional stage	F	F	Yes
Habitat structure: extent of shading	P	P	Yes
Indicators of negative change: non-native plants	P	F	No
Aquatic vegetation composition: native species richness	P	P	Yes
Total Passes:	6	6	Yes

Table 10b Summary comparison of attribute passes for qualitative and quantitative ditch assessments - Pevensey Levels (2 samples, 9 attributes)

Attribute	Qualitative	Quantitative	Comparable?
PL5			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	P	P	Yes
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	P	P	Yes
Habitat structure: channel form	F	F	Yes
Habitat structure: successional stage	P	P	Yes
Habitat structure: extent of shading	P	P	Yes
Indicators of negative change: non-native plants	P	F	No
Aquatic vegetation composition: native species richness	F	P	No
Total Passes:	7	7	Yes
PL6			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	F	F	Yes
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	P	P	Yes
Habitat structure: channel form	F	P	No
Habitat structure: successional stage	P	P	Yes
Habitat structure: extent of shading	P	P	Yes
Indicators of negative change: non-native plants	P	P	Yes
Aquatic vegetation composition: native species richness	F	P	No
Total Passes:	6	8	No

Table 10c Summary comparison of attribute passes for qualitative and quantitative ditch assessments - Berney Marshes (part of Halvergate Marshes) (6 Samples)

Attribute	Qualitative	Quantitative	Comparable?
BM1			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	N/A	N/A	N/A
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	P	P	Yes
*Habitat functioning: conductivity	P	P	Yes
Habitat structure: channel form	F	P	No
Habitat structure: successional stage	P	P	Yes
Habitat structure: extent of shading	P	P	Yes
Indicators of negative change: non-native plants	P	P	Yes
Aquatic vegetation composition: native species richness	F	P	No
Total Passes:	7	9	No
BM2			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	N/A	N/A	N/A
Habitat functioning: water quality - clarity	F	P	No
Habitat functioning: water quality - algae	P	P	Yes
*Habitat functioning: conductivity	P	P	Yes
Habitat structure: channel form	F	P	No
Habitat structure: successional stage	P	P	Yes
Habitat structure: extent of shading	P	P	Yes
Indicators of negative change: non-native plants	P	F	No
Aquatic vegetation composition: native species richness	F	P	No
Total Passes:	6	8	No

Table continued…

Attribute	Qualitative	Quantitative	Comparable?
BM3			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	N/A	N/A	N/A
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	P	F	No
*Habitat functioning: conductivity	P	F	No
Habitat structure: channel form	F	P	No
Habitat structure: successional stage	P	P	Yes
Habitat structure: extent of shading	P	P	Yes
Indicators of negative change: non-native plants	P	P	Yes
Aquatic vegetation composition: native species richness	F	P	No
Total Passes:	7	7	Yes
BM4			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	N/A	N/A	N/A
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	P	F	No
*Habitat functioning: conductivity	P	F	No
Habitat structure: channel form	F	P	No
Habitat structure: successional stage	P	P	Yes
Habitat structure: extent of shading	P	P	Yes
Indicators of negative change: non-native plants	P	P	Yes
Aquatic vegetation composition: native species richness	F	P	No
Total Passes:	7	7	Yes

Table continued…

Attribute	Qualitative	Quantitative	Comparable?
BM5			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	N/A	N/A	N/A
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	P	P	Yes
*Habitat functioning: conductivity	P	P	Yes
Habitat structure: channel form	F	P	No
Habitat structure: successional stage	P	P	Yes
Habitat structure: extent of shading	P	P	Yes
Indicators of negative change: non-native plants	P	P	Yes
Aquatic vegetation composition: native species richness	F	P	No
Total Passes:	7	9	No
BM6			
Extent of ditch feature	P	P	Yes
Habitat functioning: water availability	N/A	N/A	N/A
Habitat functioning: water quality - clarity	P	P	Yes
Habitat functioning: water quality - algae	P	F	No
*Habitat functioning: conductivity	P	P	Yes
Habitat structure: channel form	F	P	No
Habitat structure: successional stage	P	P	Yes
Habitat structure: extent of shading	P	P	Yes
Indicators of negative change: non-native plants	P	P	Yes
Aquatic vegetation composition: native species richness	F	P	No
Total Passes:	7	8	No

Attributes

3.21 The passes and failures for each of the different mandatory attributes were compared to examine patterns in condition assessment between the qualitative and quantitative methods. The comparison is summarised in Table 11, which only includes the samples for which both analyses were completed, that is, 28 samples. Non-mandatory attribute, conductivity, was included for reasons explained below.

Extent

3.22 All ditches passed on extent for both qualitative and quantitative methods, that is, no loss was noted. However, this could be misleading because a dry ditch is just as poor habitat as a filled-in one. Also, when applied to individual 20m sections, the attribute does not necessarily reflect loss of extent in other areas of the site.

Water availability

3.23 Water depth is seasonally dependent and also related to management measures such as 'penning'[4]. When qualitative surveys were undertaken at Somerset Levels (KSE: 26/5, KSW: 6/7, NM: 18/5), a total of 7 out of 20 sites failed because of insufficient water. Later in the year when quantitative surveys were undertaken (19/7, 26 & 27/9) 17 out of 20 sites failed on this attribute. Staff at the local English Nature office indicated that summer 2005 was dry, which may explain the low water levels noted. A measure of variation is expected and desirable from year to year, but regular occurrence of similar low water levels could impact site condition more seriously.

3.24 At Pevensey Levels, 1 of the 2 sites receiving qualitative assessment (29/9) failed on water level. The quantitative surveys (2, 3 & 4/9) recorded water levels below the target level in 8 out of 20 samples, and included the same assessment result for the 2 qualitative sites. Mean water depth was not recorded at Berney Marshes during the qualitative survey, so no comparison was made for this attribute.

Water clarity

3.25 Water clarity was not found to be an issue at any of the sites from the data received. At the Somerset Levels from the qualitative data – only 1 out of 30 samples failed on this attribute, at Nailsea Moor. The quantitative data (20 samples) reflected this result too in producing just 1 fail for the attribute, at KSE. No problems were noted in the qualitative (2 samples) or quantitative (20 samples) data for Pevensey Levels. At Berney Marshes only 1 of 6 sites failed the attribute in the qualitative data and 1 of 20 in the quantitative data, although these results were for different ditches.

Macro-algae

3.26 Macro algae caused 5 fails in the Somerset Levels qualitative data (30 samples), and 7 in the quantitative (20 samples). Nutrients may be a cause for concern at this site.

3.27 At Pevensey, neither site failed in the qualitative assessment and only 1 in the 20 sites quantitatively surveyed. All surveys were conducted in September, so excessive amounts of algae should have still been visible, suggesting nutrient levels are acceptable at this site.

3.28 At Berney Marshes, all 6 sites passed this attribute, but 10 of the 20 quantitatively surveyed sites failed. This difference is probably due to timing as qualitative surveys were conducted on 11/11, when algal blooms would be reduced compared to 31/8 and 1 & 2/9 when sunlight is still strong

[4] Penning is the method of using penstocks to maintain higher water levels in the meadows through the summer. At the Somerset Levels, boards are installed on or around the 1st April and removed 1st October in order to keep water levels high in summer and allow winter drainage to occur. However, dates are flexible and boards may be removed/installed at other times to maintain some water in the ditches at the appropriate level. In Somerset, summer field drain water should be 60-70cm deep and 70-90cm in main drains. In winter, a minimum of 15-20cm would ideally be maintained for the benefit of wildlife generally

enough to produce high levels of cover. The findings suggest that nutrient-enrichment may be an issue at this site.

Electrical conductivity

3.29 This attribute is not mandatory, and was excluded for Somerset Levels and Pevensey Levels because qualitative assessments did not collect this data. However, conductivity was recorded during the qualitative survey at Berney Marshes, and the measurements were used paired with the quantitative dataset to make up 9 attributes as water depth could not be used at Berney because it was not recorded in the qualitative dataset.

Channel form

3.30 Channel form was not considered to offer a good measure of attribute condition, so passes and failures of this attribute were not necessarily representative of the ditch condition. In the qualitative dataset, only trapezoidal and non-trapezoidal ditches were identified. This study assigned passes to trapezoidal ditches and fails to non-trapezoidal ones – this is a gross over-simplification of the range of habitats offered by ditches and how this relates to ditch shape. The model used for ditch profile in the quantitative dataset was also fairly arbitrary in assigning passes and fails. Ideally, an SSSI for ditches (and the UK high-diversity ditch resource as a whole) would contain a range of ditch profiles from the steep-sided trapezoidal to the irregular, poached sloping bank with or without berms and on to the fully vegetated ditch at the end of the successional cycle.

3.31 Channel form, decided as above, caused 5 out of 30 qualitative samples to fail at Somerset Levels, both to fail at Pevensey Levels, and 6 of 6 to fail at Berney Marshes. In the quantitative data, 2 out of 20 failed at Somerset Levels, 5 at Pevensey and 1 at Berney. Therefore the results do not seem to be very comparable. The benefit of the quantitative model is that it is not subjective but 'pass' or 'fail' is based upon observed profile similarity to expected profiles of a U (fail) or a V (pass) shaped ditch. However, again the actual situation is more complex as many vegetatively diverse ditches, such as those in Somerset, are maintained or naturally develop a flat bottom with sloping sides (_/).

3.32 Channel form affected overall pass-rate but was not the most reliable or influential factor.

Successional stage

3.33 Because of the broad generalisations needed to assign attribute condition for 20 m lengths when the targets apply to the network as a whole (as above). In the qualitative dataset, all samples which were in the 'early' successional stage were given a fail, a somewhat arbitrary criterion, because all successional stages are important parts of the ditch ecosystem and more frequently cleared ditches can support greatest numbers of submerged species, often the less common ones. In the quantitative dataset, the same principle was applied to pass or failure.

3.34 At Somerset Levels, qualitative results for successional stage caused 11 out of 30 samples to fail, while the quantitative data placed only 3 out of 20 ditch lengths in the 'early' category, that is, fail. At Pevensey Levels, neither qualitative sample failed on this attribute, while 4 of 20 quantitative samples failed it. At Berney Marshes, no failures were noted in the 6 qualitatively sampled sites. The quantitative data produced 5 fails out of 20 samples, but the 6 paired sites all passed, suggesting comparability in the assessment for this feature.

3.35 Overall, successional stage affected overall pass-rate but was not the most reliable or influential factor. Indeed, the percentage that fall into the 'early' successional stage effects the cycle of management for example, where ditches are cleared on a 3-year rotation, 30% would be expected to 'fail' in any given year.

Shade

3.36 Percentage cover of shade was relatively simple to record for both qualitative and quantitative surveys. At Somerset Levels, 4 of the 30 qualitative samples failed this attribute. In the quantitative data, 14 of 20 samples failed. Seasonality may have influenced this divergent result, as qualitative samples taken earlier in the summer (May and July) may have recorded less fully developed in channel and bank-vegetation than would have been recorded later in the year when the quantitative data were collected (July and September).

3.37 At Pevensey Levels, neither site failed on shade cover in the qualitative data. Six of 20 samples failed in the quantitative data. Both surveys were undertaken in September, and so should be comparable.

3.38 At Berney Marshes, none of the 6 sites failed the attribute in the qualitative data. In the quantitative data, 1 of 20 samples failed, suggesting that over shading is not presently an issue at this site.

3.39 In summary, shade affected overall pass-rate but was not the most reliable or influential factor.

Negative indicator species

3.40 At Somerset Levels, the qualitative data produced 5 fails for this attribute, out of 30 samples taken. Quantitative data for the same site reveals 8 out of 20 failures for this attribute, with % covers being more reliably recorded (and this detail is vital in assessing pass or fail dependent upon whether the non-native species is considered to be 'most invasive' where 1% or more cover fails, or simply a non-native where combined cover over 10% fails).

3.41 Pevensey Levels did not record any negative species in the qualitative data (2 samples), but 11 out of 20 samples failed this attribute in the quantitative data. Species lists collected for the qualitative survey were very limited, perhaps because surveyors were not confident in botanical identification, so there is no surprise that a higher number of failures have been recorded in the quantitative survey where detailed botanical recording was undertaken.

3.42 At Berney Marshes, again all sites passed the qualitative assessment for negative species. In the quantitative dataset, only 1 of 20 samples failed on this attribute, reflecting the low incidence recorded in the qualitative survey (although the species recorded was one of the 'most invasive' species (JNCC 2004)).

3.43 These data suggest that negative species are important causes for failures at Somerset Levels and Pevensey Levels, but not so important at Berney Marshes. However, the nature of these species is that once they become established, they spread vigorously so may require management at all sites. In addition, plants such as *Lemna minuta* and algae tend to increase in biomass and percentage cover as the summer season advances, causing potential problems in comparing surveys undertaken too many weeks apart.

Native species richness

3.44 Native species richness is one of the key features for these ditch sites. However, recording accurate occurrence of species in Appendix 2 of JNCC 2004 relies upon detailed botanical identification, including speciation of groups which are notoriously difficult such as *Charophytes*, *Callitriche* and *Potamogeton*.

3.45 In the Somerset Levels qualitative surveys, native species were recorded in detail, with 10 samples failing this attribute out of 30 surveyed. In the quantitative data, 5 out of 20 samples failed on species richness. The mean number of native species recorded quantitatively was 10.55 which compares well with 8.53 for the qualitative data.

3.46 At Pevensey, only summary species were recorded in the qualitative survey, and both sites failed this attribute. In the quantitative data, only 3 of 20 samples failed on native species richness, indicating that qualitative assessments may be under-representing the quality of this attribute where detailed botanical lists are not recorded. Overall, the mean number of native species recorded in the quantitative data was 10.55. This is widely different for qualitative data (3.5) recorded in the same month of the year.

3.47 At Berney Marshes, the qualitative dataset again only recorded summary species lists, and all 6 samples fail on this attribute. In the quantitative data, only 1 of 20 sites fails on native species, although this should be qualified by the use of the 5-species-only target for brackish ditches set out in JNCC 2004. The mean number of native species recorded in the quantitative data was 8.4. This is widely different to the qualitative average number of species (2.83) recorded in November.

Summary of key influencing attributes

3.48 The assessment explained in the previous paragraphs identifies the following attributes as likely key factors in influencing the fail-rate for data collected both qualitatively and quantitatively for this study:

- mean water depth
- macro-algae
- negative species
- native species richness.

3.49 All environmental factors will be examined as part of the quantitative condition assessment, but analyses will focus on investigating the listed factors to establish trends in and causes for condition.

Table 11 Comparison of qualitative and quantitative condition results for lowland freshwater ditches

(* = optional attribute, F = attribute fails assessment, P = attribute passes assessment, N/A = assessed due to incomplete paired data)

Ditch No	Extent		Water depth		Water clarity		Macro-algae		*Conductivity		Channel form		Successional stage		Shade		Negative spp.		Native spp. richness		No of Passes		Comparable?
	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	
KSE1	P	P	P	F	P	N/A	P	P	N/A	N/A	P	N/A	P	P	P	F	P	F	P	F	9	3	No
KSE3	P	P	P	F	P	F	F	F	N/A	N/A	P	P	F	P	P	P	P	P	P	P	7	6	No
KSE5	P	P	P	F	P	P	P	P	N/A	N/A	P	P	P	P	P	P	P	P	P	P	9	8	No
KSE6	P	P	F	F	P	P	F	P	N/A	N/A	P	P	P	P	P	F	P	F	P	P	7	6	No
KSE7	P	P	P	F	P	P	F	F	N/A	N/A	P	P	P	F	P	F	P	P	P	P	8	5	No
KSE8	P	P	P	F	P	P	P	P	N/A	N/A	P	P	P	P	P	F	P	P	F	P	8	7	No
KSW1	P	P	P	P	P	P	P	P	N/A	N/A	F	P	F	P	P	P	P	P	P	P	7	9	No
KSW2	P	P	F	P	P	P	P	P	N/A	N/A	P	P	F	P	P	F	F	F	F	P	5	7	No
KSW3	P	P	F	F	P	P	P	F	N/A	N/A	P	P	P	P	P	P	P	P	P	P	8	7	No
KSW5	P	P	F	F	P	P	P	P	N/A	N/A	F	P	P	P	F	F	F	F	F	F	4	5	No
KSW8	P	P	F	F	P	P	P	P	N/A	N/A	P	P	F	P	P	F	P	F	P	P	7	6	No
KSW9	P	P	P	F	P	P	P	F	N/A	N/A	F	P	F	F	P	P	P	P	F	P	6	6	Yes
NM2	P	P	P	F	P	P	P	P	N/A	N/A	P	P	P	P	F	F	P	F	P	F	8	5	No

Table continued...

Ditch No	Extent		Water depth		Water clarity		Macro-algae		*Conductivity		Channel form		Successional stage		Shade		Negative spp.		Native spp. richness		No of Passes		Comparable?
	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	
NM3	P	P	P	F	P	P	P	P	N/A	N/A	P	F	P	P	P	F	P	P	P	P	9	6	No
NM4	P	P	F	F	P	P	P	F	N/A	N/A	P	F	P	P	P	F	F	P	F	F	6	4	No
NM5	P	P	F	F	P	P	P	P	N/A	N/A	F	P	F	P	P	F	F	F	F	F	4	5	No
NM6	P	P	P	F	P	P	P	P	N/A	N/A	P	P	P	P	P	F	P	P	F	P	8	7	No
NM7	P	P	P	F	P	P	P	P	N/A	N/A	P	P	P	P	P	F	P	P	P	P	9	7	No
NM9	P	P	P	F	P	P	P	F	N/A	N/A	P	P	P	P	P	F	P	P	P	P	9	6	No
NM10	P	P	P	P	F	P	F	F	N/A	N/A	P	P	F	F	P	P	P	F	P	P	6	6	Yes
Total Fails:	**0**	**0**	**7**	**17**	**1**	**1**	**4**	**7**			**4**	**2**	**7**	**3**	**2**	**14**	**4**	**8**	**7**	**5**	**Total Comparable: 2**		

Table continued…

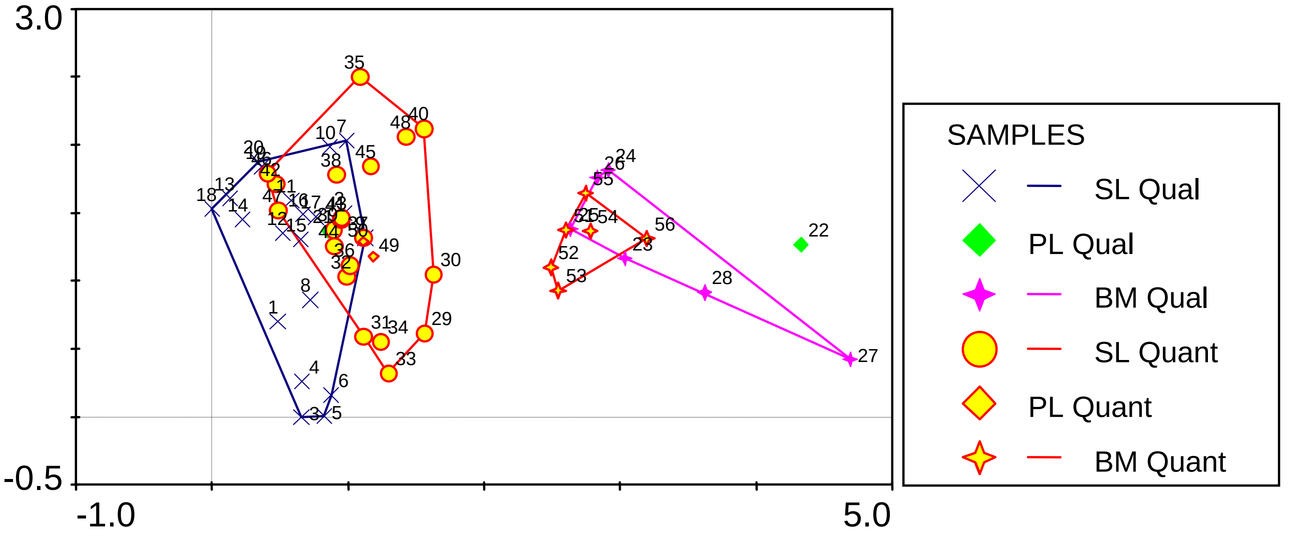
Ditch No.	Extent		Water depth		Water clarity		Macro-algae		*Conductivity		Channel form		Successional stage		Shade		Negative spp.		Native spp. richness		No of Passes		Comparable?
	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative	
PL5	P	P	P	P	P	P	P	P	N/A	N/A	F	F	P	P	P	P	P	F	F	P	7	7	Yes
PL6	P	P	F	F	P	P	P	P	N/A	N/A	F	P	P	P	P	P	P	P	F	P	6	8	No
Total Fails:	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**			**2**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**0**	**Total Comparable: 1**		
BM1	P	P	N/A	N/A	P	P	P	P	P	P	F	P	P	P	P	P	P	P	F	P	7	9	No
BM2	P	P	N/A	N/A	F	P	P	P	P	P	F	P	P	P	P	P	P	F	F	P	6	8	No
BM3	P	P	N/A	N/A	P	P	P	F	P	F	F	P	P	P	P	P	P	P	F	P	7	7	Yes
BM4	P	P	N/A	N/A	P	P	P	F	P	F	F	P	P	P	P	P	P	P	F	P	7	7	Yes
BM5	P	P	N/A	N/A	P	P	P	P	P	P	F	P	P	P	P	P	P	P	F	P	7	9	No
BM6	P	P	N/A	N/A	P	P	P	F	P	P	F	P	P	P	P	P	P	P	F	P	7	8	No
Total Fails:	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**3**	**0**	**2**	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**6**	**0**	**Total Comparable: 2**		

Comparing qualitative and quantitative data using DCA

3.50 Species lists for all 38 paired samples form the qualitative and quantitative analyses were subjected to analysis using the Canoco statistical package (Microcomputer Power) as described in the Methods chapter. The Canoco data generated axes from the species data and placed each sample in its relative position within these. Similarities between species lists collected for qualitative and quantitative datasets could be compared. We would expect to see samples from the same site appearing in the same parts of the ordination plot. However, although full species lists were generated from the quantitative survey, the detail of botanical data collected under the qualitative analysis was variable with good data being available for the Somerset Levels sites, while much less detail was provided for Pevensey Levels and Berney Marshes. This will have affected how closely the qualitative data for those sites reflects the quantitative dataset.

3.51 Figure 1 shows the relative positions of all the samples in relation to the axes generated by the species data with qualitative and quantitative samples for each site identified.

3.52 At Somerset Levels, the KSE and NM data were quite closely positioned on the diagram, indicating close parity between the samples collected following the qualitative method and the more complex and detailed quantitative procedure. The KSW data was also in the same region, but showed some difference in being positioned slightly to the left of the ordination plot. Also, the qualitative data showed wide variation not shown in the quantitative data, possibly reflecting sampler error or generalisation of species data for example, into taxonomic groups rather than species.



Sample numbers correspond with ditches set out in Appendix 3. Envelopes include samples from each site and each method, except PL where too few samples were available. Species points not shown.

Figure 1 Ordination diagram comparing qualitative and quantitative species data (presence/absence)

3.53 As only 2 samples were available for Pevensey Levels, conclusions could not be drawn.

3.54 Results for Berney Marshes were very different from Somerset Levels, with samples located higher up the ordination diagram and neither group intersecting with the other data. This probably reflects the difference in species composition due to the brackish conditions at this site.

Ditch condition using CCA

3.55 Examination of ditch condition was confined to the quantitative dataset, and all 60 samples were included, 20 for each of the 3 locations: Somerset Levels, Pevensey Levels and Berney Marshes. Analyses were run for all data and for each site separately.

3.56 Multivariate ordination techniques applied through the Canoco statistical software package were used. The aim of ordination is to arrange samples so that those close together correspond to samples that are similar in species composition and those samples that are distant are dissimilar in species composition. The ordination diagram summarises large species lists in the light of whatever is known about the environment for each sample. This summary allows detection of patterns in the relations between species and the observed environment.

3.57 The species data was transformed in the Canoco program because the abundance data used had a highly skewed distribution with many small values and a few extremely large values. Jongman et al. (1995) recommend transformation by taking logarithms: loge (yki + 1). This transformation was carried out for all species data used in this analysis. Because species data included overall % cover for some species (floating and submerged) and average % cover for others (floating and emergent), it was considered that this method would allow more representative comparisons between data recorded in the different ways.

3.58 Because of the low number of ditches which passed the condition assessment as set out in Table 5, categories were assigned to each ditch based upon the number of attributes which passed. These are as follows:

- Pass – all attributes passed (9 passes).
- Fail 1 – where only 1 or 2 attributes failed (7 or 8 passes).
- Fail 2 – where 3 or 4 attributes failed (5 or 6 passes).
- Fail 3 – where 5 or more attributes failed (4 or fewer passes).

3.59 Table 12 summarises the numbers of samples which fell into each category at each site.

Table 12 Numbers of samples falling into each condition category, at each of the 3 sites

Category	Somerset Levels	Pevensey Levels	Berney Marshes
Pass (9)	1	2	7
Fail 1 (7 or 8)	6	12	11
Fail 2 (5 or 6)	11	5	2
Fail 3 (<5)	2	1	0

Quantitative Data Only. The number of attribute passes needed is defined under 'Category'

3.60 General points on the interpretation of ordination diagrams are as follows:

- Axes are considered good representatives of the data if the Eigenvalues[5] for Axes 1 and 2 are greater than 0.5.
- Environmental variables with long arrows are more strongly correlated with the ordination axes than those with short arrows, that is, more strongly related to patterns of species shown in the diagram.

[5] Eigenvalues are a measure of the importance of the ordination axis. The first axis has the largest value, the second axis the second largest value and so on. Values of over 0.5 often denote a good separation of species along the axis (Jongman *et al.* 1995)

- Species located at the periphery of the diagram are often rare species (although all analyses down-weighted rare species), located there either because they prefer extremes, because they are rare, or the dataset only contains a few data items and cannot be successfully analysed.
- If the species point lies between the origin and an arrow head, then the variable is more important than average in determining species position in the diagram and abundance in the real world. If the origin is between the species point and the arrow head, then the variable's importance to the species is lower than average in the context of the analysis. Therefore, those species most useful in detecting correlations with axes lie between the centre and the outer edges of the diagram.
- Following the same principles, species at the centre of the diagram may be unrelated to the ordination axes, and are not generally useful in interpreting the analysis.

3.61 Table 13 contains a summary of the Eigenvalues calculated by Canoco for each site.

Table 13 Summary of Eigenvalues for axis 1 to 4 at each of the 3 survey sites

	Axis 1	Axis 2	Axis 3	Axis 4	
Somerset Levels CCA					
Eigenvalues	0.433	0.288	0.234	0.172	
Species-environment correlations	0.98	0.951	0.88	0.962	
Cumulative percentage variance					
of species data	16.8	28	37.1	43.8	
of species-environment relation	24.8	41.2	54.5	64.4	
Sum of all Eigenvalues					2.572
Pevensey Levels CCA					
Eigenvalues	0.454	0.354	0.272	0.248	
Species-environment correlations	0.975	0.989	0.932	0.985	
Cumulative percentage variance					
of species data	15.3	27.3	36.5	44.9	
of species-environment relation	21.9	39	52.1	64.1	
Sum of all Eigenvalues					2.96

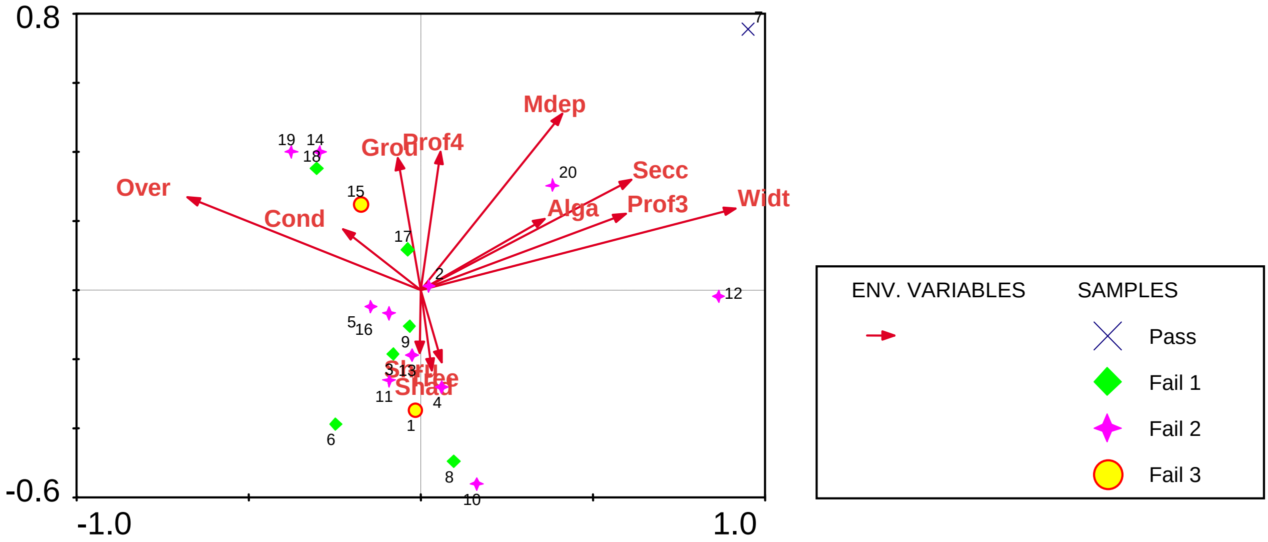
Table continued...

	Axis 1	Axis 2	Axis 3	Axis 4	
Berney Marshes CCA					
Eigenvalues	0.217	0.11	0.084	0.062	
Species-environment correlations	0.888	0.795	0.722	0.8	
Cumulative percentage variance					
of species data	17.2	25.9	32.6	37.5	
of species-environment relation	35.1	52.8	66.5	76.5	
Sum of all Eigenvalues					1.26
All Sites CCA					
Eigenvalues	0.297	0.159	0.15	0.122	
Species-environment correlations	0.896	0.87	0.802	0.804	
Cumulative percentage variance					
of species data	8.5	13.1	17.4	20.9	
of species-environment relation	26.1	40.1	53.3	64.1	
Sum of all Eigenvalues					3.487
All Sites DCA					
Eigenvalues	0.395	0.231	0.169	0.144	
Species-environment correlations	3.077	2.85	2.207	2.532	
Cumulative percentage variance					
of species data	11.3	17.9	22.8	26.9	
Sum of all Eigenvalues					3.487

Somerset Levels

3.62 The CCA analysis resulted in Eigenvalues of 0.433 and 0.288 for axes 1 and 2 respectively. Axis 1 (the x-axis) accounts for 24.8% of the variance seen in species data, while Axis 2 accounts for a further 16.4%. The cumulative percentage variance of the species-environment relation for Axes 1 and 2 is 41.2%. Axes 3 and 4 account for 13.3% and 9.9% respectively, leaving 35.6% not accounted for by the analysis. This suggests that there are other variables, not measured in this study, which could help to explain species variance between and within sites.

3.63 Figure 2 shows the CCA ordination diagram for samples and environmental variables. Ditch width (Widt) and overhanging vegetation (Over) are most strongly correlated with the axes, because their arrows are longest. Width and shading would be expected to be inversely related as % cover shaded would typically decrease on wider ditches. The single samples which passed the assessment are located at the far top right of the diagram, suggesting that conditions here were not typical of the site. Eleven failed samples lie below the x-axis and seem closely correlated with shading (Shad, Tree, Shru).



Sample numbers correspond with ditches set out in Appendix 4. Pass and fail categories are shown.

Figure 2 Somerset Levels: Ordination diagram of quantitative data – Samples and environmental variables

3.64 Figure 3 shows the species positions in the ordination diagram, overlaid with environmental variables. The open water species can be seen to dominate in the top right quadrant, associated as expected with greater depth and width, and a deeper euphotic zone. To the left of the diagram more terrestrial and semi-terrestrial species are located, for example, *Deschampsia cespitosa*, *Juncus articulatus, J. inflexus, J. effusus, J. subnodulosus, Lysimachia nummularia, Carex otrubae, Angelica sylvestris, Myosotis laxa, Galium palustris, Epilobium hirsutum, E. parvifolia, Agrostis stolonifera* and *Solanum dulcamara*. The location of sample 7 in the extreme top right suggests that the majority of ditches at Somerset Levels are too far towards the terrestrial to achieve their condition targets. This would broadly tally with findings explained from the qualitative analysis, where water depth and native species richness were identified as key factors in failures. However, successional stage was also identified and the criterion (Table 4) was that this attribute should fail if ditches were in 'early' succession, ie recently cleared out – somewhat at odds with a conclusion of increased terrestrialisation. Water depth as a key factor in failures was also identified in the quantitative condition assessment, supporting the argument for over-terrestrialisation at the Somerset Levels sites.

3.65 In both diagrams the axes are short, so caution needs to be applied to any conclusions drawn, as they may not be founded on strong correlations between species and environment variables.

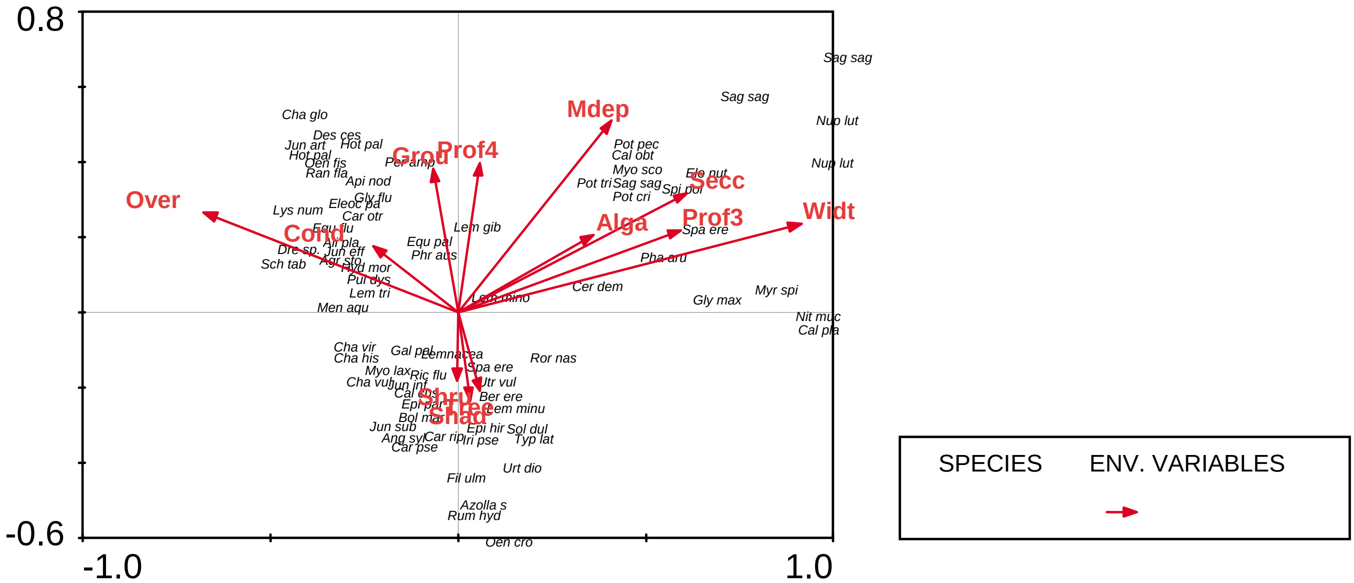
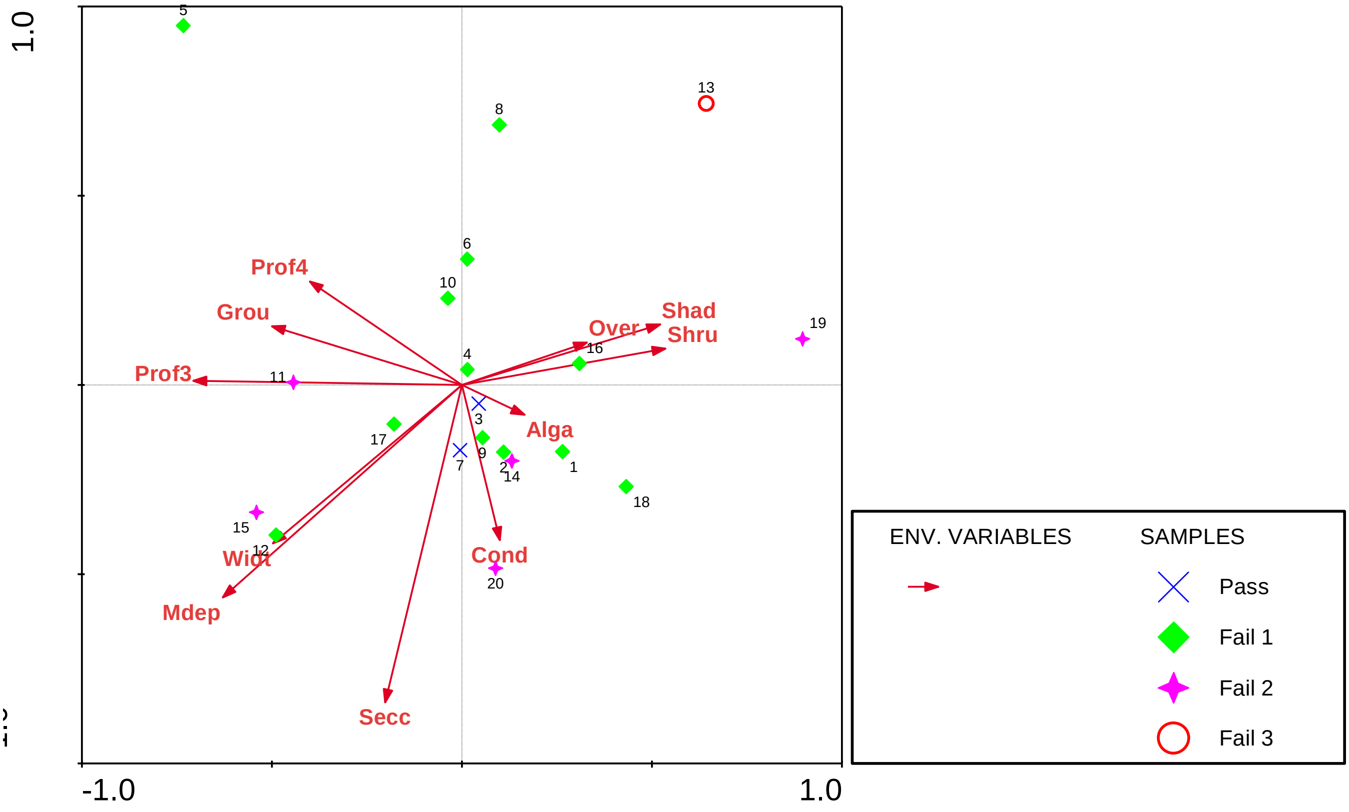


Figure 3 Somerset Levels: CCA ordination diagram of quantitative data – Species and environmental variables

Pevensey Levels

3.66 The CCA analysis for Pevensey Levels resulted in Eigenvalues of 0.454 and 0.354 for Axes 1 and 2 respectively. Axis 1 (the x-axis) accounts for 21.9% of the variance seen in species data, while Axis 2 accounts for a further 17.1%. The cumulative percentage variance of the species-environment relation for Axes 1 and 2 is 39%. Axes 3 and 4 account for 13.1% and 12% respectively, leaving 35.9% not accounted for by the analysis.

3.67 Figure 4 shows the CCA ordination diagram for samples and environmental variables for Pevensey Levels. Profile (Prof3), Secchi depth (Secc) and mean depth (Mdep) are most strongly correlated with the axes, because their arrows are longest. The 2 passes are close to the origin. Many of the ‘Fail 1’ samples appear inversely correlated to profile, Secchi measurement and mean depth. The ‘Fail 2’ samples are widely distributed around the ordination space. The ‘Fail 3’ sample was in the quandrant of the diagram associated with shading (Over, Shad, Shru).



Sample numbers correspond with ditches set out in Appendix 4. Pass and fail categories are shown.

Figure 4 Pevensey Levels: CCA ordination diagram of quantitative data – Samples and environmental variables

3.68 Figure 5 presents the species positions in the ordination space, overlaid with environmental variables. The dense area of species to the right of the vertical axis contains many terrestrial species, suggesting most of the samples here are affected by drying. This part of the diagram is associated with the environmental variables for overhanging vegetation, shading and bankside shrub cover. The 2 'Pass' samples were located close to the centre of the diagram suggesting that it is the more extreme conditions in other ditches that make them less able to achieve targets, for example, terrestrialisation for samples in the right 2 quadrants.

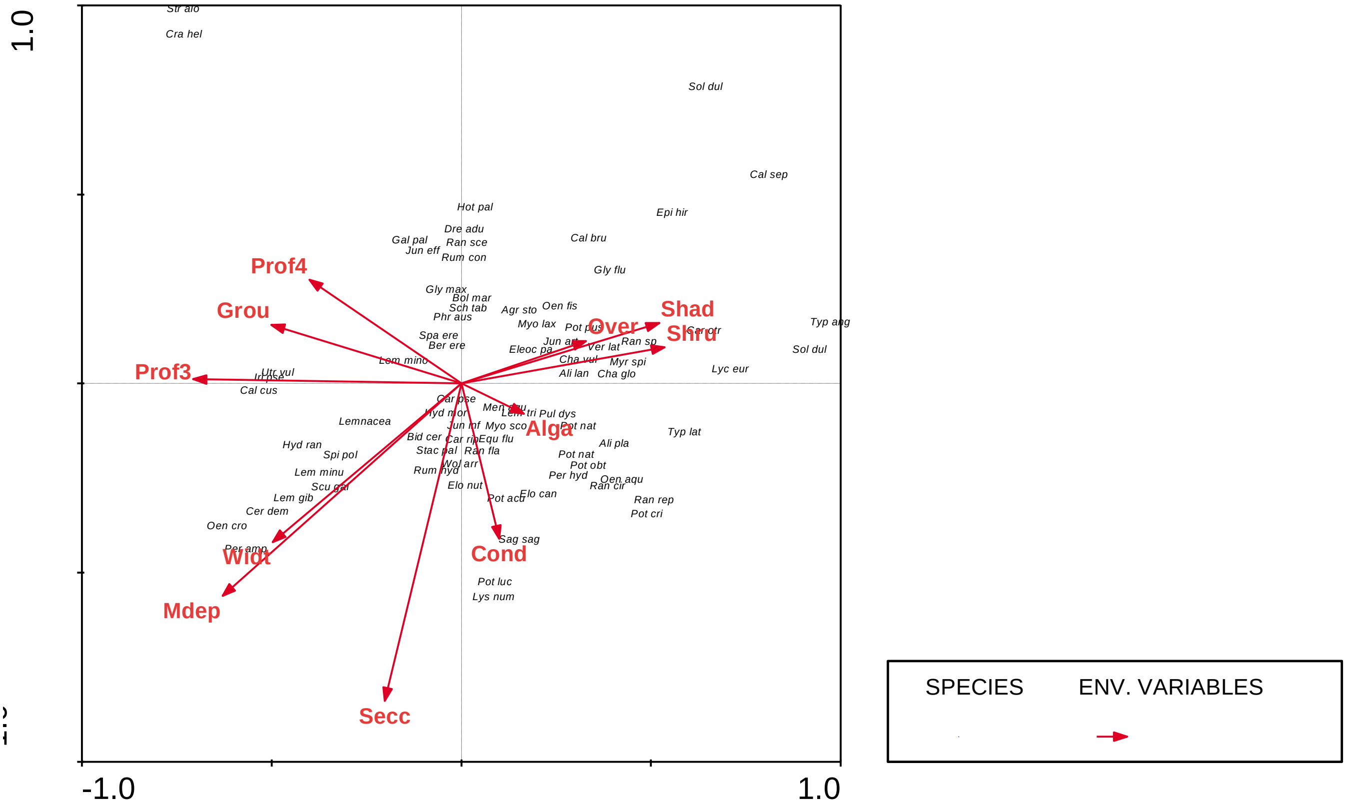
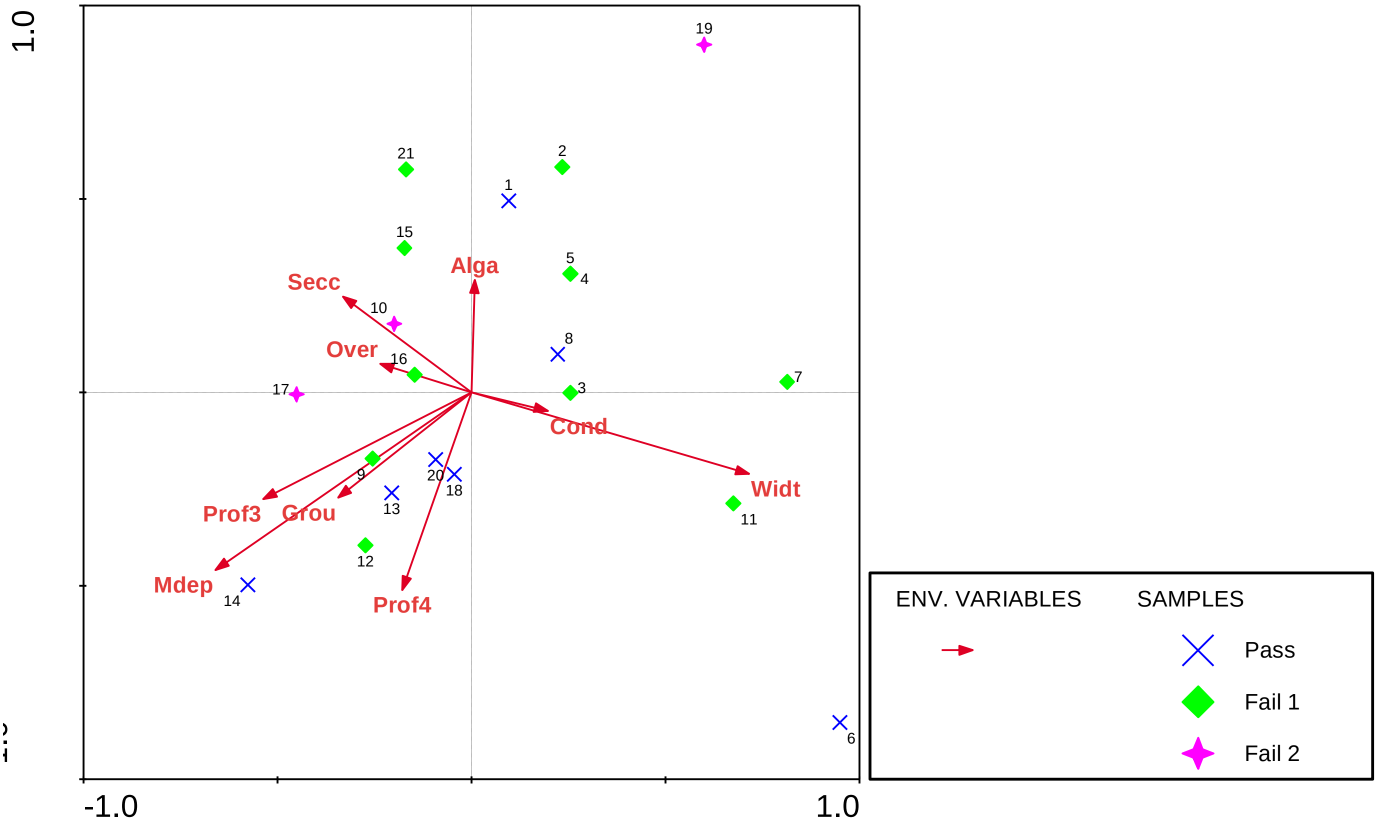


Figure 5 Pevensey Levels: CCA ordination diagram of quantitative data – Species and environmental variables

Berney Marshes

3.69 The CCA analysis for Pevensey Levels resulted in Eigenvalues of 0.217 and 0.11 for Axes 1 and 2 respectively. Axis 1 (the x-axis) accounts for 17.2% of the variance seen in species and environment data, while Axis 2 accounts for a further 17.7%. The cumulative percentage variance of the species-environment relation for axes 1 and 2 is 35.1%. Axes 3 and 4 account for 13.7% and 10% respectively, leaving 23.5% not accounted for by the analysis.

3.70 Figure 6 the CCA ordination diagram for samples and environmental variables at Berney Marshes. The diagram shows ‘Pass’ samples distributed in the top right and bottom left quadrants, along axes most closely associated with width, depth and algae. Width and depth have obvious consequences for vegetation, with higher mean depth being important for 4 of the 6 passes. Higher occurrence of algae is expected at brackish sites, especially of *Enteromorpha*, but this species does not count toward algal cover in either survey methodologies, leaving algae indicating a potential nutrient-enrichment issue at this site. Unfortunately, qualitative surveys were undertaken too late in the year to pick-up independent evidence to support this. ‘Fail 1’ samples are spread all over the diagram, suggesting no strong correlation with particular environmental factors. ‘Fail 2’ samples seem most closely associated with overhanging (Over) vegetation (terrestrialisation again), poor water clarity (Secc) and algae (Alga), although the short lengths of these arrows suggest poor correlation.



Sample numbers correspond with ditches set out in Appendix 4. Pass and fail categories are shown.

Figure 6 Berney Marshes: CCA ordination diagram of quantitative data – Samples and environmental variables

3.71 Figure 7 presents the species positions in the ordination diagram, overlaid with environmental variables. The diagram is less cluttered with species than for the other 2 sites – botanical species diversity is typically lower at brackish sites. Also evident is the lower incidence of terrestrial and semi-terrestrial species (only *Juncus articulatus, Alopecurus geniculatus, Equisetum arvense* and *Agrostis stolonifera* were recorded). These species were located in the top left quadrant (away from the ‘Pass’ samples), supporting the idea that terrestrialisation (or later succession) is associated with poorer ditch condition.

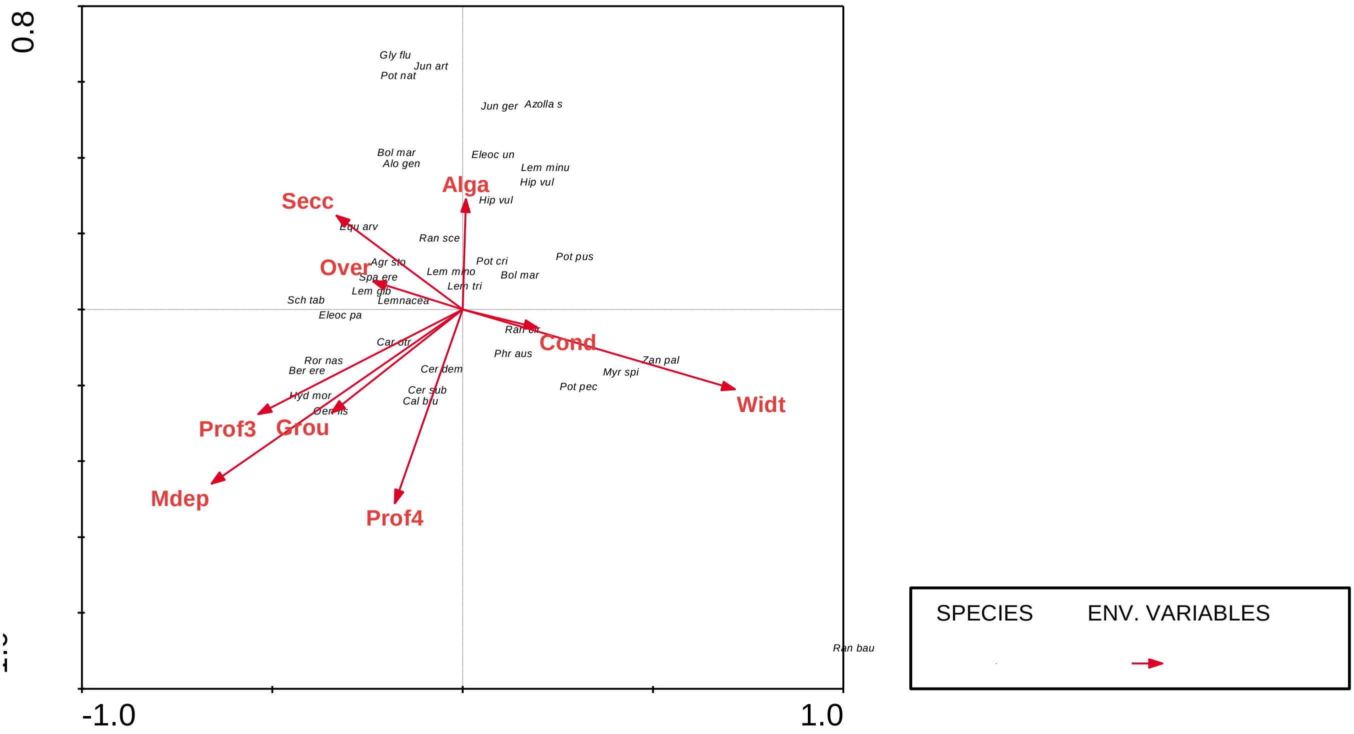
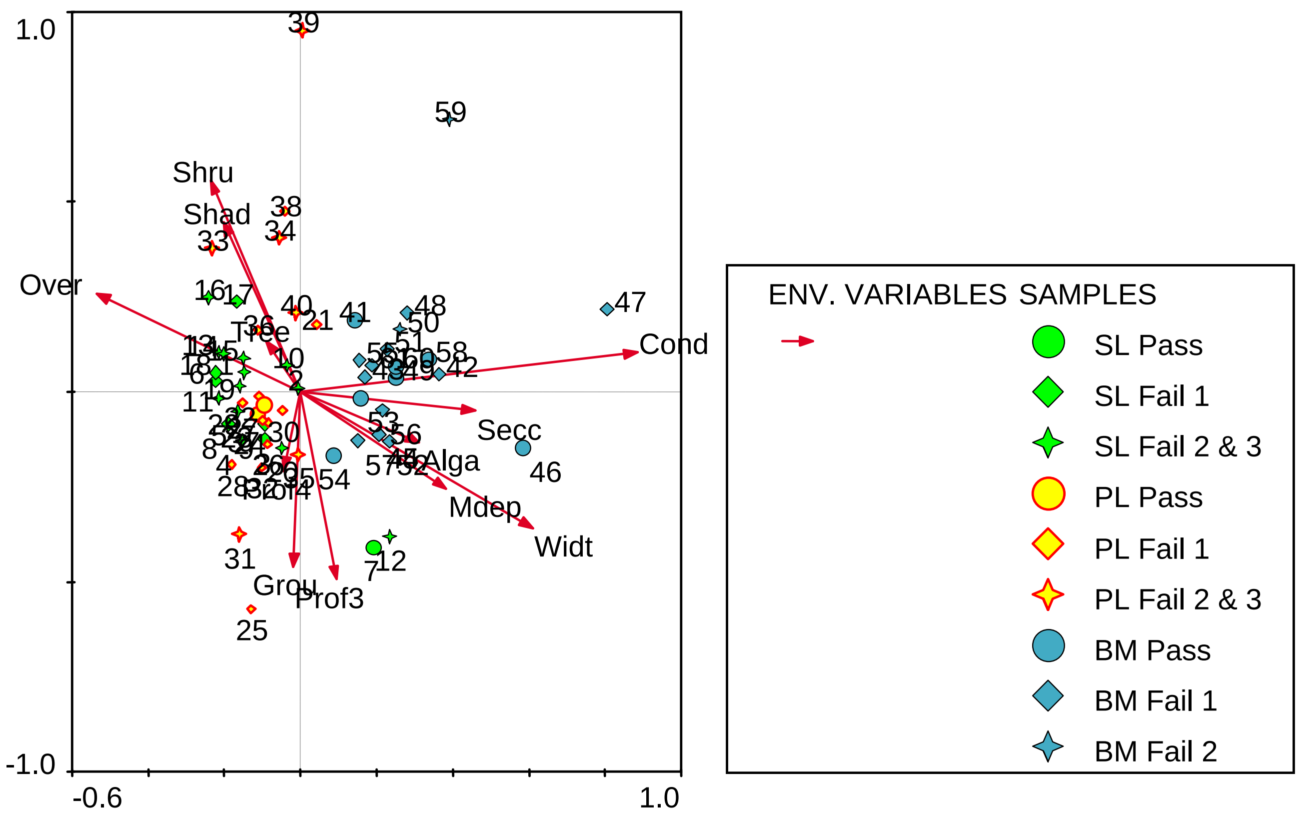


Figure 7 Berney Marshes: CCA ordination diagram of quantitative data – Species and environmental variables

All sites

3.72 The CCA analysis for all the sites at once, resulted in Eigenvalues of 0.297 and 0.159 for Axes 1 and 2. Overall, Axis 1 accounted for 26.1% of the cumulative variance in species-environment data, while Axis 2 accounted for a further 14%. Axes 3 and 4 accounted for 13.2% and 10.8% respectively, with 35.9% not accounted for by the analysis.

3.73 Figure 8 presents the CCA ordination diagram for all the 61 samples overlaid with environmental variables. The samples for the different sites are differentiated well from each other, on axes most closely allied to conductivity (Cond) (x) and shading (Shru, Shad)/profile (Prof3). As would be expected, the brackish ditches at Berney Marshes are all associated with higher conductivity. Pevensey Levels ditches lie almost parallel with the vertical axis, with the 2 ‘Pass’ samples near to the centre of the ordination diagram. Somerset Levels ditches are located to the left of the vertical axis, and closer to environmental variables related to later successional stages and terrestrialisation.



Sample numbers correspond with ditches set out in Appendix 4. Pass and fail categories are shown for all sites.

Figure 8 All Sites: CCA ordination diagram of quantitative data – Samples and environmental variables

3.74 Figure 9 shows all the species recorded in the 61 sites, distributed upon the same environmental axes. Terrestrial species (and some not listed in Appendices 1 and 2 of JNCC 2004) are located to the left of the vertical axis, associated more closely with environmental variables for increased shading (Shru, Shad) and overhanging vegetation (Over). To the right are the more open water species, and all the ‘Pass’ samples for Berney Marshes and Somerset Levels lie here.

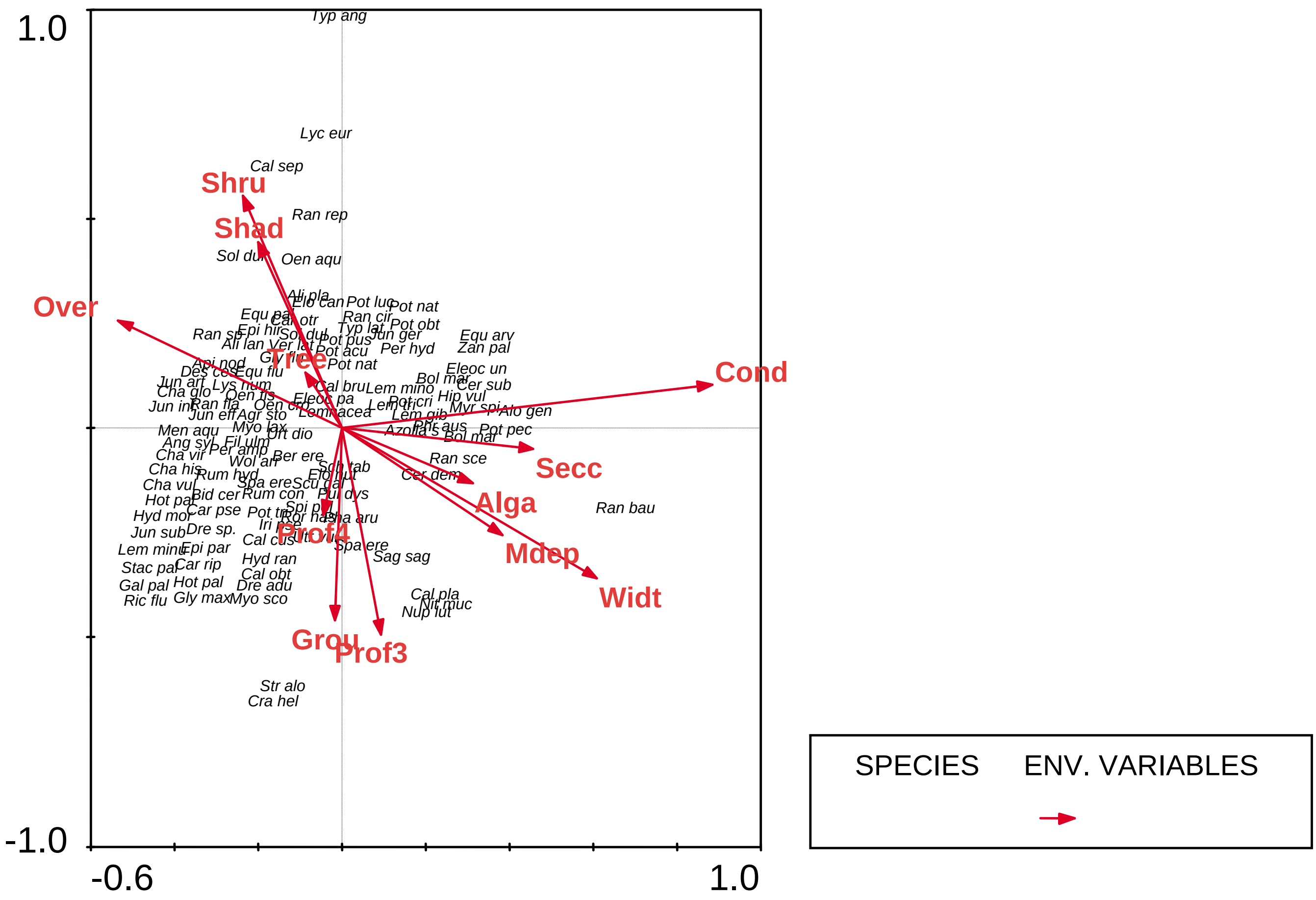


Figure 9 All Sites: CCA ordination diagram of quantitative data – Species and environmental variables

Ditch condition using DCA

3.75 This analysis was carried out to check the validity of the environmental data used for the CCA analysis described above. The idea was that if another strong factor was influencing species occurrence, then this would show by running a DCA without environmental data on the full species data for all the quantitatively sampled sites.

3.76 The DCA analysis of the species data produced Eigenvalues of 0.395 and 0.231 for Axis 1 and Axis 2 respectively. Jointly they account for 17.9% of the percentage variance in the species data, individually for 11.3% and 6.6% respectively. Overall, 73.1% of variance in species is not accounted for by the analysis, suggesting that CCA analyses explain the data better.

3.77 Nonetheless, Figure 10 shows a DCA ordination diagram of the quantitatively sampled species only, locating samples within the diagram. This was examined to see if other factors could be responsible for a wider and more informative separation of the data (DCA uses the species data only to generate the axes). All data is more closely clustered, with Berney Marshes distinct as before. Pevensey and Somerset Levels are overlapping but slightly different in their overall position, also seen before. Terrestrial species remain to the left of the vertical axis, reflecting a slight differentiation also shown in the CCA diagrams. This analysis suggests that the environmental variables recorded in this study are as effective as any in investigating patterns of species occurrence. There may be better measures for some variables though – see Conclusions.

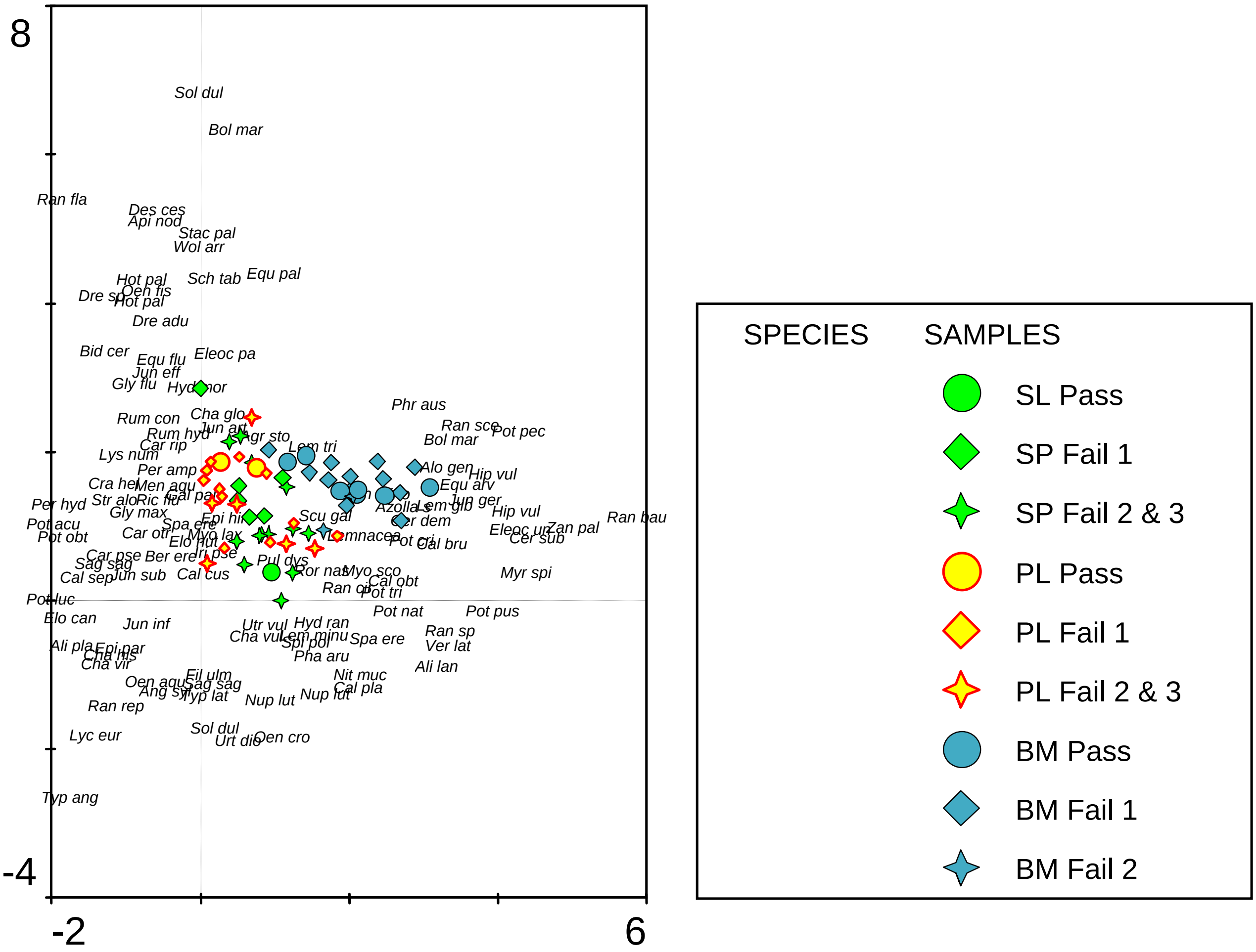


Figure 10 All Sites: DCA ordination diagram of quantitative data – Species only

4 Conclusions

4.1 This study has set out to evaluate the effectiveness of the monitoring system, to examine the comparability of the data collected and to suggest means of improving the monitoring methods.

Evaluation of current system

4.2 Condition monitoring for SSSIs sets out to be accurate, consistent and scientifically robust. The achievement of these fundamental objectives is the main topic for discussion in this chapter. At the end, suggestions are made to address shortcomings of the methods as highlighted by the analysis undertaken for this study.

Qualitative data

4.3 This study revealed wide variability in the qualitative data recording, with the following key points:

- Different proformas from the 2004 guidance were used by surveyors at different sites, that is, some used Appendix 4, some 5, some both. For the purpose of comparing this data with the quantitative data, field information needed to relate to the same 20m section, that is, the Appendix 5 form should have been used.
- Information was recorded differently – this was partly because the 2 proformas asked for slightly different information and format. However, where the targets needed %cover, this was not always recorded.
- Not present had to be assumed in many cases where the proformas were blank. For example, negative species - because the rest of the form was sparsely completed it was not always clear if the attribute had been assessed and found not present, or just not assessed.
- Varying botanical expertise caused an obvious differential in the data received. As number of species listed in Appendix 2 of the Guidance is an attribute for favourable/unfavourable condition, accurate and through recording is important. However, many species are difficult for non-botanists to identify. Where surveyors recorded botanical species lists in great detail, the Appendix 5 proforma did not have space for all the species recorded.
- DAFOR was rarely recorded in any of the samples, with presence only being indicated in most cases.
- Numbers of sites sampled – recording at Pevensey Levels where only 2 ditches were sampled – was too small to allow robust comparisons with the quantitative data, or to effectively evaluate a site at all.
- Timing of surveys – twenty ditch surveys were undertaken in May (before the recommended survey season), 1 set of 2 samples was collected in late September and 1 set of 6 samples were collected in November (both well after the end of the stated survey period). That leaves only 10 CSM sites sampled in the correct period, according to the Guidance. Wide variability in aquatic species visible for recording must have resulted from this 7 month dispersion in sampling dates.
- Equipment – not all survey teams used a conductivity meter – this was assumed to be because they did not have one. If conductivity is an important attribute, then survey equipment must be available to staff, along with adequate training in using such equipment.

4.4 The list above shows that consistency between CSM surveys at the different sites studied was poor. It appeared that, although individual area teams had run training on the guidance and the surveys themselves, there was no overall lead taken. Added to this was apparent confusion over which proformas to use.

4.5 For the next round of validation, the following measures are recommended:

- Update both field survey proformas (Appendices 4 & 5 of the guidance) to include clearer instructions to the surveyor as to the information needed for example, % cover. These should also ensure that the information recorded helps to determine the target as inconsistencies were found between the proformas and the targets measures set out in Table 1 of the 2004 Guidance. The Appendix 5 proforma of the guidance should be extended to allow more species recording with a lined table with 10 columns for each transect sample.
- National training for all ditch-monitoring staff to ensure consistency in approach across Natural England. This would address a) how to apply the guidance and conduct field surveys, and b) cover detailed ID of ditch species on Appendix 1 and 2 of the guidance.
- Full suite of ditches should be assessed at all the sites. Somerset Levels ditches were well represented in the 2005 dataset with 30 samples collected, and plenty of detail given on species occurrence. Pevensey Levels and Berney Marshes were not so well represented, making conclusions hard to draw from the data.

4.6 Alternatively, survey work could be completed by a national specialist team, or it could be put out to contractor as was done with the quantitative survey. These options offer the inherent benefit of a more consistent approach, which could also be achieved by field officers with training on guidance and field techniques. This training of own staff approach has been used by other organisations to achieve good levels of consistency for example, the Environment Agency's river habitat survey.

Quantitative data

4.7 The data received was highly consistent and generally of good quality, neatly presented (if not in a readily useable format for statistics packages), with full and detailed species lists and all environmental variables recorded at all sites. These data were all collected by a single contractor with specialist botanical expertise covering key ditch groups such as *Potamogeton* and *Charophytes*. If, in future studies, these data are all entered into spreadsheet table matrix with samples along one direction and species and environmental variables along the other, then much re-working and potential for mis-typing would be removed from running a similar comparison to this of qualitative and quantitative data.

4.8 Species recording was by % biomass of submerged species and % cover of other emergent and floating species. These are not directly comparable, but it is difficult to see how else the different growth types could be recorded. In the analysis, log transformations were used which would hopefully smooth out distortions to the data caused by using slightly different measures.

4.9 In terms of the environmental variables recorded, turbidity and peatiness scales were not used, because they were not considered robust data for multivariate statistics. Turbidity was considered well covered by the Secchi disc measurement. Peatiness would also feature in the Secchi depth measurement, but could be more empirically recorded using the hazen scale (mg/l Pt/Co) for filtered colour (excluding suspended material). Water samples are collected and compared to a hazen colour chart, sent off for analysis or analysed using a dedicated machine (can be expensive to buy).

4.10 Channel form was a difficult environmental variable to represent. This study focussed upon looking at ditch profile and several methods were tried including a) taking a ratio of width to maximum depth, b) calculating the difference between the observed profile and a standard 'ideal' V-shaped ditch, termed 'Prof3', and c) calculating the ratio between the difference from a V-shaped ditch and the difference from a U-shaped ditch, termed 'Prof4'. The data analysis indicated that vegetation showed most connection to the second model, 'Prof3', as the arrows were invariably longer in the ordination studies. However, this failed to represent the ideal ditch system that would contain ditches of a range of shapes and in all stages of successional advancement. For example, the presence of poaching and berms is good as long as there is not too much, as is a new, deep U-shaped ditch.

4.11 An alternative approach might be to consider a scoring scheme for habitat features present in the 20m section, for example, open water, vertical banks, sloping banks, berms, poaching, tussocky vegetation. In this approach, higher scores would reflect more diverse habitat. Equally, it may be relevant to measure the 'freeboard' which is the distance from the water surface to the bank top. Conversations with local officers indicate that this is a key measure in ditch quality with ditches with a shallower freeboard offering better habitat for wider range of plants and other species.

4.12 Successional stage was recorded but not used in the analysis because of its direct relation to the vegetation data.

Comparability of qualitative and quantitative methods

4.13 The JNCC 2004 Guidance is aimed at condition monitoring for whole ditch networks. Targets for passing and failing had to be altered to apply to individual ditch sections within this study. In both the qualitative and quantitative data, this resulted in fairly arbitrary decisions about ditch pass or failure for some attributes, for example, channel form and successional stage. These decisions did not necessarily reflect the ditch condition within its context in the wider SSSI.

4.14 The comparison of attribute passes and failures resulted in poor comparability of attributes between the assessment methods (Table 10). Generally, qualitative assessments resulted in better pass-rates than quantitative assessments. However, this pattern applied mainly to the Somerset Levels data where 30 samples were collected qualitatively and these were recorded with full species lists. The reverse pattern was noted for Pevensey Levels and Berney Marshes were species recording was poor in the qualitative samples, but the sites achieved better pass-rates in the quantitative analysis.

4.15 However, there was overall comparability in that water depth and native species richness were the key attributes causing failures in both qualitative and quantitative datasets. Water depth is clearly a key attribute upon which all the others depend and must already be a priority management objective at all ditch SSSIs in England. Native species richness depends upon a range of environmental factors, as well as botanical competence and seasonal timing, which both influenced the results for this study and would be addressed through appropriate training initiatives for survey staff. Macro-algae and negative species also showed as important attributes causing fails for both qualitative and quantitative datasets.

4.16 In addition, the analysis of the more detailed quantitative data indicated that environmental variables already considered by the CSM assessment remain the key factors although a significant amount of vegetation variation was unexplained by any of the environmental measurements. Therefore, this suggests that the CSM is looking at the right factors, but just needs to be clearer in how these are recorded.

Implications and improvements for Common Standards Monitoring

4.17 Rationales for suggested improvements are discussed above. These can be summarised as follows:

- Initiate consistency training for field surveyors in applying the ditch monitoring methods and guidance.
- Amend monitoring proformas to be more consistent with targets, and to include more species recording space.
- Ensure all field survey personnel have appropriate equipment and botanical skills.

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Appendix 1 Validation monitoring on lowland wet ditches: Survey Report: N.F. Stewart, Dec 2005

Introduction

The country conservation agencies and the Joint Nature Conservation Committee are currently undertaking a major review of the state of the Sites of Special Scientific Interest. This has required the development of survey methods for assessing the quality of different habitats, generally referred to as "Common Standards Monitoring". In many cases this has required the development of new survey methods, the aim being to find a balance between simplicity and the need for only semi-specialist surveyors while collecting data that is meaningful in terms of assessing habitat quality.

The method for surveying ditches has been drafted (JNCC March 2005) but has not been fully field tested. The aim of this survey was to collect more detailed botanical data from ditches which were also the subject of the more rapid Common Standards Monitoring Surveys during 2005 in order to assess the effectiveness of the latter method. The data from this survey will be used in a correlative analysis between the two methods which is beyond the scope of this report. However, a number of issues arose during this survey which need clarification, both in terms of interpretation of the data and more general issues that need further discussion.

Methods

20 sample ditches were selected for survey in each of three ditch SSSIs in England, the Somerset Levels (8 in Nailsea Moor, 12 in King's Sedgemoor), Halvergate Marshes, Norfolk (all in Berney Marshes) and Pevensey Levels, East Sussex. The survey work was undertaken between June and September 2005.

In the Somerset Levels, the selected ditches were chosen from those previously selected by English Nature for Common Standards Monitoring. In the Somerset Levels, the ditches were selected in consultation with staff of RSPB (Berney Marshes) and English Nature (Pevensey Levels) with the aim of including a range of ditch types as well as some geographic spread. Common Standards Monitoring surveys have subsequently been undertaken in most cases.

At each ditch, a 20 metre section was selected. In two sectors of the Somerset Levels (Nailsea Moor and eastern area in King's Sedgemoor) the location of these sections was the same as that used in the English Nature Common Standards Monitoring Survey. For the remainder, this information was not available, or the ditches had not already been surveyed. For these, the location was pre-selected by using random numbers (generated from car registration plates, using the last number of old-style plates with three-figure numbers). The section was selected at part of the way along the ditch, avoiding the 5 metres at each end and any culverts. The direction used in this calculation was in all cases south to north except in the few cases where the ditch ran due east-west, in which case the west end was considered the start point. The start and end point of the ditch section was also oriented in the same manner.

Table A Summary of ditch types in the three survey areas

	Somerset Levels	Berney Marshes	Pevensey Levels
Floating *Lemnaceae* dominant	4	3	1
Lemna trisulca/floating *Lemnaceae*	1	6	
Lemna trisulca/Hydrocharis	4	4	5
Mixed submerged macrophytes	5	6	5
Nuphar/Sagittaria	1		
Hydrocotyle ranunculoides/Lemna			3
Stratiotes aloides			1
Shade dominated (+/- *Lemna*)	2		1
Swamp dominated (+/- *Lemna*)	3		3
Unvegetated		1	
Dry (*Agrostis/Glyceria/Callitriche*)			1

The data collected almost entirely related to the 20 metre section. For each section the following general data was collected:

- Date.
- Surveyor.
- GPS start and end point.
- Water clarity - several methods used; see later discussion.
- Water peatiness - 5 point scale.
- Conductivity.
- Ditch width.
- Ditch profile - water depth recorded at 50cm intervals from the water's edge to the midpoint or edge of reach whichever was the further.
- Successional stage - classified as "early", "mid" or "late". Also assessed for the ditch segment as a whole.
- Bankside percentage vegetation cover, subdivided into ground layer, shrub layer and tree layer.
- Percentage of ditch channel overhung by bank vegetation and by tree/shrub shade.

Within the 20 metre section, 10 sub-sample points were used at 2 metre intervals. At each sub-sample point, the following botanical data was recorded:

- Biomass percentage of each submerged and floating macrophyte species based on a grapnel trawl.
- Estimated total percentage cover and DAFOR rating of submerged and floating macrophytes and of macro-algae.
- Estimated cover of each floating species in a c.50 cm across the ditch with floating duckweeds recorded collectively.
- Estimated cover of each emergent species growing in the water in a c.50 cm strip across the ditch.

An overall percentage cover and DAFOR rating for each submerged and floating macrophyte species was estimated for the whole 20 metre section.

In all cases, percentages were estimated usually to 10% or sometimes 5% except where the cover was very low (0-5%) or very high (95-100%). When estimating aquatic macrophyte biomasses, the lesser components were usually assessed first and the dominant species adjusted up or down to ensure a total of 100%.

DAFOR ratings were based on; Rare <3% cover, Occasional 4-10% cover, Frequent 11-30% cover, Abundant 31-70% cover, Dominant 71-100% cover.

Definitions and problem areas

Water clarity

The initial intention was to do Secchi disc reading at five points along the 20 metre section. This was extremely problematic for several reasons;

- Many ditches sampled had Secchi depths much greater than the ditch depth.
- The disc is hung from a string which involves leaning out over the ditch or wading in (if shallow enough) with consequent stirring up of the sediment.
- In duckweed-covered ditches it was often difficult to keep an opening in the cover long enough to make a reading. The shade of the duckweed itself probably also reduced the light reaching the disc, reducing the depth reading.
- The disc often settled on ditch vegetation (submerged and emergent).

An improved method was to use a ranging pole in stead of the disc. In this survey, a folding 2-metre rule was used as a ranging pole. It was useful to fold out one section of the rule so that it was horizontal, giving more area to assess the extinction point. Where it was possible to do both methods, the "Secchi pole" tended to give a reading 10% less than the Secchi disc, except in one ditch (BM18) where the turbidity was pale brown clay particles of similar colour to the metre rule where the reading was 20% less. The advantage of using a pole was that it was much easier to direct the part to be viewed into locations where it was easier to see, for example, beyond duckweed accumulations at the ditch edge or in gaps in submerged vegetation. It was also easier to create a hole in the duckweed cover and make a reading before it closed in. However, there was still a majority of the ditches surveyed where the Secchi depth was greater than the ditch depth.

A five point scale was therefore used which was more qualitative but seemed fairly practical. Similar scales have been used in other ditch surveys.

1) Completely clear.
2) Slightly turbid - fairly clear but with a hint of turbidity.
3) Moderately turbid - possible to just make out the ditch bottom or vegetation at 50 cm.
4) Turbid - visibility c.20-50cm.
5) Very turbid - visibility <20cm.

Peatiness

This was not originally considered for inclusion in the survey but was noted in most of the ditches surveyed. A five point scale was used.

1) Colourless - gin.
2) Slight colour - lemon juice.
3) Moderate colour - white wine (for example, deeper coloured type such as Chardonnay).
4) Peaty - weak tea.
5) Very peaty - black coffee.

This system is usable where the water is fairly clear but breaks down in more turbid water where other colours predominate. These colours were noted but no attempt was made to scale them.

Conductivity

Measured in microSiemens per centimetre with a "Fox box" meter.

Ditch profile

Depths were taken to the level where some (slight) resistance was felt with the ranging pole. This is a matter of practicality because where visibility is low due to turbidity or vegetation cover it is difficult to assess the exact level of the sediment surface. Very soft aqueous sediments on the surface of the ditch bottom are therefore included in the ditch depths.

In a few cases, there was a floating raft of vegetation on a turf mat. In these cases, both the depth to the raft turf and the depth to the bottom were recorded. The latter was measured by piercing through the raft turf with the ranging pole but any soft sediment on the base would have been difficult to "feel".

Successional stage

This feature was based on the definition in the Common Standards Monitoring guidelines (JNCC 2005). Late succession ditches were defined as greater than c.70% emergent cover across the middle of the ditch. The guidelines define early succession as "those that have been de-silted or reprofiled in the same year as the monitoring visit and so contain little aquatic plant growth". This appears to be quite a narrow definition as most ditches quickly vegetate with submerged and floating plants (particularly duckweeds) unless they have been very heavily dredged. In practice only one ditch probably fitted this definition (BM18) and a broader definition was used here. This was based on emergent cover of less than 10% across the middle of the ditch (that is, excluding the marginal band) rather than using the submerged or floating aquatic flora. Nevertheless, there were examples which had obviously been slubbed out within the preceding year which still had sufficient emergents to classify as mid-succession, while ditches that had been well-dredged more than a year previously could have a well-developed aquatic community with few mid-channel emergents.

Successional stage was usually assessed lengthways along the line of the ditch but variation also occurred across the ditch. This was a particular issue with some of the larger ditches where the main channel is probably dredged regularly (often at least annually), while a broad margin may be left untouched and have the character of a late succession ditch (including rafting swamp). In these cases, the difference has been accounted for in the percentages of successional stage and the fact noted in the comments.

Bankside vegetation and overhanging vegetation

The bank was taken up to an obvious break of slope but not more than 2 metres above the water. Some doubt occurred over whether to classify bramble as ground layer or shrub layer. Generally, significant bramble patches were classified as shrub layer but this has mostly been noted in the data where it was an issue.

Reduced ground layer cover occurred mainly in four situations:

- Where grazing was present.
- Where there was significant tree or shrub shade.
- Where the bank was very steep/vertical, although not always associated with obvious erosion.
- Where there had been recent dredging/ditch restoration.

In a few cases where the ditch had been significantly lowered, a bare draw down zone had been exposed. This has been noted where it was an issue.

Overhanging tree/shrub shade was not initially included in the survey scope but was included because of the impact of significant shade on the ditch vegetation. The two were not distinguished although there are differences in their impact, that is, shrub shade tends to be denser but with less leaf litter.

Aquatic biomass proportions

A particular problem when assessing aquatic vegetation quantitatively, is the difficulty in many situations of getting a clear view of the vegetation growing. This can be due to turbidity, algal cover or, in wide ditches, seeing across the width of the ditch. The method used by assessing relative biomass on grapnel trawls is consistent and quantitative but has some inherent weaknesses:

- In particular, plants with stems are picked up preferentially over duckweeds. For example, there were many occasions where, say, a 10%:90% cover of frogbit and duckweed respectively resulted in a trawl proportion of 90%:10% in favour of the frogbit. The overall assessment of cover for the 20m section should, however, allow for a weighting system to compensate for this.
- The relationship between biomass and spatial cover is poor when comparing floating and submerged species. For example, a 100% cover of *Lemna* can have a very small biomass. The separate assessment of cover of floating species was introduced to help address this.
- Relative biomass can give a false picture of actual biomass. That is, one frond of duckweed will score 100 if there is no other aquatic vegetation. The assessment of the total cover of aquatic vegetation gives a scale although it is often quite difficult to assess this with any accuracy.
- Grapnel trawling may miss beds of particular species. This is most obvious when floating species can be seen at the sub-sampling point but do not get picked up by the grapnel. However, over the 10 sub-sample points these variations even out, and on the whole it was felt by the surveyor that overall the proportions turned out about right (within the limits of the problems discussed above). In only four cases out of sixty an additional species was noted that wasn't picked up by the trawls. In all of these the species were extremely rare. It is possible that some of these would have been picked up with a greater number of trawls, but with the law of diminishing returns, ten seemed a reasonable number.

Floating and emergent species cover

Emergent species were recorded if they were growing in the water. However, different water levels affects the number of marginal species included. This is not particularly a problem (except in terms of recording time) since the proportions involved are low.

The main focus of both this survey and the Common Standards Monitoring method being compared was the submerged and floating aquatic vegetation rather than the emergents. The inclusion of the latter within the survey was a late-stage because of the impact that emergents have towards the structure of the ditch. However, in retrospect, much of this information may be superfluous to the analysis and could be simplified to emergent cover, perhaps subdivided into structural types (for example, reed grasses and sedges against dicots and low-growing monocots). A further distinction could be made between the marginal band (c.0.5m wide) and the remaining central part.

Total cover of floating species and of emergent species was not recorded during this survey and, in retrospect, this was probably an omission. Some indication can be gained from totalling the individual species covers but it should be noted that these often overlap so that the actual total cover will be less than the sum of the individual components.

Discussion

One of the difficulties with ditch surveys is that there is often considerable variation between ditches and between the same ditch in different years of the succession/clearance cycle. This means that in order to get an overview of the ditches within a site it is necessary to survey a significant number of ditches to cover the range of variation present. The approach of the Common Standards Monitoring Survey method is a two-tier survey; a structured walk covering a large number of ditches recording certain key features and a more detailed study of the species and vegetation of a selection of ditches (up to 10 per SSSI). Even with the latter, the greater the number of ditches surveyed, the more useful it will be for making comparisons between surveys. However, time is the main limitation on the number of ditches that can be surveyed on a regular basis.

Although the current survey was more detailed than the detailed part of the Common Standards Monitoring Survey, it is useful to look at the time spent on different aspects of this survey. The average time spent per ditch was about one hour, broadly speaking divided up as follows:

- 10 minutes recording general features.
- 15 minutes recording cover of emergents, floating species.
- 15 minutes trawling and recording biomass proportions.
- 5 minutes checking recording forms and any problem areas.
- 15 minutes walking between ditches.

The main features that increased survey time included:

- Difficulty of access to the water, for example, dense reed fringe, dense scrub.
- Greater diversity of aquatic species, particularly when similar species occurred (or might occur) together, for example, several duckweeds, more than one fine-leaved pondweed.
- Greater diversity of emergents (up to 20 species to check and score for each sub-sample).
- Greater distance between ditch sections.

Distance between ditches

The ditches selected in the Somerset Levels were close together, although in separate blocks which reduced the transit times between them. In the other two areas the distances between ditches were longer with the aim of a greater geographic spread. If the proportion of ditches being surveyed within a site are reduced the time per ditch increases because to the greater distance between sample sites.

Emergent cover

As discussed above under 'Floating and emergent species cover', there may be scope for simplifying the recording of emergent cover as it is the structural features of the emergents that affect the submerged and floating aquatic flora more than the species themselves. This could reduce the survey time by up to 10 minutes per ditch. Possibilities include:

- Recording emergent cover only.
- Recording emergent cover separately for the marginal band (c.0.5 metres wide) from the remaining central channel.
- Recording structurally different species together for example, reed grasses and sedges as opposed to dicots and low monocots.

General features

For the most part, the general features are fairly quick to record and could include other features (for example, freeboard, adjacent land-use) without significantly affecting the survey time. On this survey, the most time-consuming measurement was the water clarity and it is recommended that a clarity score and/or using a rigid pole to assess visibility should be used in preference to a Secchi disc.

Acknowledgements

I would like to thank Clive Bealey of English Nature for arranging this survey, setting up local contacts in each of the three survey areas and for discussion and advice about the survey method. In the three survey areas, I am grateful particularly to Karen Pollock (English Nature, Somerset Levels), Kristoffer Hewitt (English Nature, Pevensey Levels) and Mark Smart and staff (RSPB, Berney Marshes) for advice on the selection of ditches for survey and arranging access to the sites. I am also grateful to the owners that allowed access to their land although in most cases I did not have direct contact with them.

References

Joint Nature Conservation Committee. 2005. Common Standards Monitoring Guidance for Ditches. Version March 2005. ISSN 1743-8160.

Sample ditch locations

Table B Locations of ditches surveyed on Berney Marshes

		Start		End	
1	TG	4712	0599	4713	0601
2	TG	4702	0607	4703	0609
3	TG	4693	0573	4694	0575
4	TG	4738	0649	4739	0650
5	TG	4738	0622	4739	0623
6	TG	4698	0550	4699	0552
7	TG	4637	0531	4639	0531
8	TG	4641	0550	4642	0552
9	TG	4636	0564	4637	0566
10	TG	4646	0477	4664	0478
11	TG	4606	0480	4604	0480
12	TG	4595	0501	4594	0503
13	TG	4590	0472	4589	0474
14	TG	4535	0456	4533	0456
15	TG	4538	0483	4538	0485
16	TG	4560	0496	4558	0497
17	TG	4642	0577	4642	0579
18	TG	4707	0711	4709	0711
19	TG	4668	0673	4669	0675
20	TG	4650	0676	4652	0676

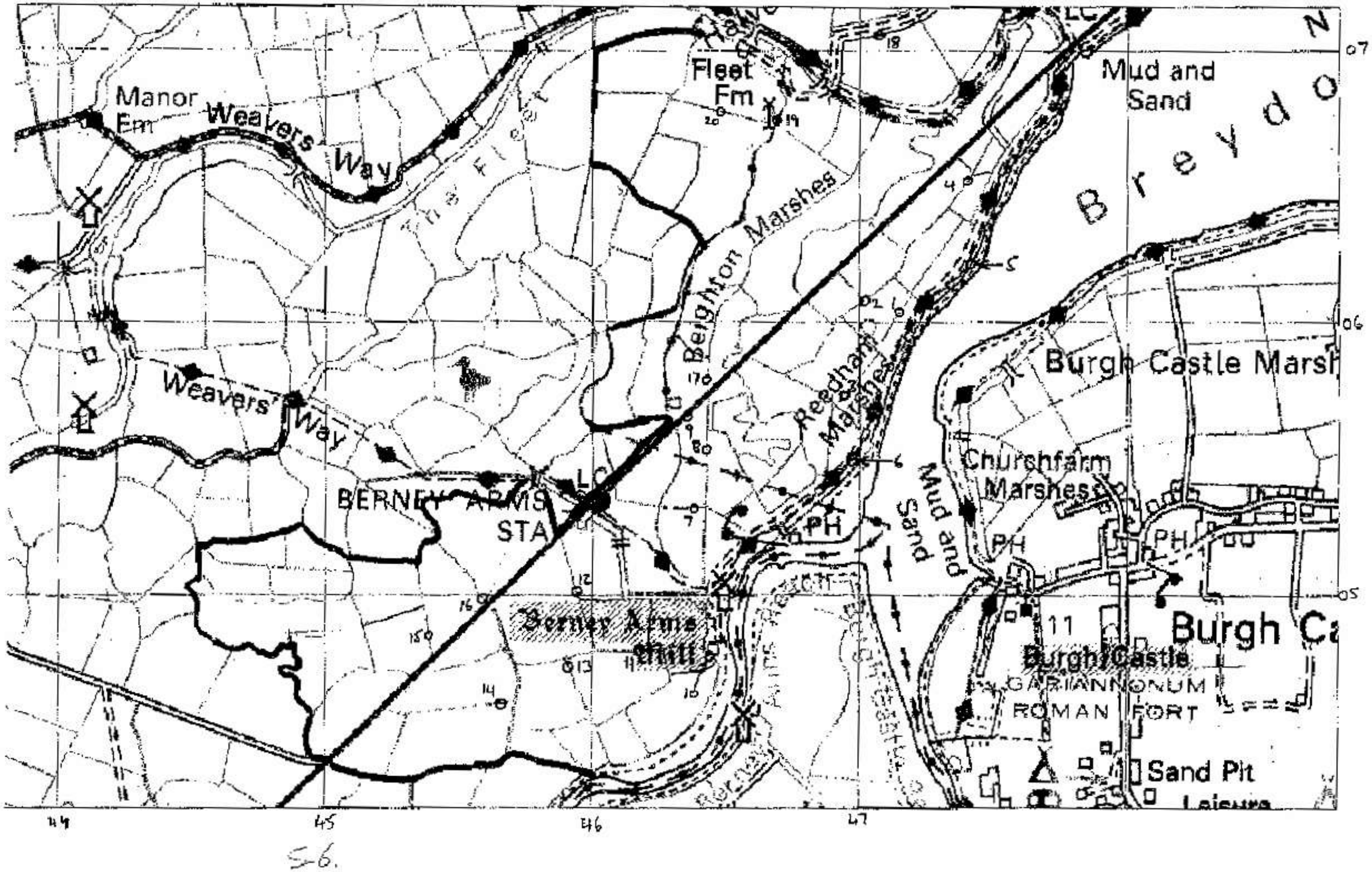

Figure A Ditch locations on Berney Marshes

Table C Locations of ditches surveyed on Pevensey Levels

		Start		End	
1	TQ	6693	0574	6694	0576
2	TQ	6686	0528	6687	0529
3	TQ	6744	0566	6744	0568
4	TQ	6725	0583	6727	0584
5	TQ	6521	0634	6523	0635
6	TQ	6538	0622	6538	0624
7	TQ	6563	0597	6563	0599
8	TQ	6599	0620	6600	0621
9	TQ	6591	0685	6590	0686
10	TQ	6556	0658	6556	0660
11	TQ	6258	0807	6259	0809
12	TQ	6209	0788	6208	0790
13	TQ	6269	0663	6270	0661
14	TQ	6254	0632	6252	0633
15	TQ	6283	0604	6281	0606
16	TQ	6317	0579	6316	0581
17	TQ	6346	0677	6348	0678
18	TQ	6394	0640	6393	0641
19	TQ	6424	0548	6422	0549
20	TQ	6404	0553	6405	0554

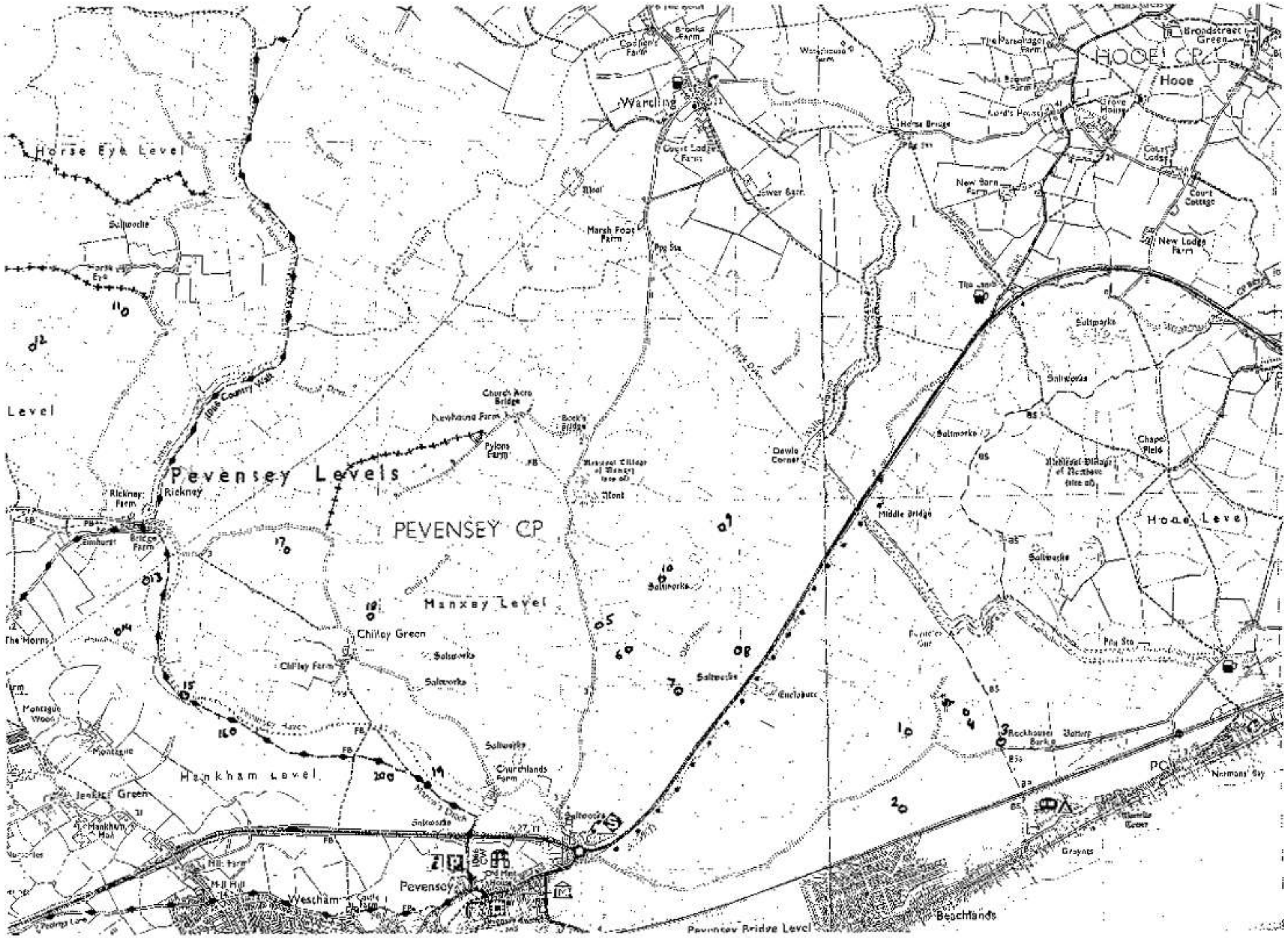

Figure B Ditch locations on Pevensey Levels

Table D Locations of ditches surveyed in the Somerset Levels

		Start		End	
King's Sedgemoor, east section					
KSE1	ST	4047	3300	4045	3301
KSE3	ST	4041	3315	4041	3317
KSE5	ST	4056	3332	4054	3333
KSE6	ST	4059	3346	4057	3347
KSE7	ST	4057	3353	4055	3354
KSE8	ST	4057	3361	4055	3362
King's Sedgemoor, west section					
KSW1	ST	3798	3503	3798	3505
KSW2	ST	3819	3495	3820	3497
KSW3	ST	3813	3488	3812	3489
KSW5	ST	3837	3475	3836	3476
KSW8	ST	3866	3464	3867	3466
KSW9	ST	3878	3482	3876	3483
Nailsea Moor					
NM2	ST	4395	7042	4393	7042
NM3	ST	4399	7048	4398	7050
NM4	ST	4352	7040	4352	7042
NM5	ST	4363	7033	4631	7032
NM6	ST	4452	7043	4454	7044
NM7	ST	4447	7053	4448	7051
NM9	ST	4440	7071	4441	7069
NM10	ST	4425	7071	4427	7072

Figure C Ditch locations on Eastern section of King's Sedgemoor

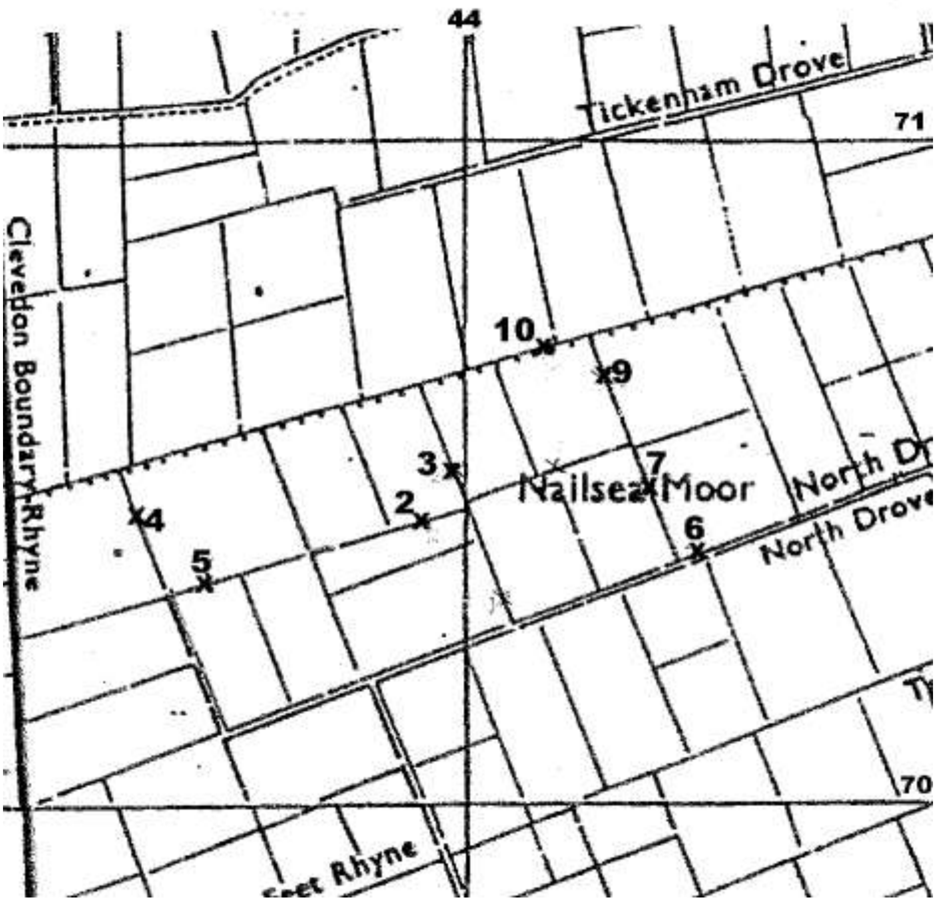

Figure D Ditch locations on Nailsea Moor

Figure E Ditch locations on Western section of King's Sedgemoor

Table E Example recording forms

LOWLAND WET DITCHES **GENERAL FEATURES**

Site name ______ **Ditch No** ______

Surveyor ______ **Date** ______

GPS coordinates **Start**

End

Water clarity

Secchi depth (cm)	Mean	
Turbidity scale (1-5)	Mean	(1 = clear)
Colour (1-5)	Mean	(1 = colourless)

Conductivity (microS/cm)

Ditch profile

Ditch width (metres)

Depth at 50cm intervals from edge of water

Successional stage

% of 20m length	Early	Mid	Late
% of whole ditch	Early	Mid	Late

Bankside vegetation

% ground layer

% shrub layer

% tree layer

% of ditch overhung by ground layer vegetation

% of ditch shaded by shrubs/trees

Comments

LOWLAND WET DITCHES **SPECIES RECORD**

Site	Ditch No	Surveyor	Date

Submerged/floating species	1	2	3	4	5	6	7	8	9	10	Overall	Overall
	% of aquatic macrophyte biomass										% cover	DAFOR
Aquatic macrophyte % cover												
Aquatic macrophyte DAFOR												
Macro-algae % cover												
Macro-algae DAFOR												
Floating species	1	2	3	4	5	6	7	8	9	10	Overall	Overall
	% of ditch area										% cover	DAFOR
Emergent species (in ditch)	1	2	3	4	5	6	7	8	9	10	Overall	Overall
	% of ditch area										% cover	DAFOR
Tree/shrub shade												

Appendix 2 Theory

Ditch Profile Model 3 (Prof3)

Use equation for a straight line: Y = m*X + c

to estimate the gradient (m) and intercept (c) if the ditch has a straight profile from 0.5cm to a later measurement. This model uses the measurements taken at 0.5m and the maximum depth distance. Using the above formula, the expected depths at each distance from the edge can then be calculated if the ditch had a straight line profile.

Using a chi-squared type approach, you can then calculate the difference between the observed depth (the actual measurements) and expected depth at each 'X' value (distance from ditch edge). If these values are squared and then the squares summed, a final figure is obtained (in the cell with horizontal shading) which gives and indication of how different the observed profile is from a straight line profile. The cell with vertical shading is the actual chi squared value.

Table F Ditch Profile Model 3 (Prof3) - Expected: V shape

X Distance from edge (m)	Water depth (cm)	Y Ditch profile (cm)
0	0	0
0.5	10	-10
1	20	-20
1.5	30	-30
2	40	-40
2.5	50	-50
3	60	-60

y3.0-y0.5	x3.0-x0.5	m	c
85	2.5	34	-7
expected	**obs-exp**	**o-e squared**	
-7	7	49	-7
10	0	0	0
27	3	9	0.33333333
44	16	256	5.81818182
61	9	81	1.32786885
78	2	4	0.05128205
95	0	0	0
		399	0.53066606

Table G Ditch Profile Model 3 (Prof3) - Observed: KSE3

X		Y
Distance from edge (m)	**Water depth (cm)**	**Ditch profile (cm)**
0	0	0
0.5	10	-10
1	20	-20
1.5	60	-60
2	75	-75

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
65	1.5	43.3333333	-11.66666667
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
-11.66666667	11.66666667	136.111111	-11.66666667
10	0	0	0
31.66666667	-11.66666667	136.111111	4.298245614
53.33333333	6.666666667	44.4444444	0.833333333
75	0	0	0
		316.66667	-6.535087719

In summary, the output figure (pink box) provides a measure of deviation from a standardised (‘ideal’) V-shaped profile.

Ditch Profile Model 4 (Prof4)

This model is an evolution of the previous Prof3 one. It compares the output of the Prof3 model with another expected value calculated in the same way for a U-shaped ditch. The final figure is a ratio of the two, as follows:

- (sum of squares of observed-expected for V-shape) / (sum of squares of observed –expected U-shape).
- In theory, higher values are closer to a U-shape ditch and lower values are closer to V-shape.

Table H Ditch Profile Model 4 (Prof4) - Expected: U shape

X dist from edge (m)		Y depth (cm)
0	0	0
0.5	100	-100
1	100	-100
1.5	100	-100
2	100	-100
2.5	100	-100
3	100	-100

y3.0-y0.5	x3.0-x0.5	m	c
0	2.5	0	100
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
90	-100	10000	100
90	0	0	0
90	0	0	0
90	0	0	0
90	0	0	0
90	0	0	0
90	0	0	0
		10000	100

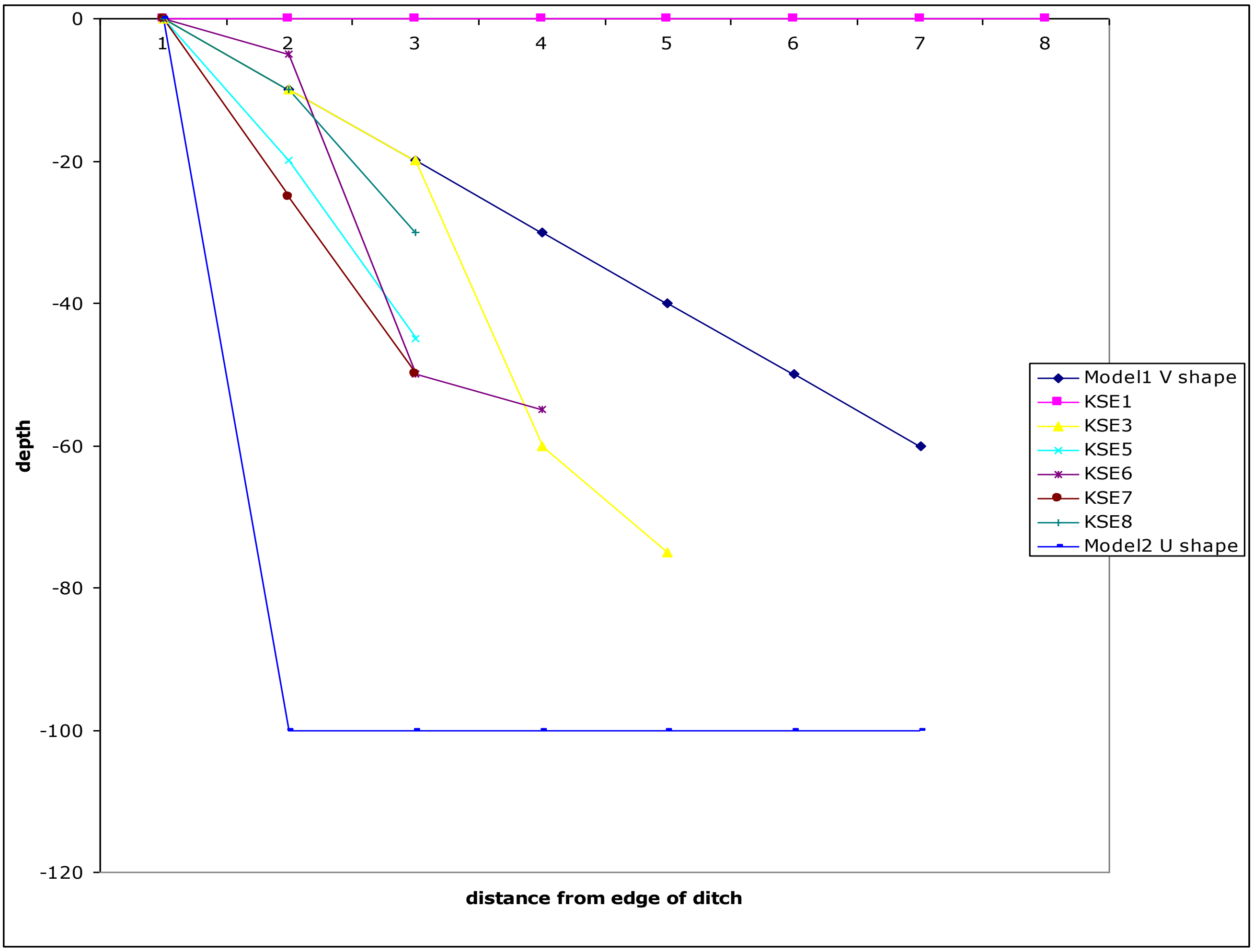

Figure F Profile Model 3 (Prof3)

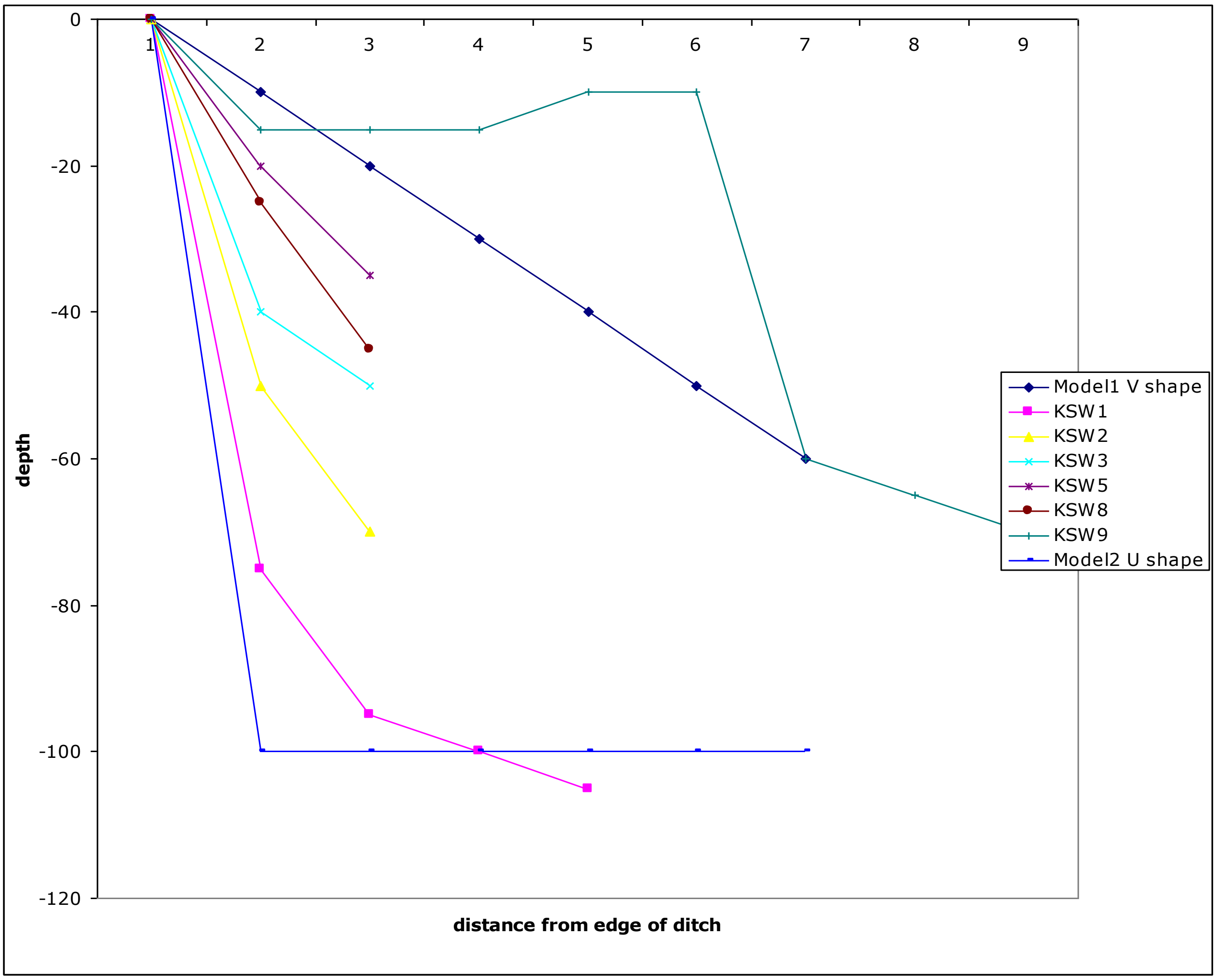

Figure G Profile Model 3 (Prof3)

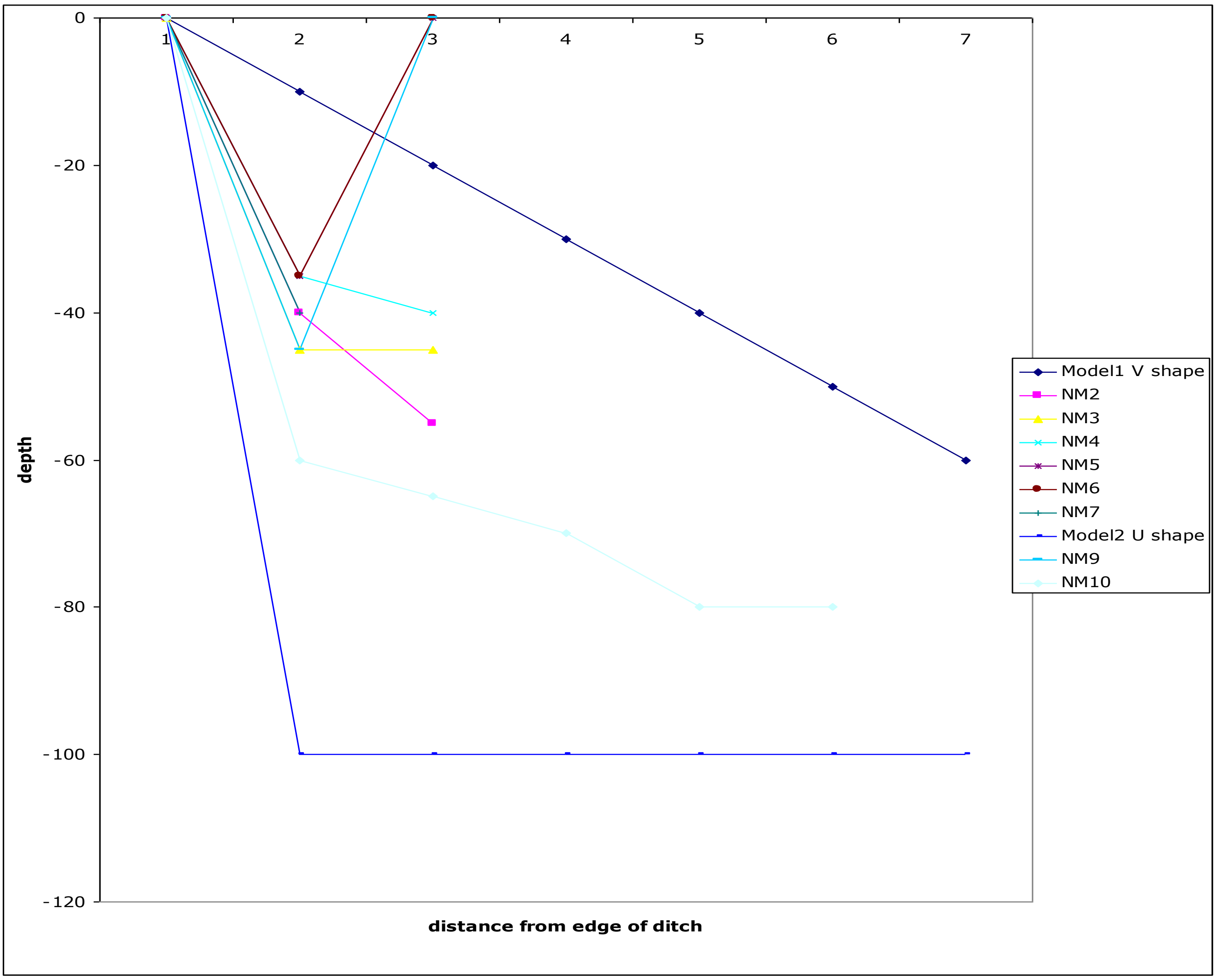

Figure H Profile Model 3 (Prof3)

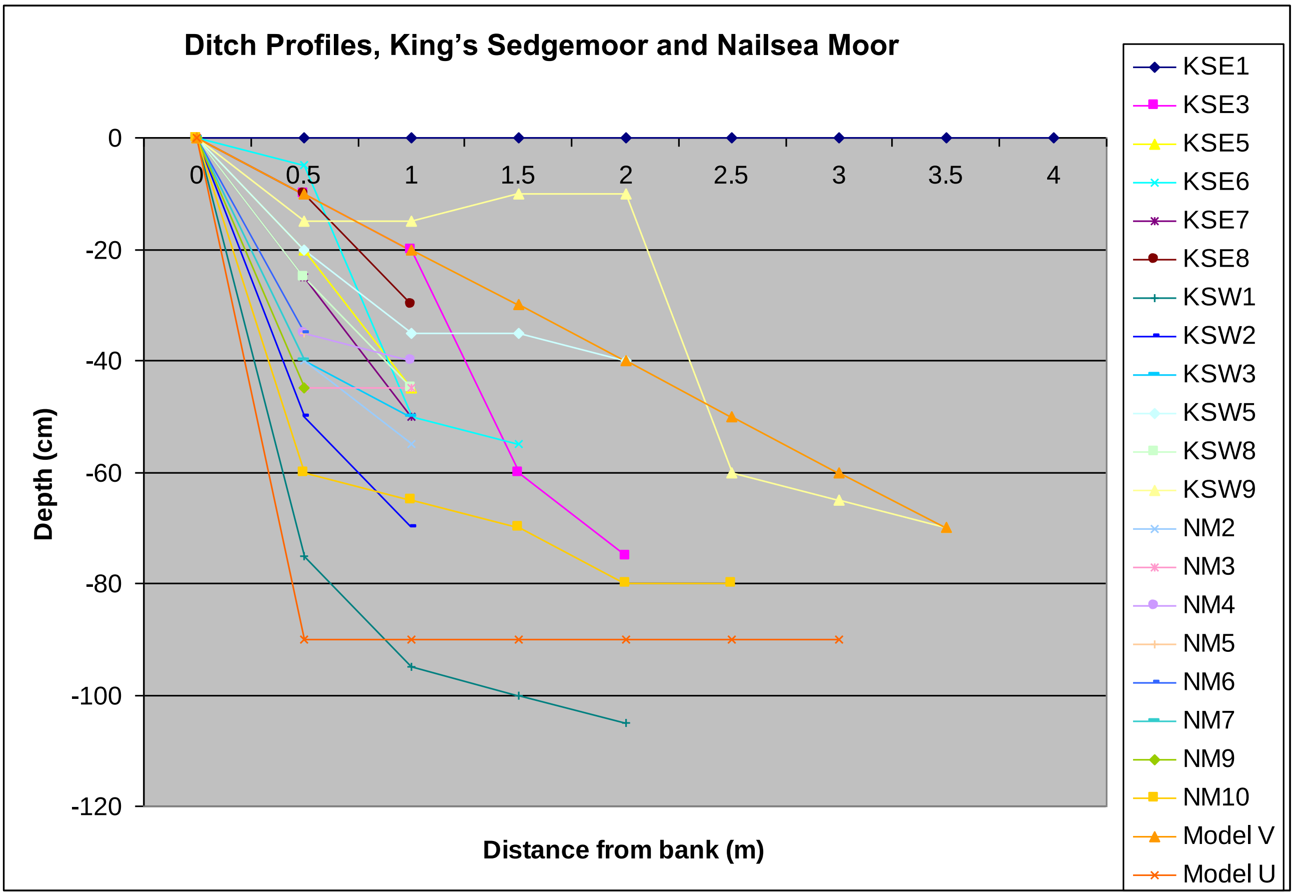

Figure I Profile Model 4 (Prof4) Ditch Profiles, King's Sedgemoor and Nailsea Moor

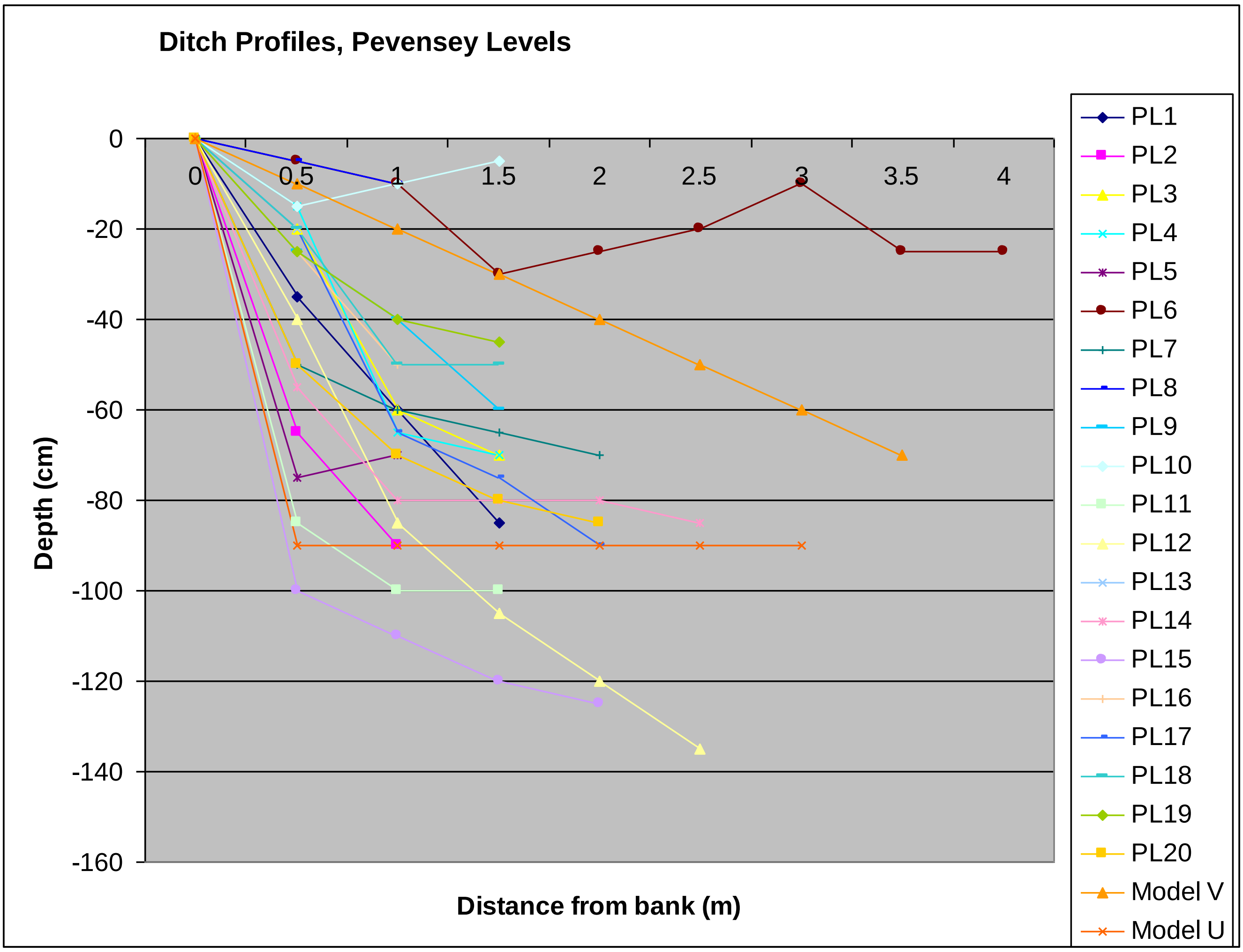

Figure J Profile Model 4 (Prof4) Ditch Profiles, Pevensey Levels

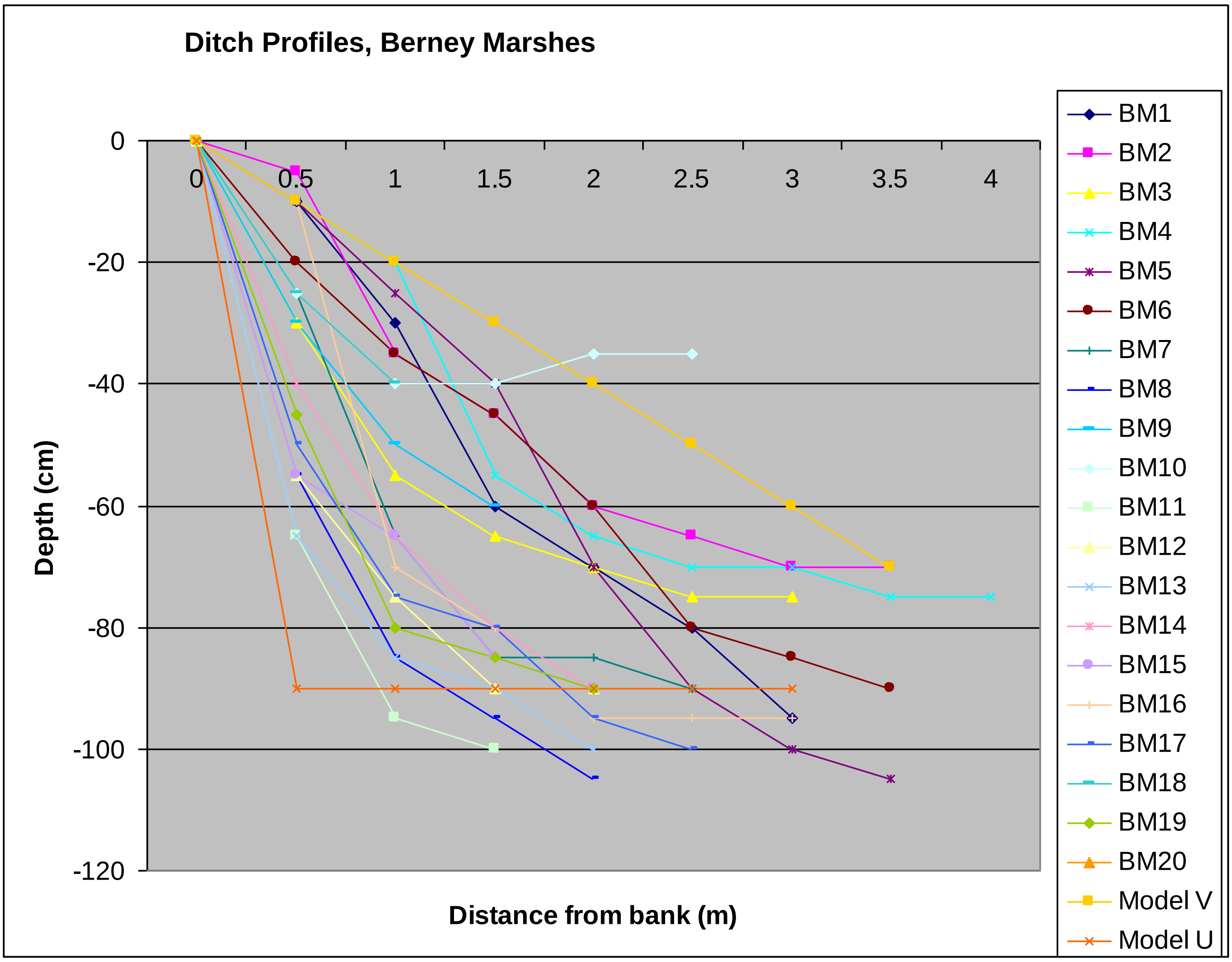

Figure K Profile Model 4 (Prof4) Ditch Profiles, Berney Marshes

Ditch Profile Model 3 (Prof3) tables

Table I Ditch Profile Model 3 (Prof3) - Expected: Model 1 V shape

X dist from edge (m)		Y depth (cm)
0	0	0
0.5	10	-10
1	20	-20
1.5	30	-30
2	40	-40
2.5	50	-50
3	60	-60

y3.0-y0.5	x3.0-x0.5	m	c
50	2.5	20	0
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
0	0	0	0
10	0	0	0
20	0	0	0
30	0	0	0
40	0	0	0
50	0	0	0
60	0	0	0
		0	0

Table J Ditch Profile Model 3 (Prof3) - Expected: Model 2 U shape

X		Y
	dist from edge (m)	depth (cm)
0	0	0
0.5	100	-100
1	100	-100
1.5	100	-100
2	100	-100
2.5	100	-100
3	100	-100

y3.0-y0.5	x3.0-x0.5	m	c
0	2.5	0	100
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
100	-100	10000	100
100	0	0	0
100	0	0	0
100	0	0	0
100	0	0	0
100	0	0	0
100	0	0	0
		10000	100

Table K Ditch Profile Model 3 (Prof3) - Observed: KSE 1

X		Y
	dist from edge (m)	depth (cm)
0	0	0
0.5	0	0
1	0	0
1.5	0	0
2	0	0
2.5	0	0
3	0	0
3.5	0	0

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
0	2.5	0	0

expected	obs-exp	o-e squared	(o-e)^2 / e
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
		0	0

Table L Ditch Profile Model 3 (Prof3) - Observed: KSE 3

X		Y
dist from edge (m)		depth (cm)
0	0	0
0.5	10	-10
1	20	-20
1.5	60	-60
2	75	-75
2.5		
3		
3.5		

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
65	1.5	43.33333	-11.6667

expected	obs-exp	o-e squared	(o-e)^2 / e
-11.6667	11.66667	136.1111	-11.6667
10	0	0	0
31.66667	-11.6667	136.1111	4.298246
53.33333	6.666667	44.44444	0.833333
75	0	0	0
96.66667			
118.3333			
140			
		316.6667	-6.53509

Table M Ditch Profile Model 3 (Prof3) - Observed: KSE 5

X		Y
dist from edge (m)		depth (cm)
0	0	0
0.5	20	-20
1	45	-45
1.5		
2		
2.5		
3		
3.5		

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
25	0.5	50	-5
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
-5	5	25	-5
20	0	0	0
45	0	0	0
70			
95			
120			
145			
170			
		25	-5

Table N Ditch Profile Model 3 (Prof3) - Observed: KSE 6

X		Y
dist from edge (m)		depth (cm)
0	0	0
0.5	5	-5
1	50	-50
1.5	55	-55
2		
2.5		
3		
3.5		

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
50	0.5	100	-45
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
-45	45	2025	-45
5	0	0	0
55	-5	25	0.454545
105	-50	2500	23.80952
155			
205			
255			
305			
		4550	-20.7359

Table O Ditch Profile Model 3 (Prof3) - Observed: KSE7

X		Y
dist from edge (m)		depth (cm)
0	0	0
0.5	25	-25
1	50	-50
1.5		
2		
2.5		
3		
3.5		

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
25	0.5	50	0
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
0	0	0	0
25	0	0	0
50	0	0	0
75			
100			
125			
150			
175			
		0	0

Table P Ditch Profile Model 3 (Prof3) - Observed: KSE 8

X		Y
dist from edge (m)		depth (cm)
0	0	0
0.5	10	-10
1	30	-30
1.5		
2		
2.5		
3		
3.5		

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
20	0.5	40	-10
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
-10	10	100	-10
10	0	0	0
30	0	0	0
50			
70			
90			
110			
130			
		100	-10

Table Q Ditch Profile Model 3 (Prof3) - Observed: KSW 1

X		Y
dist from edge (m)		depth (cm)
0	0	0
0.5	75	-75
1	95	-95
1.5	100	-100
2	105	-105
2.5		
3		
3.5		

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
30	1.5	20	65
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
65	-65	4225	65
75	0	0	0
85	10	100	1.176471
95	5	25	0.263158
105	0	0	0
115			
125			
135			
		4350	66.43963

Table R Ditch Profile Model 3 (Prof3) - Observed: KSW 2

X dist from edge (m)		Y depth (cm)
0	0	0
0.5	50	-50
1	70	-70
1.5		
2		
2.5		
3		
3.5		

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
20	0.5	40	30
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
30	-30	900	30
50	0	0	0
70	0	0	0
90			
110			
130			
150			
170			
		900	30

Table S Ditch Profile Model 3 (Prof3) - Observed: KSW 3

X		Y
dist from edge (m)	depth (cm)	dist from edge (m)
0	0	0
0.5	40	-40
1	50	-50
1.5		
2		
2.5		
3		
3.5		

ymaxDdist-y0.5	x3.0-x0.5	m	c
10	0.5	20	30
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
30	-30	900	30
25	15	225	9
50	0	0	0
75			
100			
125			
150			
175			
		1125	39

Table T Ditch Profile Model 3 (Prof3) - Observed: KSW 5

X		Y
dist from edge (m)		depth (cm)
0	0	0
0.5	20	-20
1	35	-35
1.5	35	
2	40	
2.5		
3		
3.5		

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
20.00	1.50	13.33	13.33
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
13.33	-13.33	177.78	13.33
20.00	0.00	0.00	0.00
26.67	8.33	69.44	2.60
33.33			
40.00			
46.67			
53.33			
60.00			
		247.22	15.94

Table U Ditch Profile Model 3 (Prof3) - Observed: KSW 8

X		Y
dist from edge (m)		depth (cm)
0	0	0
0.5	25	-25
1	45	-45
1.5		
2		
2.5		
3		
3.5		

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
20	0.5	40	5
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
5	-5	25	5
25	0	0	0
45	0	0	0
65			
85			
105			
125			
145			
		25	5

Table V Ditch Profile Model 3 (Prof3) - Observed: KSW 9

X dist from edge (m)		Y depth (cm)
0	0	0
0.5	15	-15
1	15	-15
1.5	15	-15
2	10	-10
2.5	10	-10
3	60	-60
3.5	65	-65
4	70	-70

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
55.00	3.50	15.71	7.14
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
7.14	-7.14	51.02	7.14
15.00	0.00	0.00	0.00
22.86	-7.86	61.73	2.70
30.71	-15.71	246.94	8.04
38.57	-28.57	816.33	21.16
46.43	-36.43	1327.04	28.58
54.29	5.71	32.65	0.60
62.14	2.86	8.16	0.13
70.00	0.00	0.00	0.00
		2543.88	68.36

Table W Ditch Profile Model 3 (Prof3) - Observed: NM 2

X		Y
	dist from edge (m)	depth (cm)
0	0	0
0.5	40	-40
1	55	-55
1.5		
2		
2.5		
3		
3.5		

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
15	0.5	30	25
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
25	-25	625	25
40	0	0	0
55	0	0	0
70			
85			
100			
115			
130			
		625	25

Table X Ditch Profile Model 3 (Prof3) - Observed: NM 3

X dist from edge (m)		Y depth (cm)
0	0	0
0.5	45	-45
1	45	-45
1.5		
2		
2.5		
3		
3.5		

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
0	0.5	0	45
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
45	-45	2025	45
45	0	0	0
45	0	0	0
45			
45			
45			
45			
45			
		2025	45

Table Y Ditch Profile Model 3 (Prof3) - Observed: NM 4

X		Y
dist from edge (m)		depth (cm)
0	0	0
0.5	35	-35
1	40	-40
1.5		
2		
2.5		
3		
3.5		

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
5	0.5	10	30
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
30	-30	900	30
35	0	0	0
40	0	0	0
45			
50			
55			
60			
65			
		900	30

Table Z Ditch Profile Model 3 (Prof3) - Observed: NM 5

X dist from edge (m)		Y depth (cm)
0	0	0
0.5	35	-35
1		0
1.5		
2		
2.5		
3		
3.5		

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
20	2	10	55
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
55	-55	3025	55
60	0	0	0
65	0	0	0
70	0	0	0
75	5	25	0.333333333
80	0	0	0
85			
90			
		3050	55.33333333

Table Aa Ditch Profile Model 3 (Prof3) - Observed: NM 6

X		Y
dist from edge (m)		depth (cm)
0	0	0
0.5	35	-35
1		0
1.5		
2		
2.5		
3		
3.5		

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
-5	0.5	-10	80
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
80	-80	6400	80
75	0	0	0
70	0	0	0
65			
60			
55			
50			
45			
		6400	80

Table Ab Ditch Profile Model 3 (Prof3) - Observed: NM 7

X		Y
dist from edge (m)		depth (cm)
0	0	0
0.5	40	-40
1		
1.5		
2		
2.5		
3		
3.5		

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
20	3	6.666666667	1.666666667
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
1.666666667	-1.666666667	2.777777778	1.666666667
5	0	0	0
8.333333333	1.666666667	2.777777778	0.333333333
11.66666667	18.33333333	336.1111111	28.80952381
15	10	100	6.666666667
18.33333333	1.666666667	2.777777778	0.151515152
21.66666667	-11.66666667	136.1111111	6.282051282
25	0	0	0
1.666666667	23.33333333	544.4444444	326.6666667
		1125	370.5764236

Table Ac Ditch Profile Model 3 (Prof3) - Observed: NM 9

X		Y
dist from edge (m)		depth (cm)
0	0	0
0.5	45	-45
1		0
1.5		
2		
2.5		
3		
3.5		

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
85	2.5	34	-7

expected	obs-exp	o-e squared	(o-e)^2 / e
-7	7	49	-7
10	0	0	0
27	3	9	0.333333333
44	16	256	5.818181818
61	9	81	1.327868852
78	2	4	0.051282051
95			
112			
		399	0.530666055

Table Ad Ditch Profile Model 3 (Prof3) - Observed: NM 10

X		Y
dist from edge (m)		depth (cm)
0	0	0
0.5	60	-60
1	65	-65
1.5	70	-70
2	80	-80
2.5	80	-80
3		
3.5		

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
65	2.5	26	-8
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
-8	8	64	-8
5	0	0	0
18	17	289	16.05555556
31	14	196	6.322580645
44	16	256	5.818181818
57	8	64	1.122807018
70	0	0	0
83	-13	169	2.036144578
		1038	23.35526961

Table Ae Ditch Profile Model 3 (Prof3) - Observed: PL 5

X		Y
dist from edge (m)		depth (cm)
0	0	0
0.5	75	-75
1	70	-70
1.5		
2		
2.5		
3		
3.5		

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
45	2	22.5	18.75
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
18.75	-18.75	351.5625	18.75
30	0	0	0
41.25	13.75	189.0625	4.583333333
52.5	12.5	156.25	2.976190476
63.75	6.25	39.0625	0.612745098
75	0	0	0
86.25	-11.25	126.5625	1.467391304
97.5			
18.75			
		862.5	28.38966021

Table Af Ditch Profile Model 3 (Prof3) - Observed: PL 6

X		Y
dist from edge (m)		**depth (cm)**
0	0	0
0.5	5	-5
1	10	-10
1.5	30	-30
2	25	-25
2.5	20	-20
3	10	-10
3.5	25	-25
	25	-25

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
65	3	21.66666667	-0.833333333
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
-0.833333333	0.833333333	0.694444444	-0.833333333
10	0	0	0
20.83333333	-0.833333333	0.694444444	0.033333333
31.66666667	23.33333333	544.4444444	17.19298246
42.5	22.5	506.25	11.91176471
53.33333333	16.66666667	277.7777778	5.208333333
64.16666667	5.833333333	34.02777778	0.53030303
75	0	0	0
85.83333333	-10.83333333	117.3611111	1.367313916
		1481.25	35.41069744

Table Ag Ditch Profile Model 3 (Prof3) - Observed: BN 1

X	dist from edge (m)	Y depth (cm)
0	0	0
0.5	10	-10
1	30	-30
1.5	60	-60
2	70	-70
2.5	80	-80
3	95	-95
3.5		

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
95	3	31.66666667	-5.833333333
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
-5.833333333	5.833333333	34.02777778	-5.833333333
10	0	0	0
25.83333333	-0.833333333	0.694444444	0.02688172
41.66666667	-1.666666667	2.777777778	0.066666667
57.5	12.5	156.25	2.717391304
73.33333333	16.66666667	277.7777778	3.787878788
89.16666667	10.83333333	117.3611111	1.316199377
105	0	0	0
		588.8888889	2.081684523

Table Ah Ditch Profile Model 3 (Prof3) - Observed: BM 2

X		Y
dist from edge (m)		depth (cm)
0	0	0
0.5	5	-5
1	35	-35
1.5	45	-45
2	60	-60
2.5	65	-65
3	70	-70
3.5	70	-70

ymaxDdist-y0.5	xmaxDdist-x0.5	m	c
70	3	23.33333333	8.333333333
expected	**obs-exp**	**o-e squared**	**(o-e)^2 / e**
8.333333333	-8.333333333	69.44444444	8.333333333
20	0	0	0
31.66666667	3.333333333	11.11111111	0.350877193
43.33333333	1.666666667	2.777777778	0.064102564
55	5	25	0.454545455
66.66666667	13.33333333	177.7777778	2.666666667
78.33333333	6.666666667	44.44444444	0.567375887
90	0	0	0
8.333333333			
		330.5555556	12.4369011

Table Ai Ditch Profile Model 3 (Prof3) - Observed: BM 3

X dist from edge (m)		Y depth (cm)
0	0	0
0.5	30	-30
1	55	-55
1.5	65	-65
2	70	-70
2.5	75	-75
3	75	-75
3.5		0
		0

Table Aj Ditch Profile Model 3 (Prof3) - Observed: BM 4

X dist from edge (m)		Y depth (cm)
0	0	0
0.5	10	-10
1	20	-20
1.5	55	-55
2	65	-65
2.5	70	-70
3	70	-70
3.5	75	-75
4	75	-75

Table Ak Ditch Profile Model 3 (Prof3) - Observed: BM 5

X		Y
dist from edge (m)		depth (cm)
0	0	0
0.5	10	-10
1	25	-25
1.5	40	-40
2	70	-70
2.5	90	-90
3	100	-100
3.5	105	-105

Table Al Ditch Profile Model 3 (Prof3) - Observed: BM 6

X		Y
dist from edge (m)		depth (cm)
0	0	0
0.5	20	-20
1	35	-35
1.5	45	-45
2	60	-60
2.5	80	-80
3	85	-85
3.5	90	-90
		0

Table Am Calculations for Ditch Profile Model (Prof4), Pt.1 X Measurement (Observed)

Ditch	No. measurements	X Measurement (Observed) 0	0.5	1	1.5	2	2.5	3	3.5	4	Max depth	Distance at max depth
Model V	8	0	10	20	30	40	50	60	70		70	3.5
Model U	7	0	90	90	90	90	90	90			90	3
KSE1	4	0	0	0	0						0	1.5
KSE3	5	0	10	20	60	75					75	2
KSE5	3	0	20	45							45	1
KSE6	4	0	5	50	55						55	1.5
KSE7	3	0	25	50							50	1
KSE8	3	0	10	30							30	1
KSW1	5	0	75	95	100	105					105	2
KSW2	3	0	50	70							70	1
KSW3	3	0	40	50							50	1
KSW5	5	0	20	35	35	40					40	2
KSW8	3	0	25	45							45	1
KSW9	8	0	15	15	10	10	60	65	70		70	3.5
NM2	3	0	40	55							55	1
NM3	3	0	45	45							45	1
NM4	3	0	35	40							40	1

Table continued…

	No. measurements	X Measurement (Observed)									Max depth	Distance at max depth
Ditch		**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**		
NM5	2	0	35								35	0.5
NM6	2	0	35								35	0.5
NM7	2	0	40								40	0.5
NM9	2	0	45								45	0.5
NM10	6	0	60	65	70	80	80				80	2.5
PL1	4	0	35	60	85						85	1.5
PL2	3	0	65	90							90	1
PL3	4	0	20	60	70						70	1.5
PL4	4	0	15	65	70						70	1.5
PL5	3	0	75	70							75	1
PL6	8	0	5	10	30	25	20	10	25	25	30	3.5
PL7	5	0	50	60	65	70					70	2
PL8	3	0	5	10							10	1
PL9	4	0	25	40	60						60	1.5
PL10	4	0	15	10	5						15	1.5
PL11	4	0	85	100	100						100	1.5
PL12	6	0	40	85	105	120	135				135	2.5
PL13	2	0	20								20	0.5
PL14	6	0	55	80	80	80	85				85	2.5

Table continued…

	No. measurements	X Measurement (Observed)									Max depth	Distance at max depth
Ditch		**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**		
PL15	5	0	100	110	120	125					125	2
PL16	3	0	25	50							50	1
PL17	5	0	20	65	75	90					90	2
PL18	4	0	20	50	50						50	1.5
PL19	4	0	25	40	45						45	1.5
PL20	5	0	50	70	80	85					85	2
BM1	7	0	10	30	60	70	80	95			95	3
BM2	8	0	5	35	45	60	65	70	70		70	3.5
BM3	7	0	30	55	65	70	75	75			75	3
BM4	8	0	10	20	55	65	70	70	75	75	75	3.5
BM5	8	0	10	25	40	70	90	100	105		105	3.5
BM6	8	0	20	35	45	60	80	85	90		90	3.5
BM7	6	0	25	65	85	85	90				90	2.5
BM8	5	0	55	85	95	105					105	2
BM9	4	0	30	50	60						60	1.5
BM10	6	0	25	40	40	35	35				40	2.5
BM11	4	0	65	95	100						100	1.5
BM12	5	0	55	75	90	90					90	2

Table continued…

	No. measurements	X Measurement (Observed)									Max depth	Distance at max depth
Ditch		**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**		
BM13	5	0	65	85	90	100					100	2
BM14	5	0	40	65	80	90					90	2
BM15	5	0	55	65	85	90					90	2
BM16	7	0	10	70	80	95	95	95			95	3
BM17	6	0	50	75	80	95	100				100	2.5
BM18	3	0	25	40							40	1
BM19	5	0	45	80	85	90					90	2
BM20	4	0	40	70	80						80	1.5

Table An Calculations for Ditch Profile Model (Prof4), Pt.2 V-shaped ditch Expected

		V-shaped ditch, Expected								
Ditch	**m**	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**
Model V	20	0	10	20	30	40	50	60	70	
Model U	30	0	15	30	45	60	75	90		
KSE1	0	0	0	0	0					
KSE3	37.5	0	18.75	37.5	56.25	75				
KSE5	45	0	22.5	45						
KSE6	36.6666667	0	18.3333333	36.6666667	55					
KSE7	50	0	25	50						
KSE8	30	0	15	30						
KSW1	52.5	0	26.25	52.5	78.75	105				
KSW2	70	0	35	70						
KSW3	50	0	25	50						
KSW5	20	0	10	20	30	40				
KSW8	45	0	22.5	45						
KSW9	20	0	10	20	30	40	50	60	70	
NM2	55	0	27.5	55						
NM3	45	0	22.5	45						
NM4	40	0	20	40						

Table continued…

		V-shaped ditch, Expected								
Ditch	**m**	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**
NM5	70	0	35							
NM6	70	0	35							
NM7	80	0	40							
NM9	90	0	45							
NM10	32	0	16	32	48	64	80			
PL1	56.6666667	0	28.3333333	56.6666667	85					
PL2	90	0	45	90						
PL3	46.6666667	0	23.3333333	46.6666667	70					
PL4	46.6666667	0	23.3333333	46.6666667	70					
PL5	75	0	37.5	75						
PL6	8.57142857	0	4.28571429	8.57142857	12.8571429	17.1428571	21.4285714	25.7142857	30	
PL7	35	0	17.5	35	52.5	70				
PL8	10	0	5	10						
PL9	40	0	20	40	60					
PL10	10	0	5	10	15					
PL11	66.6666667	0	33.3333333	66.6666667	100					
PL12	54	0	27	54	81	108	135			
PL13	40	0	20							
PL14	34	0	17	34	51	68	85			

Table continued…

		V-shaped ditch, Expected								
Ditch	**m**	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**
PL15	62.5	0	31.25	62.5	93.75	125				
PL16	50	0	25	50						
PL17	45	0	22.5	45	67.5	90				
PL18	33.3333333	0	16.6666667	33.3333333	50					
PL19	30	0	15	30	45					
PL20	42.5	0	21.25	42.5	63.75	85				
BM1	31.6666667	0	15.8333333	31.6666667	47.5	63.3333333	79.1666667	95		
BM2	20	0	10	20	30	40	50	60	70	
BM3	25	0	12.5	25	37.5	50	62.5	75		
BM4	21.4285714	0	10.7142857	21.4285714	32.1428571	42.8571429	53.5714286	64.2857143	75	
BM5	30	0	15	30	45	60	75	90	105	
BM6	25.7142857	0	12.8571429	25.7142857	38.5714286	51.4285714	64.2857143	77.1428571	90	
BM7	36	0	18	36	54	72	90			
BM8	52.5	0	26.25	52.5	78.75	105				
BM9	40	0	20	40	60					
BM10	16	0	8	16	24	32	40			
BM11	66.6666667	0	33.3333333	66.6666667	100					
BM12	45	0	22.5	45	67.5	90				

Table continued…

		V-shaped ditch, Expected								
Ditch	**m**	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**
BM13	50	0	25	50	75	100				
BM14	45	0	22.5	45	67.5	90				
BM15	45	0	22.5	45	67.5	90				
BM16	31.6666667	0	15.8333333	31.6666667	47.5	63.3333333	79.1666667	95		
BM17	40	0	20	40	60	80	100			
BM18	40	0	20	40						
BM19	45	0	22.5	45	67.5	90				
BM20	53.3333333	0	26.6666667	53.3333333	80					

Table Ao Calculations for Ditch Profile Model (Prof4), Pt.3 V-shaped ditch, (obs-exp)^2

	V-shaped ditch, (obs-exp)^2									V-shaped ditch: Sum (obs-exp)^2
Ditch	**0**	**0.5**	**1.0**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	
Model V	0	0	0.0	0	0	0	0	0		0
Model U	0	5625	3600.0	2025	900	225	0			12375
KSE1	0	0	0.0	0						0
KSE3	0	76.5625	306.3	14.0625	0					396.875
KSE5	0	6.25	0.0							6.25
KSE6	0	177.777778	177.8	0						355.5555556
KSE7	0	0	0.0							0
KSE8	0	25	0.0							25
KSW1	0	2376.5625	1806.3	451.5625	0					4634.375
KSW2	0	225	0.0							225
KSW3	0	225	0.0							225
KSW5	0	100	225.0	25	0					350
KSW8	0	6.25	0.0							6.25
KSW9	0	25	25.0	400	900	100	25	0		1475
NM2	0	156.25	0.0							156.25
NM3	0	506.25	0.0							506.25

Table continued…

Ditch	V-shaped ditch, (obs-exp)^2 0	0.5	1.0	1.5	2	2.5	3	3.5	4	V-shaped ditch: Sum (obs-exp)^2
NM4	0	225	0.0							225
NM5	0	0								0
NM6	0	0								0
NM7	0	0								0
NM9	0	0								0
NM10	0	1936	1089.0	484	256	0				3765
PL1	0	44.4444444	11.1	0						55.55555556
PL2	0	400	0.0							400
PL3	0	11.1111111	177.8	0						188.8888889
PL4	0	69.4444444	336.1	0						405.5555556
PL5	0	1406.25	25.0							1431.25
PL6	0	0.51020408	2.0	293.877551	61.7346939	2.04081633	246.938776	25		632.1428571
PL7	0	1056.25	625.0	156.25	0					1837.5
PL8	0	0	0.0							0
PL9	0	25	0.0	0						25
PL10	0	100	0.0	100						200
PL11	0	2669.44444	1111.1	0						3780.555556
PL12	0	169	961.0	576	144	0				1850

Table continued…

PL13	0	0								0

	V-shaped ditch, (obs-exp)^2									V-shaped ditch: Sum (obs-exp)^2
Ditch	**0**	**0.5**	**1.0**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	
PL14	0	1444	2116.0	841	144	0				4545
PL15	0	4726.5625	2256.3	689.0625	0					7671.875
PL16	0	0	0.0							0
PL17	0	6.25	400.0	56.25	0					462.5
PL18	0	11.1111111	277.8	0						288.8888889
PL19	0	100	100.0	0						200
PL20	0	826.5625	756.3	264.0625	0					1846.875
BM1	0	34.0277778	2.8	156.25	44.4444444	0.69444444	0			238.1944444
BM2	0	25	225.0	225	400	225	100	0		1200
BM3	0	306.25	900.0	756.25	400	156.25	0			2518.75
BM4	0	0.51020408	2.0	522.44898	490.306122	269.897959	32.6530612	0		1317.857143
BM5	0	25	25.0	25	100	225	100	0		500
BM6	0	51.0204082	86.2	41.3265306	73.4693878	246.938776	61.7346939	0		560.7142857
BM7	0	49	841.0	961	169	0				2020
BM8	0	826.5625	1056.3	264.0625	0					2146.875
BM9	0	100	100.0	0						200
BM10	0	289	576.0	256	9	25				1155

Table continued…

Ditch	V-shaped ditch, (obs-exp)^2 0	0.5	1.0	1.5	2	2.5	3	3.5	4	V-shaped ditch: Sum (obs-exp)^2
BM11	0	1002.77778	802.8	0						1805.555556
BM12	0	1056.25	900.0	506.25	0					2462.5
BM13	0	1600	1225.0	225	0					3050
BM14	0	306.25	400.0	156.25	0					862.5
BM15	0	1056.25	400.0	306.25	0					1762.5
BM16	0	34.0277778	1469.4	1056.25	1002.77778	250.694444	0			3813.194444
BM17	0	900	1225.0	400	225	0				2750
BM18	0	25	0.0							25
BM19	0	506.25	1225.0	306.25	0					2037.5
BM20	0	177.777778	277.8	0						455.5555556

Table Ap Calculations for Ditch Profile Model (Prof4), Pt.4 U-shaped ditch, Expected

	U-shaped ditch, Expected									U-shaped ditch, (obs-exp)^2									U-shaped ditch: sum (obs-exp)^2	Ratio of V to U shape (V/U)
Ditch	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**		
Model V	0	70	70	70	70	70	70	70		0	3600	2500	1600	900	400	100	0		9100	0
Model U	0	90	90	90	90	90	90			0	5625	3600	2025	900	225	0			12375	1
KSE1	0	0	0	0						0	0	0	0						0	0
KSE3	0	75	75	75	75					0	3164.063	1406.25	351.5625	0					4921.875	0.08064
KSE5	0	45	45							0	506.25	0							506.25	0.01235
KSE6	0	55	55	55						0	1344.444	336.1111	0						1680.55556	0.21157
KSE7	0	50	50							0	625	0							625	0
KSE8	0	30	30							0	225	0							225	0.11111
KSW1	0	105	105	105	105					0	6201.5625	2756.25	689.0625	0					9646.875	0.48040
KSW2	0	70	70							0	1225	0							1225	0.18367
KSW3	0	50	50							0	625	0							625	0.36
KSW5	0	40	40	40	40					0	900	400	100	0					1400	0.25
KSW8	0	45	45							0	506.25	0							506.25	0.01234
KSW9	0	70	70	70	70	70	70	70		0	3600	2500	1600	900	400	100	0		9100	0.16209

Table continued…

Ditch	U-shaped ditch, Expected									U-shaped ditch, (obs-exp)^2									U-shaped ditch: sum (obs-exp)^2	Ratio of V to U shape (V/U)
	0	0.5	1	1.5	2	2.5	3	3.5	4	0	0.5	1	1.5	2	2.5	3	3.5	4		
NM2	0	55	55							0	756.25	0							756.25	0.2066
NM3	0	45	45							0	506.25	0							506.25	1
NM4	0	40	40							0	400	0							400	0.5625
NM5	0	35								0	0								0	0
NM6	0	35								0	0								0	0
NM7	0	40								0	0								0	0
NM9	0	45								0	0								0	0
NM10	0	80	80	80	80	80				0	4096	2304	1024	256	0				7680	0.49023
PL1	0	85	85	85						0	3211.111	802.7778	0						4013.889	0.01384
PL2	0	90	90							0	2025	0							2025	0.19753
PL3	0	70	70	70						0	2177.778	544.4444	0						2722.222	0.06939
PL4	0	70	70	70						0	2177.778	544.4444	0						2722.222	0.14898
PL5	0	75	75							0	1406.25	0							1406.25	1.01778
PL6	0	30	30	30	30	30	30	30		0	661.225	459.1837	293.8775	165.3061	73.46939	18.36735	0		1671.429	0.37821
PL7	0	70	70	70	70					0	2756.25	1225	306.25	0					4287.5	0.42857
PL8	0	10	10							0	25	0							25	0
PL9	0	60	60	60						0	1600	400	0						2000	0.0125
PL10	0	15	15	15						0	100	25	0						125	1.6

Table continued…

	U-shaped ditch, Expected									U-shaped ditch, (obs-exp)^2									U-shaped ditch: sum (obs-exp)^2	Ratio of V to U shape (V/U)
Ditch	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**		
PL11	0	100	100	100						0	4444.444	1111.111	0						5555.556	0.6805
PL12	0	135	135	135	135	135				0	11664	6561	2916	729	0				21870	0.08459
PL13	0	20								0	0								0	0
PL14	0	85	85	85	85	85				0	4624	2601	1156	289	0				8670	0.52422
PL15	0	125	125	125	125					0	8789.0625	3906.25	976.5625	0					13671.88	0.56114
PL16	0	50	50							0	625	0							625	0
PL17	0	90	90	90	90					0	4556.25	2025	506.25	0					7087.5	0.0653
PL18	0	50	50	50						0	1111.111	277.7778	0						1388.889	0.208
PL19	0	45	45	45						0	900	225	0						1125	0.1778
PL20	0	85	85	85	85					0	4064.063	1806.25	451.5625	0					6321.875	0.2921
BM1	0	95	95	95	95	95	95			0	6267.3611	4011.111	2256.25	1002.778	250.69444	0			13788.19	0.01727
BM2	0	70	70	70	70	70	70	70		0	3600	2500	1600	900	400	100	0		9100	0.13186
BM3	0	75	75	75	75	75	75			0	3906.25	2500	1406.25	625	156.25	0			8593.75	0.29309
BM4	0	75	75	75	75	75	75	75		0	4132.6531	2869.8980	1836.7347	1033.1633	459.18367	114.79592	0		10446.4286	0.12615
BM5	0	105	105	105	105	105	105	105		0	8100	5625	3600	2025	900	225	0		20475	0.02442
BM6	0	90	90	90	90	90	90	90		0	5951.020	4132.654	2644.8980	1487.755	661.225	165.3061	0		15042.86	0.03728
BM7	0	90	90	90	90	90				0	5184	2916	1296	324	0				9720	0.20782

Table continued…

Ditch	U-shaped ditch, Expected 0	0.5	1	1.5	2	2.5	3	3.5	4	U-shaped ditch, (obs-exp)^2 0	0.5	1	1.5	2	2.5	3	3.5	4	U-shaped ditch: sum (obs-exp)^2	Ratio of V to U shape (V/U)
BM8	0	105	105	105	105					0	6201.563	2756.25	689.0625	0					9646.875	0.22255
BM9	0	60	60	60						0	1600	400	0						2000	0.1
BM10	0	40	40	40	40	40				0	1024	576	256	64	0				1920	0.60156
BM11	0	100	100	100						0	4444.444	1111.111	0						5555.556	0.325
BM12	0	90	90	90	90					0	4556.25	2025	506.25	0					7087.5	0.34744
BM13	0	100	100	100	100					0	5625	2500	625	0					8750	0.34857
BM14	0	90	90	90	90					0	4556.25	2025	506.25	0					7087.5	0.12169
BM15	0	90	90	90	90					0	4556.25	2025	506.25	0					7087.5	0.24868
BM16	0	95	95	95	95	95	95			0	6267.361	4011.111	2256.25	1002.778	250.694	0			13788.19	0.27656
BM17	0	100	100	100	100	100				0	6400	3600	1600	400	0				12000	0.22917
BM18	0	40	40							0	400	0							400	0.0625
BM19	0	90	90	90	90					0	4556.25	2025	506.25	0					7087.5	0.28748
BM20	0	80	80	80						0	2844.444	711.1111	0						3555.556	0.12813

Appendix 3 Sample references: qualitative

Table Aq Sample references for ordination diagrams; qualitative and quantitative comparison

Data Type	Ditch Number	Sample Number
Qualitative	KSE1	1
	KSE3	2
	KSE5	3
	KSE6	4
	KSE7	5
	KSE8	6
	KSW1	7
	KSW2	8
	KSW3	9
	KSW5	10
	KSW8	11
	KSW9	12
	NM2	13
	NM3	14
	NM4	15
	NM5	16
	NM6	17
	NM7	18
	NM9	19
	NM10	20
	PL5	21
	PL6	22
	BM1	23
	BM2	24
	BM3	25

Table continued…

Data Type	Ditch Number	Sample Number
	BM4	26
	BM5	27
	BM6	28
Quantitative	KSE1	29
	KSE3	30
	KSE5	31
	KSE6	32
	KSE7	33
	KSE8	34
	KSW1	35
	KSW2	36
	KSW3	37
	KSW5	38
	KSW8	39
	KSW9	40
	NM2	41
	NM3	42
	NM4	43
	NM5	44
	NM6	45
	NM7	46
	NM9	47
	NM10	48
	PL5	49
	PL6	50
	BM1	51
	BM2	52
	BM3	53
	BM4	54
	BM5	55
	BM6	56

Appendix 4 Sample referencing for ordination diagrams; quantitative samples

Table Ar All sites

Ditch	Sample	Ditch	Sample	Ditch	Sample	Ditch	Sample	Ditch	Sample	Ditch	Sample
KSE1	1	NM2	13	PL1	21	PL14	34	BM1	41	BM13	54
KSE3	2	NM3	14	PL2	22	PL15	35	BM2	42	BM14	55
KSE5	3	NM4	15	PL3	23	PL16	36	BM3	43	BM15	56
KSE6	4	NM5	16	PL4	24	PL17	37	BM4s	44	BM16	57
KSE7	5	NM6	17	PL5	25	PL18	38	BM4n	45	BM17	58
KSE8	6	NM7	18	PL6	26	PL19	39	BM5	46	BM18	59
KSW1	7	NM9	19	PL7	27	PL20	40	BM6	47	BM19	60
KSW2	8	NM10	20	PL8	28			BM7	48	BM20	61
KSW3	9			PL9	29			BM8	49		
KSW5	10			PL10	30			BM9	50		
KSW8	11			PL11	31			BM10	51		
KSW9	12			PL12	32			BM11	52		
				PL13	33			BM12	53		

Table As Somerset Levels (KSE/NM), Pevensey Levels (PL) and Berney Marshes (BM)

Ditch	Sample	Ditch	Sample	Ditch	Sample
KSE1	1	PL1	1	BM1	1
KSE3	2	PL2	2	BM2	2
KSE5	3	PL3	3	BM3	3
KSE6	4	PL4	4	BM4s	4
KSE7	5	PL5	5	BM4n	5
KSE8	6	PL6	6	BM5	6
KSW1	7	PL7	7	BM6	7
KSW2	8	PL8	8	BM7	8
KSW3	9	PL9	9	BM8	9
KSW5	10	PL10	10	BM9	10
KSW8	11	PL11	11	BM10	11
KSW9	12	PL12	12	BM11	12
NM2	13	PL13	13	BM12	13
NM3	14	PL14	14	BM13	14
NM4	15	PL15	15	BM14	15
NM5	16	PL16	16	BM15	16
NM6	17	PL17	17	BM16	17
NM7	18	PL18	18	BM17	18
NM9	19	PL19	19	BM18	19
NM10	20	PL20	20	BM19	20
				BM20	21

Appendix 5 Field sheets

Site: Date:

Record **approximate wet biomass** (% of total sample) for each species and overall DAFOR for whole section (**D** - 100-70% cover, **A** - 70-30% cover, **F -** 30-10% cover, **O** - 10-3% cover, **R** - <3% cover)

Species/Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Overall % Cover	Overall DAFOR
Emergents (in channel)																	
Total cover of macro-algae (est. % cover and DAFOR)																	

LOWLAND WET DITCHES

Site name... **Plot/ditch name/No**...............................

Date.............................. **Surveyor**……………………………………

GPS co-ords (Ordnance Survey 8 figure) @ two ends of 20m length: **1. x**……………………… **y**………………………..
2. x……………………… **y**………………………..

Whole 20m Length Assessment

Water Clarity: Secchi disk depth in cm (5 samples) **AND/OR** (see guidance) % of section with: clear water………………………….
slight turbidity/coloration…………
marked turbidity/coloration……….

Conductivity: meter reading: ....µScm^{-1}

Ditch Profile: water depth @ 0.5m intervals from bank

Successional stage: indicate % successional stage for whole ditch (underline successional stage for 20m length):

Early:	Mid:	Late:

Bankside vegetation: % cover estimates in ground, shrub & tree layers and % of ditch section overhung:

% ground layer	% shrub layer	% tree layer	% ditch overhung