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REPORT ON THE MANAGEMENT

OF THE DRAINAGE REGIME WITHIN

EXMINSTER MARSHES

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EXECUTIVE SUMMARY

In response to concerns that Exminster marshes are drying out and to evaluate the current management a study was made of the sites hydrology and ecological status. Field surveys were undertaken in the late summer of 1992, a period of low flows, with observations on flooding extending to May 1993.

Inputs and outputs to the marshes were determined together with the flow regime within ditches. The temporary Alphin/Matford Brook intake was seen to be the major input to the system during low flow conditions. Ditches in which flow was unsatisfactory were identified and the number of dry ditches found to have increased since 1988. A simplified level survey was produced identifying areas of low ground likely to flood.

Investigations on flooding within the catchment found that there is adequate storage capacity within the Exminster Marshes to provide protection to Alphington during conditions experienced in the 1960 flood.

Flooding of the marshes had an expected theoretical return period of more than once each year. Surface flow across the marshes followed moderate falls of rain where the catchment was already saturated. These conditions were more common during the winter but could be expected at any season.

Using a 1988 NCC full botanical survey of the sites ditch system as a base line along with records of past management the effectiveness of management practices in maintaining ditch diversity was investigated. De-weeding was generally found to maintain ditch diversity.

A study of the distributions of certain rare plants at the site was made. Several species recorded in 1988 were not subsequently found in 1992, however results were not conclusive.

Data was presented on several of the marshes bird populations and these were found to be generally increasing.

Recommendations for future management were made.

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FIGURE 1 - STUDY AREA

1.1 Introduction to the Site

The Exminster marshes is an area of grazing marsh of around 267 hectares. These marshes form the major part of a larger grazing marsh and flood storage area of 458 hectares which is situated to the south of Exeter on the west side of the Exe estuary. The Exminster marshes (fig 1) is bordered to the north by the A 379, to the west by the railway line and the east by Turf Canal. The southern boundary runs from the railway line crossing along the track to the Turf Lock outfall.

The history of the marshes management is not fully known. Prior to the extension of the Exeter Canal from Topsham to Turf Lock in 1827 the area was exposed to the marine influence of the Exe Estuary. It is not clear if the saline intrusion stopped then or persisted until the construction of the railway in the 1870's. The railway divided the grazing marsh into two areas 40% on the landward side and 60% between the railway and canal. More recent transport developments have impacted on the marshes with the construction of the Exminster bypass and the extension of the M5 motorway both occurring in the 1970's.

1.2 Grazing marshes in the UK

During the last few decades grazing marshes in England have been under pressure, from drainage operations and more intensive management. Management changes have included infilling of ditches, lowering of water tables as well as the increased use of pesticides and artificial fertilizers. This has resulted in a decline in the quality and quantity of grazing marshes which in turn has increased the need to manage remaining areas to ensure their conservation.

Grazing marsh habitat is particularly uncommon in the south west, and the Exminster marshes are the major site within this area. Both the general decline of grazing marsh habitat and its scarcity within the south west makes the Exminster marshes of local and national importance.

1.3 Exminster marshes : A protected area

The marshes are covered by several official designations:

i) Part of the Exe Estuary SSSI (Site of Special Scientific Interest)

ii) Part of the Exe Estuary SPA (Special Protection Area under EC Birds Directive 79/409)

iii) Part of the Exe Estuary Ramsar Site (Ramsar convention on wetlands of International Importance - especially as Waterfowl Habitat)

iv) County Nature Conservation Zone as designated in Devon County Structure Plan

v) The area south of the motorway bridge falls within a Coastal Preservation Area (also a County Structure Plan policy area)

vi) The areas within Exeter City Boundary are designated Valley Parks and Sites of Nature Conservation Interest.

1.4 Engineering functions

The marshes provide the storage requirements needed as part of the Alphington Flood Alleviation Scheme. The scheme involved increasing flood capacity of the Alphin Brook to allow for flood flows of 3500 cusecs. Sufficient storage is required within the marshes to meet this input plus the discharge from other tributaries estimated at 500 cusecs, coinciding with a series of high tides.

1.5 Conflicting Management interest

Exminster marshes is important because of its role in flood defence, its considerable conservation interest and its commercial value as an area suitable for grazing stock. It is important to balance all these interests when considering how the area is to be managed.

1.6 Aims of this report

This report aims to provide background information and the preparation of new management guide lines for the marshes. Specifically:

i) to provide a statement of NRA policy and to outline the past and present management of the site;

ii) to determine the existing water regime within the marshes including inputs, outputs and flow directions within the ditches.

iii) To investigate the options for increased winter flooding;

iv) to investigate the ecology of the ditches to determine the effects of current management practices on the ditch flora;

v) to present information on the numbers and distributions of the marshes bird populations;

vi) to provide specific recommendations on the management of the marshes.

2. NRA POLICY AND CURRENT SITE MANAGEMENT

2.1 Present management

The NRA is currently seeking to review its management regime for the site in line with MAFF guidelines and its new conservation duties. At present the NRA recognises as its primary roles.

i) To maintain the sites flood storage capacity.

ii) The protection of the area's agricultural land, property and stock.

iii) The provision of water levels within the ditch system to ensure stock control and watering.

iv) To maintain the area's nature conservation value.

2.2 Methods

In order to achieve the tasks listed above the NRA employs the following methods:-

i) Control and Enforcement

(a) Control development and infilling of the flood storage area.

(b) Control water abstraction within the area and surrounds to protect the wetland character of the site.

(c) Control the nature of discharges to surface and groundwaters entering the site in order to protect the water quality within the marshes.

ii) Ditch Maintenance

The NRA has used permissive powers under the Water Resources and the Land Drainage Acts to desilt and deweed the mained ditch system within the marshes. The ditches are cleared of weed growth in the Autumn and Winter months to allow for the through flow of streams and the evacuation of flood waters. No detailed records are kept of the extent or method of ditch clearance. The requirement for work has been at the discretion of the engineering staff and the requirements of the land owners.

iii) Water Level Control

Manipulation of water levels within ditches has been undertaken in recent years by means of:-

(a) Abstraction of water from the Alphin Brook to feed the Exminster marshes ditch system.

(b) The provision of 5 sluices to redirect flow towards the west side of the marsh and generally retain water within the marshes.

iv) Maintenance of nature conservation value

This has largely been a by-product of the flood defence role and has been achieved by:

(a) Resisting development and infilling of the flood storage area.

(b) Maintaining habitat diversity by weed clearance of the ditches (see appendix 2).

(c) Restricting operational activities to outside the nesting season for breeding birds.

(d) Control of ditch levels during times of low flow.

3. HYDROLOGY

3.1 Introduction

A comprehensive understanding of the water regime is essential before making any recommendations on the management of the marshes. Concern has been expressed by landowners, conservation groups and the general public over the water level in the ditches during the summer, and the presence or absence of flooding largely confined to the winter period.

In order to gain a further understanding of this central issue the following factors were investigated:-

i) All measurable inputs/outputs to and from the system and the quantification of flow rates where possible.

ii) Flow directions within the ditch system.

iii) The effect of tidal fluctuations on the water regime.

iv) The fall of water through the marsh and the position and falls associated with all sluices at the site.

v) The establishment of low lying areas within the marsh and the area's underlying geology.

vi) the form and extent of the winter flooding and a desk survey on historic flood events, storage requirements and flood risk.

3.2 Methods

3.2.1 Measurements of the Inputs and Outputs

Surface water inputs to the marshes (Appendix 1) were investigated and where the input was sufficient the flow was measured by NRA hydrometric services personnel using a current flow meter. The outfall at the Turf Lock was measured in the same way.

In addition to these practical measurements the inputs were also subjected to theoretical assessments by NRA hydrometric services personnel. Archive data of practical measurements of several inputs made in 1989/90 were also made available (appendix 2).

The intake from the Alphin Brook was constructed to provide additional water to the ditch system during periods of low flow to ensure stock control and stock watering, and operates episodically within each tidal cycle. Flow was measured practically using the current flow meter. In addition during a mean tide the intake was observed during the tide cycle and the period during which it operated was recorded. The theoretical assessment of the Alphin Brook intake was made by NRA engineering staff, following a level survey.

3.2.2 Assessment of the flow directions within the ditches

The direction of flow in each ditch was assessed by measuring the distance moved by an orange in a five minute period. Oranges have a density which ensures that they float with a minimum volume above the water surface, thus reducing air current interference. This enabled flow direction to be determined at levels below gauging accuracy.

3.2.3 Water Levels

The position of all the sluices and similar structures was established (Appendix 1) and the water levels associated with each were measured.

3.2.4 Levels survey and underlying geology

A full levels survey was completed by engineering staff in the 1960s. A simplified version of this was produced, to aid in the assessment of low lying areas Appendix 1(figure 4). The underlying geology was assessed using existing bore hole data (appendix 1).

3.2.5 Surface Flooding

Field observations were made during the winter and early summer 92/93 recording the form, extent and duration of flooding within the marshes.

3.3 Results of Hydrometric survey

3.3.1 Measurement of Inputs and Outputs

A comprehensive study of inputs to the site was hampered by the difficulties in finding inputs that were measurable and of all the possible ones only Exminster Brook, was large enough to be measured. All other inputs were below the detection limit of the gauging equipment. The results of this one input along with the output from Turf Locks are presented in Appendix 1 table 1.

The results of the theoretical assessments and those of the archive data of flow gauging made in 1989/90 are also presented in Appendix 1 table 1.

The assessment of the operation of the Alphin Brook intake was performed during a medium tide. The actual tide height was 3.3m at high tide, which was at 11.30 BST. Flow in the Alphin Brook at low tide on this particular occasion was 0.0537 cumecs.

At low tide, the water level in the Alphin Brook is below the level of both pipes which form the intake. As tide levels rise the connection between the Brook and the Exe closes, and the Brook backs up. When the water level backs up sufficiently for the level to be higher than the pipes the intake begins to operate. This continues until out flow to the river resumes as tide levels fall.

The times at which each pipe operated during the period of investigation is presented in table 2.

3.3.2 Assessment of flow directions within the ditches

The flow direction of many of the ditches was assessed and it was possible to get an appreciation of the main flow pattern through the marshes (fig. 3). In some cases ditches were too heavily vegetated to measure flow direction and in others the ditches were completely dry or appeared to have no flow. It should be recognised that fig.3 does not represent a definitive flow pattern which will apply under any circumstances, it is a snapshot situation during a dry summer. It is likely that the flow regime is subject to considerable variation depending on the amount of water entering the marshes and the state of vegetation growth within individual ditches.

3.3.3 Water Levels

The water level differences associated with the sluices (fig 3) are presented in appendix 1 together with any general observations. All but one of the sluices was shown to maintain a water difference (sluices A, B, D, E).

3.3.4 Levels survey

The site survey shows a range of high and low lying areas (fig 4) but the overall gradient across the site is relatively small at approximately 1:3500.

Geological Investigation

Historic borehole investigations (Appendix 1) show a thick layer of clay beneath a layer of estuarine alluvium and alluvial gravel.

3.3.5 Surface flooding, Flood Design and Storage Requirements

The Alphington flood relief scheme is designed to cope with the flows generated during the major flood of 1960. This flood followed a period of exceptionally high and prolonged rainfall with an expected return frequency of once in a thousand years. The flow entering the marshes was estimated at 4000 cusecs (99 cumecs) from a catchment of 20 sq miles (51.8 km^2). The marshes provide a storage up to 6 feet O.D. with the main flow entering the site over the weir at the northern end. The flood water passes through the marsh via ditches and surface flow and discharges into the estuary at the Turf outfall. How much flood storage the marshes will provide is complicated by the tidal and physical characteristics of the site. The drainage of the incoming flood waters will depend on several factors and to quote a single figure for the storage capacity would be inaccurate and misleading.

Surface Water flooding

Field observations of flooding events were made between October to May 92/93. Standing water was present on fields for much of November, December and the early part of January. The marshes remained free from surface waters until the end of May when the survey site was again inundated from the Alphin Brook.

All these floods followed a similar pattern with flood water flowing over the weir at the northern end of the site and travelling over a period of days to the Turf outfall. It was clear that the speed of the floods passage was dependent on the severity of the event and that standing water remained on low fields throughout the marsh for a period of weeks after the flood wave had passed through the system. The passage of the flood across the marshes followed a broad meandering route and was delayed by the presence of dykes, hedgebanks and the roads to Lime Kilns and the Turf Hotel which concentrated this broad surface flow to a number of low lying constrictions. The closure of the outfall at Turf during high tide periods had an influence on the ditch levels in the immediate area of the outfall <200m. It was not evident that the outfall closure influenced the rate of travel of the surface waters anywhere within the marsh.

3.4 Discussion of hydrological Results

Low Flows

(a) Inputs

During periods of low flows the only natural surface water input of significance is provided by Exminster Brook. The survey found that this flow was inadequate to support the water levels in the ditches. Other inputs were effectively negligible with little or no flow being measured. During the study the flow in the ditches was supplemented by the operation of the intake from the Alphin/Matford Brook. This intake installed by the NRA provided the major input to the marsh operating for approximately four hours in each tidal cycle. The tidal pulse generated by this intake was not observable lower in the marshes.

(b) Flow direction and ditch levels

Despite local variations in flow and flow direction there was found to be a clear, and not unexpected fall of water through the ditches from Alphin Brook to Turf Lock. The survey can provide little more than a snapshot of the flows as changing states of vegetation growth will influence flow direction. It would appear that ditch flow during low flows is concentrated into two major parallel systems running down the marsh. The ditch closest to the canal being the more significant of the two. Exminster Brook has a minor role to play at times of low flow in providing water to the west side of the marshes. Fig.3 shows that certain areas of the marshes are isolated from the through flow. The presence of these "back waters" has been recognised by the maintenance engineers who have installed sluices to direct flow towards areas identified as needing water. Additionally they serve to increase the travel time of water passing through the middle and upper sections of the marshes maintaining water levels. Of the five sluices only B and E maintained a significant difference of water level. Sluice B held back some 0.6m of water and its removal would most certainly detrimentally effect water levels in the ditches upstream, as would the removal of sluice E. Sluice C probably has little influence since it is not much more than a pipe and sluice A although it may not influence water levels dramatically may be partly responsible for the lack of a measurable flow in ditch 42.

No direct historical data was available on water levels to support the public perception that the marshes are drying out. However local landowners report problems in stock control due to the drying up of ditches, whilst warnings come from the observations of local naturalists and environmental groups. Since 1988 the number of dry or overgrown ditches has indeed increased. Appendix 1 shows the distribution of dry ditches identified in the NCC survey, which then accounted for 5.5% of the total ditch length. In 1992 they accounted for 6.6% and this despite increased efforts to augment the flow of water into the site. Changes in the national rainfall pattern in recent years is one possible cause of lower water levels. Rainfall data taken locally does show a slight drop in annual rainfall (appendix 1). Any ground water input to the site could have been affected by changes in the physical characteristics of the catchment such as recent road building and housing programmes within Exminster, the construction of the M5 and ground water abstraction. Dry ditches may also be the result of alterations in the pattern of flow within the marsh or the silting up of ditches and lack of maintenance.

To establish high ditch levels within the marshes a number of new sluices will be needed. These will raise water levels and reduce the travel time of waters moving through the ditch system. The location of these sluices are indicated on Fig (16). The final height of the sluices will need to be established by field trials.

It is also apparent that in order to protect the flow within the ditches during periods of drought the intake from the Alphin Brook will need to be fully implemented and if possible improved. The improvement could involve constructing a weir downstream of the intake to raise the level of the Brook to remove the present tidal influence and allowing 24 hour operation. The water quality of the Alphin Brook is failing to meet its water quality objective of 1b. Consideration should be given to the effect of larger amounts of this water entering into the marshes and its possible effect on the ecology of the ditches.

c. Outputs

Only one output from the marshes was recognised, that of Turf Lock, producing an outflow of some 0.475 cumecs. Measurable inputs failed to match this figure either practically or when calculated theoretically implying a considerable imbalance between surface water inputs and measurable outputs. This difference could be made up from a ground water pressure head feeding the marshes, leakage from the canal or simply storage by discharge.

Furthermore the Turf Lock outfall was recognised as tidally operated, the marshes only being drained at times of low tide. This results in a back up of water within the marshes while the outfall is closed. Further investigations have shown this to be concentrated around ditches 122 and 124 and not spread evenly further up the marshes (appendix 1). This suggests the improvements made to the Turf Lock outfall to more efficiently drain the marshes during peak flows have little influence on water levels during low flows.

SURFACE WATER FLOODING

The flooding which was observed over the winter of 1992/93 supports the view that the absence of flooding in the preceding year was a result of rainfall patterns, rather than a change in management practices. There are no accurate records of flooding frequency or duration. Local information suggests that flooding of fields and roads occurs about twice each year and is more likely to occur during the winter. The RSPB and English Nature have expressed a desire to see surface water on the marshes during the winter period to attract wading birds and wildfowl. This conflicts with the NRA's flood defence requirements to maximise storage capacity. The issues of the surface flooding of Exminster Marshes are:-

Q. What storage is required to prevent a reoccurrence of the flooding of Alphington in 1960 given a similar set of circumstances.

A. The storage requirement is based on historical information and field evidence collected by Sir M Macdonald and partners the consultant engineers following the floods of September 1960. In their report of June 1961 and developed in subsequent reports, storage requirements were determined by the need to hold volumes generated by the 1960 flood coinciding with a high tide. This flood followed a rainfall pattern with an expected return frequency of 1 in every 1000 years. Storage availability was calculated on the flooding of "Powderham Marshes" the complete marsh system to a height of 6 feet O.D. a height selected to protect Exminster Railway Station. Sufficient storage was found to exist within Exminster Marshes to meet this event based on the capacity available from ground level to 6 feet O.D. excluding the other marshes. The Macdonald report calculated the storage within the marshes to be more than double that needed to store the 1960 flood even when the marshes were tide locked. The volume required was estimated as 1000 acre feet with an available storage of 2170 acre feet. Since this time storage capacity has been reduced by the construction of the M5 and Exminster Bypass. Additional work has taken place to increase the size of the Turf outfall which compensates for this storage loss.

Q. What is the level of protection provided to Alphington and is it consistent with other NRA flood defence schemes.

A. The return period for the peak flow of 3500 cu secs estimated for the Alphin Brook under the 1960 flood conditions cannot be calculated on the basis of evidence from gauging stations. The flow was based on Field observations after the flood event and is complicated by obstructions to flow. The rainfall event has been investigated and has an expected return frequency of 1 in 1000 years. If one relates this to a flood return frequency of the same order which is not unreasonable given the flashy nature of the Brook and the geology of the catchment then protection exceeds the 1 in 100 year flood protection normally provided by NRA flood defence schemes.

Q. What is an acceptable level of winter flooding within the marshes taken in isolation from the potential impact on Alphington.

A. There are no accurate long term records of flooding on the marshes. The marshes are recognised as flooding approximately twice year. The major flood wave is typically of short duration passing through the system in days rather than hours. Surface water remains in fields within depressions for a period of weeks rather than days. It is recognised that flooding occurs to roads, tracks, car parks and properties in addition to agricultural fields. This flooding causes inconvenience and financial loss and the NRA would not undertake or condone actions which would exacerbate these conditions to the detriment of any interested parties.

Q. Can winter flooding be increased as a result of engineering works or changes to management techniques?

A. The options to reasonably allow/create winter flooding within the marshes are limited by a number of factors.

i) **Enhanced Inputs**

Flood water enters the study area via the weir to the north of the site. It is neither possible or feasible to increase the frequency of these events which are rainfall dependent.

Diversion of the Alphin and Matford Brook which presently enters the Exe via an outfall under the Exeter Canal into the Exminster Marshes is physically possible. Concern must be expressed about the water quality from these streams.

ii) **Controlling outputs.**

There is only one outfall from Exminster Marshes. The Turf outfall was designed to rapidly discharge major floods at low tides. The influence of this outfall on the overall water level within the marshes is crude and does not enable the control of water levels other than around (within 200 metres of) the outfall.

iii) The flat nature of the marshes (1:3500) means that the positioning of sluices on the ditches within the marsh to cause local flooding is problematic. The principal problems being the back flooding of fields and property where it could form a nuisance, or the re-routing of flows which could dry up existing ditches.

4.0 DITCH ECOLOGY

4.1 Introduction

This section of the report is primarily concerned with an assessment of the impact of recent water levels and management practices on the important ditch flora found at the site. It uses as its baseline the results of a full botanical survey of the marshes produced by the NCC in 1988. By using the various distinct plant communities recognised by the NCC survey to classify a random selection of 49 ditches Appendix 2 (figure 8) an assessment of the current state of the ditch flora could be made. This could then be viewed alongside recent management practices to help in the overall assessment.

The survey was carried out in late August/early September 1992. The method used was essentially an extension of that used in the NCC survey and is summarised below.

4.2 Methods

The NCC study sampled all 145 ditches located at the site using a "characteristic" 20m section of each ditch. It was considered the best way to represent the vegetation of that ditch and was used as a unit of study. A full species list was compiled along with DAFOR abundance ratings. Plants were grouped into three classes; aquatic, inundation and emergent.

The results of this survey were analyzed using TWINSPAN (Two-Way INdicator SPecies ANalysis; Hill 1979) which is a sophisticated method of sub-dividing a group of samples into smaller sub-units based on their species composition. This technique was chosen as an alternative to the National Vegetation Classification (NVC) which when applied to ditch systems often proves problematical. It produced a number of recognisably different floral communities within the ditch system separated by virtue of differences in the species they contained and the various associations these species formed. For each class the TWINSPAN analysis produced a range of floral communities.

One main advantage with this method is that during the process of sub-division certain "indicator species" are identified within the data set, and these form the basis of a dichotomous key which can subsequently be used to classify the vegetation of a sample. A new ditch can hence be classified purely by the presence, absence and abundance of just these key species without the need for a full botanical survey. Using the keys produced by the 1988 survey, the 49 randomly selected ditches were reclassified.

Aquatic vegetation was defined as those species which were either wholly submerged, free floating, or rooted with floating leaves and those species which for most of the summer have the majority of their biomass below the water surface. The TWINSPAN analysis identified 6 separable aquatic end groups (A1 - A6).

Emergent species were those which grow along the waters edge, or within the aquatic zone and that for most of the summer have the majority of their biomass above the water surface. The TWINSPAN analysis identified 4 separable emergent end groups (El - E4).

Inundation species were defined as those found close to the water's edge on the lower bank. The NCC survey found little variation within this group across the site and hence for the purposes of this study inundation species were not considered when reclassifying each ditch.

A description of the various aquatic and emergent end groups is presented in Appendix 2.

A sample data recording sheet is given in Appendix 9 and includes the TWINSPAN keys used to classify each ditch. Each key is started at the top with subsequent divisions according to those species present. A score is calculated at each stage of division, the result of which dictates the direction to take. Numbers in brackets refer to measures of abundance (as outlined in the NCC survey) with the presence of a species noted only when this number is matched or bettered. For each species positioned on the left of the key that is noted at a site a -1 is awarded, while for a species t the right a +1. When these marks are summated to produce a final score for that division the direction to follow is indicated by the numbers found at the next junction. For instance a 1 on the left would indicate that if the total equalled or was less than 1 the left hand branch of the key should be taken. A +2 on the right would alternatively indicate that should the total equal or better +2 the right hand branch should be taken. This process is repeated down the key until the final division is made and the resulting end group is indicated.

In addition to the work a plant assemblages the study looked at changes in the occurrence of locally important plant species. These were recorded as present or about within a 20 metre "typical" section of the sampled ditch. Table 4 (7) gives the species selected for each ditch. Several physical features were recorded; the water depth, water width, freeboard and the slope of the banks. A note of the weather on the day of sampling was also made, including wind strength and direction. To aid in a comparison with the 1988 survey measurements of freeboard were placed in to 3 classes;

0 - 50 cm	class A
51 - 100 cm	class B
>100 cm	class C

4.3 Results

Table 3 presents the results of the TWINSPAN classification along with measurements of freeboard. Ditches are divided into those which received maintenance in 1991/92 and those which did not. Results from the 1988 NCC survey are included for comparison. A rough measure of the physical status of the ditch is also included by using flow information from figure 3 (cf Hydrometric survey).

The various proportions of each ditch type within the total sample of ditches was calculated for both 1988 and 1992 (figure 3). This overview was then broken down to show the change in proportions of each ditch type within both the managed and unmanaged subsets (figures 9 - 11)table 4.

This showed the number and proportion of each ditch type in '88 that remained of that type, or if not to which ditch type was changed to, in the '92 survey. For example how many managed AI ditches remain AI, or how many become A2 etc. These calculations provide a useful indication of change between the ditch types but do not however give an absolutely clear picture of any successional sequence due to the 'overview' nature of the study and the small sample size.

Table 5 shows the proportions of the various flow types within the sample as a whole, and within the two subsets. Only 1992 data was available.

Table 6 (a,b,c) shows the proportions of each freeboard class within the whole date set and within the two subsets for 1988/92.

4.4 Discussion of Ecological Results

This study had two basic aims. Firstly to determine the effectiveness of current site management on maintaining the ditch flora and secondly to provide some degree of information on the present ecological state of the marshes. Ditch systems are not static and the progressive degradation of a ditch through siltation and litter deposition producing a ditch choked with emergents and lacking any aquatic macrophytes is well documented. Management through dredging and de-weeding aims to prevent this process and to provide a range of conditions within the ditches suitable to support a diversity of vegetation types.
The ability to evaluate the NRA's management effectiveness of the Exminster marshes ditches is complicated by a number of factors:-

(a) The NRA do not keep records of past ditch clearance or written accounts of the techniques employed. Ditches have been deweeded as a result of assessment of need a decision made by engineering staff, normally with consultation with the landowners. The presence of stock, ground conditions and season have all been determining factors.

(b) The NRA does not have permissive powers to deweed all the ditches within the marsh.

(c) Landowners are allowed and often do undertake ditch maintenance operations within the marshes using different techniques and timing to that employed by the NRA.

It has been assumed in this study that no significant ditch maintenance has taken place between 1988 and 1992 other than by the NRA. It is also understood that the NRA's 1991/92 winter programme was consistent with the previous three years.

Figure 6a appears to indicate that management has indeed served to maintain a balance between the various aquatic end groups since 1988, although the loss of end group A2 is an exception to this. The apparent loss of A2 from this subset could have been due partly to the lack of A2 ditches initially (there were only 2 ditches within this subset in 1988). However both these ditches maintained a relatively rich aquatic community and the loss of group A2 can be primarily related to an absence of Lemna trisulca when these ditches were reclassified.

Figure 10b denoting unmanaged ditches seems to point to a current imbalance between aquatic end groups, with an increase in species poor group A6 since 1988 and most notably a loss of relatively species rich group A2. Here the loss of A2 appears to be related to a loss in conditions suitable for aquatic plants. Many of these ditches found in 1988 to be A2 were identified in 1992 as having a poor flow while being largely dominated by emergents and several identified as relatively species poor group A6. The unmanaged subset accounted for all those ditches which in 1992 contained no aquatic vegetation, and the number of these ditches had increased significantly since 1988.

An improved water supply is therefore required to maintain the aquatic plant community end groups and suppress the emergent end groups.

Figures 11a and 11b both show a similar trend in emergent end groups between 1988 and 1992, one of increased E1 (relatively species rich group) and E2 while less E3 (also relatively species rich) and E4. Despite this both subsets retain a fair diversity of emergent end groups. This suggests that other factors have a greater role influencing emergent communities than does the management regime. It is possible however that the grazing of emergents by stock, which was much in evidence for many ditches, provided an unintentional form of management, helping to maintain diversity.

For both aquatic and emergent plants the increased number of dry ditches identified by the hydrometric survey is of concern since it was noted that dry ditches soon became mere grassy dips in the fields, mimicking their species composition. Although an accurate survey of these ditches was not done they did not appear to offer additional habitat diversity to the site.

Measurements of freeboard appear to indicate that within managed ditches there has been an overall increase in deeper freeboards. For unmanaged ditches the proportion of shallow freeboards has increased. A lower water table could be one explanation for an increase in deeper freeboards although such a drop would be expected to apply to all ditches. Siltation and litter deposition may well have caused the freeboards of unmanaged ditches to fall. However no firm conclusions can be drawn from this data since the rainfall patterns of '88 and'92 are quite dissimilar while the extra inputs afforded by the Alphin/Matford Brook intake applies only to the 1992 data. Day to day variations in the water table would make any reliable comparisons impossible.

In summary it would appear that the marshes continue to support a diverse floral community and that current management practices are helping to maintain this.

5.0 BIRD ECOLOGY

5.1 Introduction

A desk study was made on selected bird species to see if the numbers present were increasing or decreasing. The species selected for study covered both summer breeding birds, over wintering and winter migrant species. Information was provided by the RSPB, EN and the DBPS.

5.2 Population data

Cetti's warbler cettia cetti

This is a sedentary species which over the last 30 years has colonised England. As it is a resident feeding on insects it tends to be badly affected by cold winters. It breeds in areas of low tangled vegetation in wet or damp situations. The table below shows the number of singing males recorded around the study site for the period 1985 - 1992.

1985	1986	1987	1988	1989	1990	1991	1992
6	4	6	11	13	14	10	11

Additionally, a small number of birds are known to hold territories in a few other sites north of the study area. The 1992 total is therefore probably about 15. The Exe could hold up to 6% of the British breeding population.

Sedge Warbler Acrocephalus schoenobaenus

This species is a summer migrant characteristic of vegetation of many waterside habitats. They tend to be less selective than Reed Warblers in their nesting site preference but land to be restricted to the drier regions of wetland areas. The number of territories held within the marshes and surrounds are shown below.

1985	1986	1987	1988	1989	1990	1991
24	51	48	61	61	57	36

Reed Warbler Acrocepholus scirpaceas

Similar to the previous species reed warblers are summer migrants and as the name suggests are already associated with reed beds. The number of breeding territories held are shown below.

1985	1986	1987	1988	1989	1990	1991
	55	49	60	59	66	46

Reed Bunting Emberiza schoeniclus

Reed buntings are resident birds and in recent times have expanded their ecological range from wetland areas to encompass a range of drier habitats. The table of breeding territories is shown below.

1985	1986	1987	1988	1989	1990	1991
13	35	15	17	19	17	19

Lapwing Vanellus vanellus

Lapwings breed in a great variety of habitats and were once common throughout lowland Britain. Numbers have always been low in western areas and recent trends have shown a general decline in population breeding density in southern Britain. The numbers shown in the table below represent about 7% of Devon's breeding population.

1987	1988	1989	1990	1991	1992
14	14	26	32	27	18

Redshank Tringa totanus

Redshank usually favour nesting in damp marshland and grassy fields. Similar to the Lapwing breeding density has always been low in western and particularly south western areas of Britain and Ireland. Low numbers breed within Devon around the upper marshes of the south eastern estuaries but became extinct as a breeding bird following the severe winter of 1962/63. The Exminster marshes were recolonised in 1973 and now contains a stronghold of the counties breeding population. Those fields regularly used for breeding are indicted in Fig 14. Counts of breeding pairs are presented below

1987	1988	1989	1990	1991	1992
3	7	10	10	6	5

Wintering Populations

The use of the marshes by over wintering wild fowl and wading birds is considered to be of primary importance by the RSPB and EN. it is well known that flooding events during the winter attracts birds present from the Exe Estuary to the marshes. Counts of wildfowl and waders are fairly comprehensive for the estuary but are limited within the marshes. No data exists to show the distribution of birds within the Exminster marshes. The table below shows the numbers of three internationally significant bird populations present on the Exe Estuary and the maximum recorded presence within the survey area.

MAX COUNTS ON: A EXE EST B EXMINSTER MARSHES

	87 A	87 B	88 A	88 B	89 A	89 B	90 A	90 B	91 A	91 B	92 A	92 B
Wigeon	2754		2033		1329		3349		2298			
Brent	2500		1724		2795	440	2665	600	2317	920		1200
Black-Tailed Godwit	520	370	552	300	546	70	656		785	15		50

5.3 Discussion

A desk study of the changes in the numbers of selected bird species present within the marshes must be treated with caution. At its best, and viewed within the context of national and local trends, it can be shown that certain habitats persist within the study area. These habitats are also of sufficient quantity and quality to attract or maintain the presence and numbers of the target bird species.

The data given above shows that the six breeding birds studied have all maintained or increased their breeding territories over recent years. The population dynamics of all the species are complex and major population controls for the species are thought to range from drought conditions in overwintering grounds, to cold winters to climate change. It is reasonable to assume from the data provided that local conditions have remained favourable for the species studied. The Exminster marshes provides an important county and regional site for these species.

The situation with regard to the overwintering birds on the marshes is difficult to evaluate. The data for the marshes is extremely limited and where available does little to confirm the importance of the marshes within the context of the Exe Estuary. It must be acknowledged however the marshes are badly unrecorded for wildfowl and waders and that winter flooding does provide additional feeding and nesting areas for the birds of the estuary. The excellent work the RSPB has done at Bowling Green Marsh on the east side of the estuary demonstrates how birds may be attracted to fields with a high water table and permanently flooded areas. In addition to the provision of new wildlife habitats it has also proved to be an important amenity feature for birdwatchers.

6.0 RECOMMENDATIONS

The recommendations of this report cover 4 key areas

1. Manipulation of inputs/outputs;
2. Manipulation of the flow regime within the ditches;
3. Ditch maintenance procedures;
4. Future monitoring

6.1 Inputs/Outputs

Options to manipulate surface water inputs centre on the temporary Alphin/Matford Brook outfall.

a) Low Flows
To ensure sufficient water levels in the ditches during periods of low flow the following actions are required.

   i. The NRA should formalise the operation of the two outfalls from the Alphin/Matford Brook.

   ii. The operating period for these outfalls should be during low tide extended to provide a flow. This will reduce the tidal pulse of freshwater presently in operation and increase the total volume of water entering the system.

b) High Flows
Surface flooding of the Exminster Marshes follows high rainfall events particularly if preceded by a wet period. These events can not be artificially generated and it would not be possible to create a similar flooding pattern by other means.

Outputs
The Turf Outfall design and operation does not allow for surface flooding within the marsh to be manipulated by controlling the rate of discharge. Retention of water would create relatively deep flooding close to the outfall and have little influence over the majority of the marsh.

6.2 Manipulation of Flow

In order to ensure a comprehensive wet ditch system with high water levels and increase the frequency of localised surface flooding where desirable the following actions are required.

1. All existing sluices should be formally recognised.

2. New sluices to be built in locations shown in Appendix 4 figure 16. The site selection is based on low flow studies and ditch characteristics experienced during 1992. Owing to the changing nature of flows resulting from maintenance and vegetation growth the sites will need to be experimental in terms of exact location and sluice height. Fig 17. shows the suggested design to allow for increased levels while maintaining the ditches high flow capacity. Sluices will be required to gradually increase the overall water height by a series of small stepped rises.

3. Isolated ditch systems should be reconnected to the remaining ditches.

6.3 Ditch maintenance procedures

The following procedures are recommended for ditch maintenance within the marshes.

a) Mechanical de-weeding of ditches should take place between October to March.

b) The frequency of deweeding is shown in Fig 18 a.b.c.d. The two mained arterial ditches are to be de-weeded yearly to ensure the efficient through flow of water from Countess Weir to Turf Lock. Those ditches recognised as supplying inputs to the marshes are also to be maintained on a yearly cycle. The remaining ditches are to be de-weeded on a 6 year cycle as indicated. Work on non-mained ditches will require the cooperation of landowners within the marshes and English Nature.

c) Uprooted vegetation should be disposed of evenly within 5 metres of the ditch. When placing material along the top of the banks the construction of ridges or raised banks should be avoided.

d) Dredging has not been used on any of the ditches managed by the NRA. The de-weeding programme described above should be sufficient to maintain the ditches as required. Any dredging should be done on a minimum five year cycle and ditches reprofiled to form greater habitat diversity.

e) Dry ditches should be dug out to provide further wetland habitat and landowners should be encouraged to provide new ditch habitats. It will be necessary to consider the effect of these new ditches on the existing system prior to the NRA consenting such work. All excavated material will need to be removed from the flood storage area.

6.4 Monitoring Procedures

The following monitoring procedures should take place to provide feedback and allow changes to be made to the actions set out in 6.1 - 6.3.

a) A biological ditch monitoring programme to evaluate the effects of the maintenance procedures based on the EN and NRA surveys.

b) A low flow study following the implementation of the new Alphin Brook outfall and sluice network.

c) A surface flooding recording procedure should be implemented.

d) An annual collation of bird records for the marshes should be undertaken.

6.5 Implementation

Subject to successful consultation and agreement the works should be installed during the current financial year. Alterations to maintenance procedures and the working programme should start in the Autumn of 1993.

[USERS.TEM.FRC]PN-050893-JAL-EXECUTIVESUMMARY

APPENDIX 1

HYDROLOGY

Figure 2 - Inputs & Outputs of Exminster Marshes

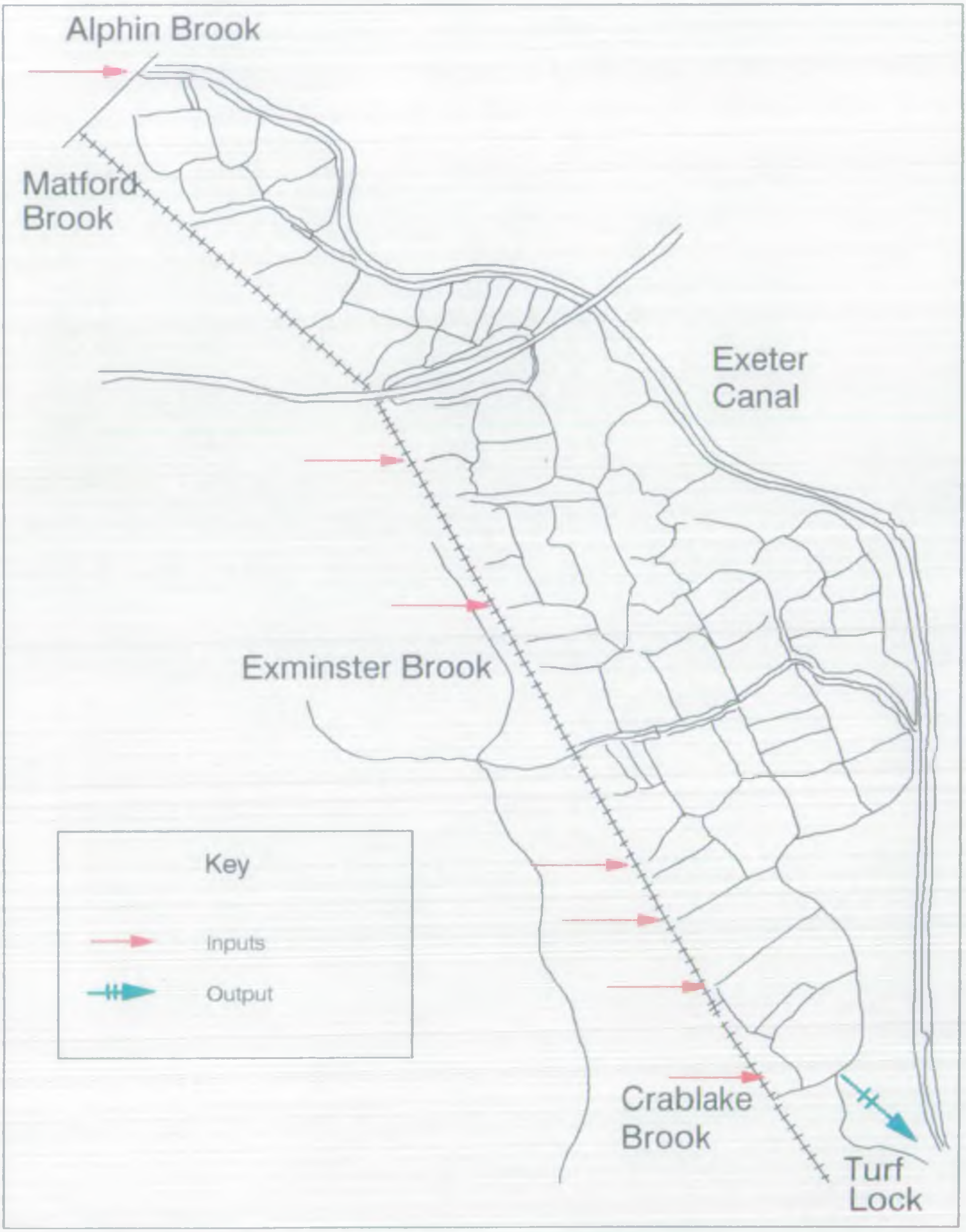


Figure 3 - Observed flow directions within the ditches and positions of sluices

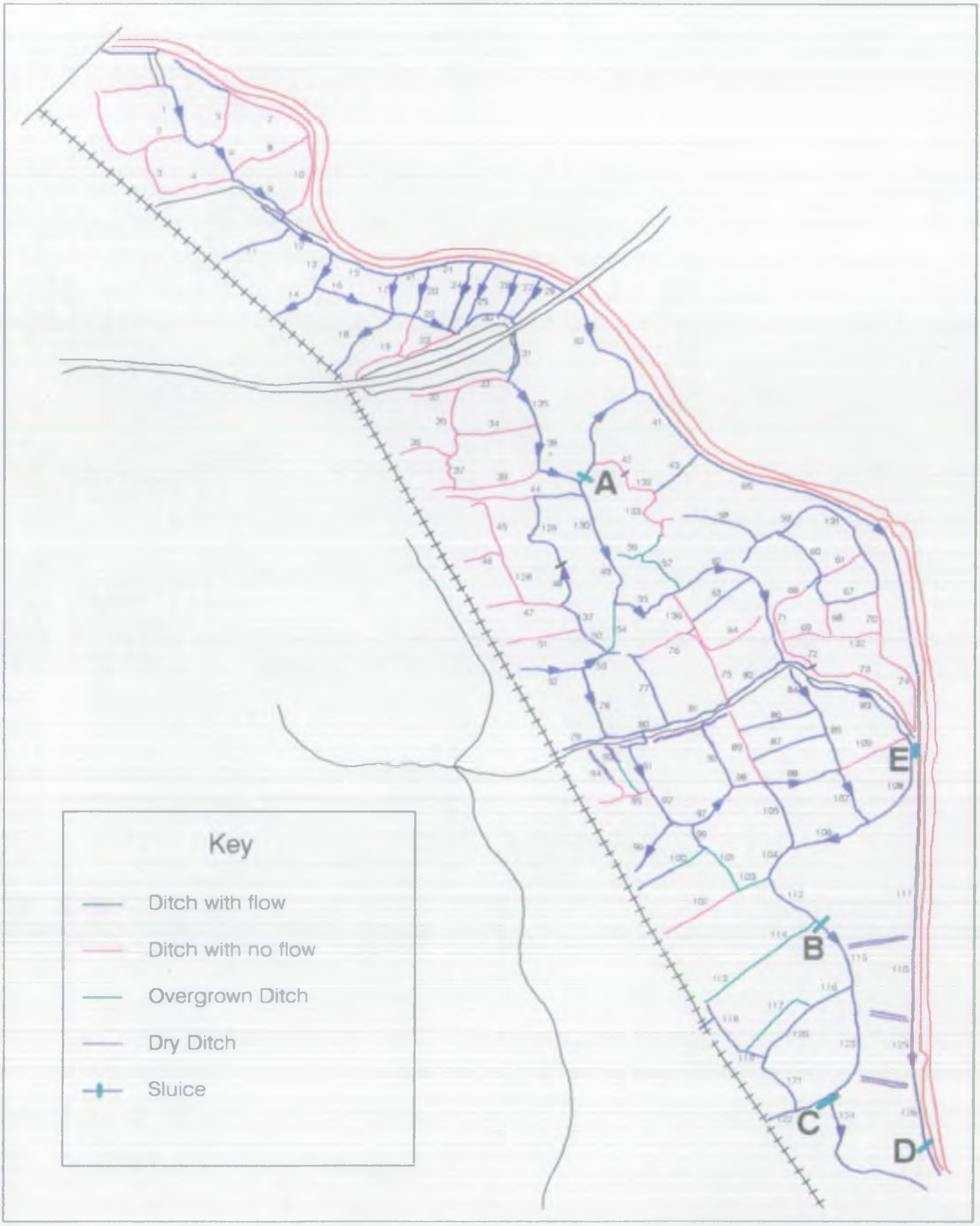


Figure 4-Simplified levels survey

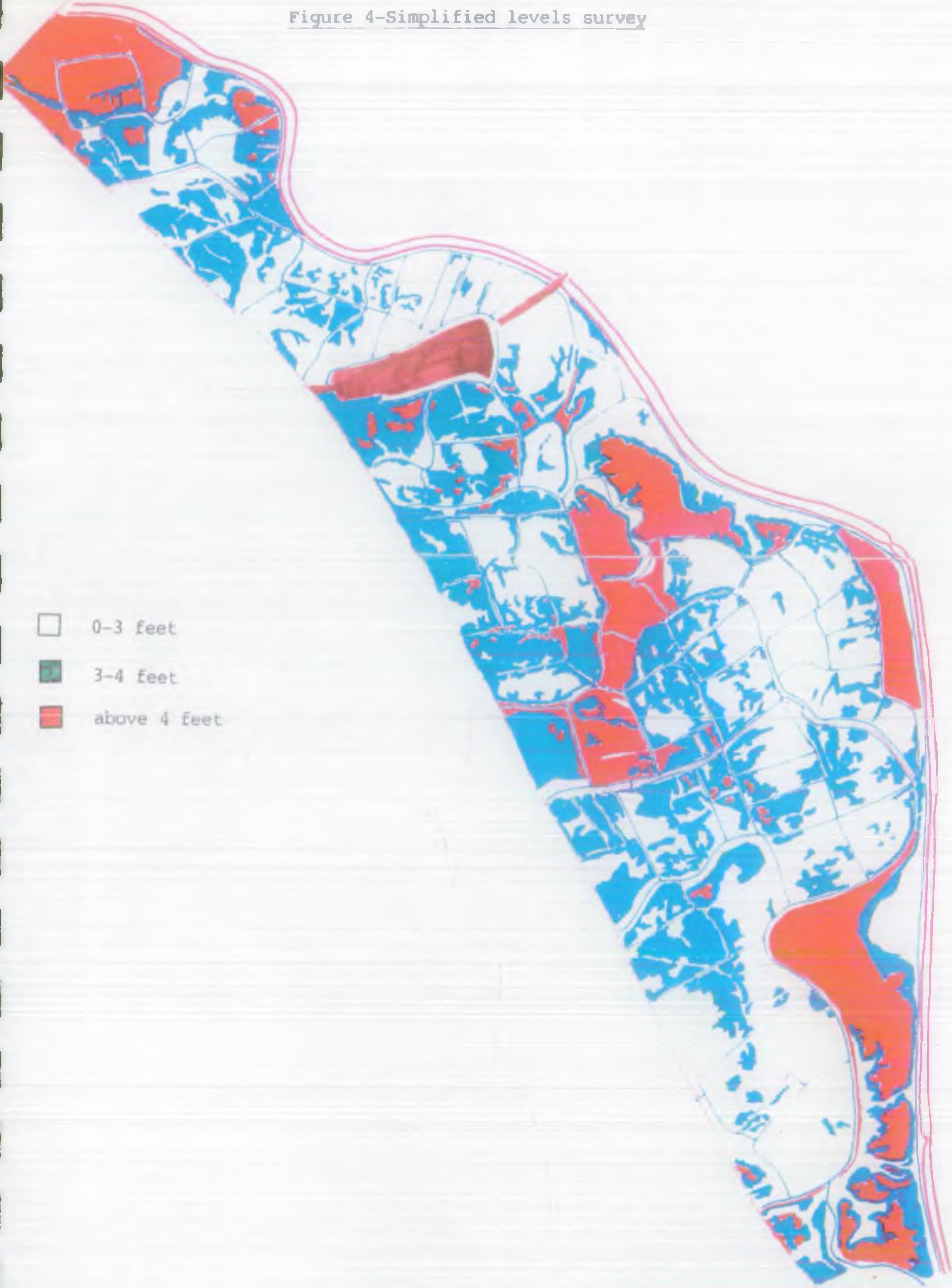


Figure 5 - Bore hole data indicating underlying geology

Fig 5

Bore hole data indicating underlying geology.

1.	NGR 9532 8863	
	SL + 1.16	
	Estuarine Alluvium and Alluvial gravel	
	Grey and brown mottled clay	1 07
	Clayey silt	1 98
	Silty clay	3 05
	Brown gravel	7 92
	Exeter Formation	
	Broadclyst sandstone member	
	Breccia	9 14
	Sandstone	10 66
2.	NGR 9514 8853	
	SL + 1 10	
	Estuarine Alluvium and Alluvial gravel	
	Grey and brown silty clay with organic and peaty traces	3 50
	Gravel with occasional cobbles	6 90
	Exeter Formation	
	Broadclyst sandstone member	
	Sandstone, reddish brown fine grained	7 30
	Breccia	9 40
3.	NGR 9531 8804	
	SL + 1.10	
	Estuarine Alluvium and Alluvial Gravel	
	Silty Clay	1 03
	Sandy silt with layers and lenses of clay	3 05
	Gravel	7 77
	Gravel and cobbles	9 45
	Exeter Formation	
	Broadclyst sandstone member Red Breccia	10 97
	Sandstone and siltstone	11 20
	Breccia	13 41
	Red sandstone	17 87
4.	NGR 9569 8738	
	Estuarine Alluvium and Alluvial Gravel	
	Brown Clay	3 81
	Gravel	9 75
	Exeter Formation	
	Broadclyst sandstone member	
	Sandstone	45 69

Fig 6

Appendix 1- Patterns of annual rainfall for Exminster marshes

Station name - Kenton (altitude 30.0m)

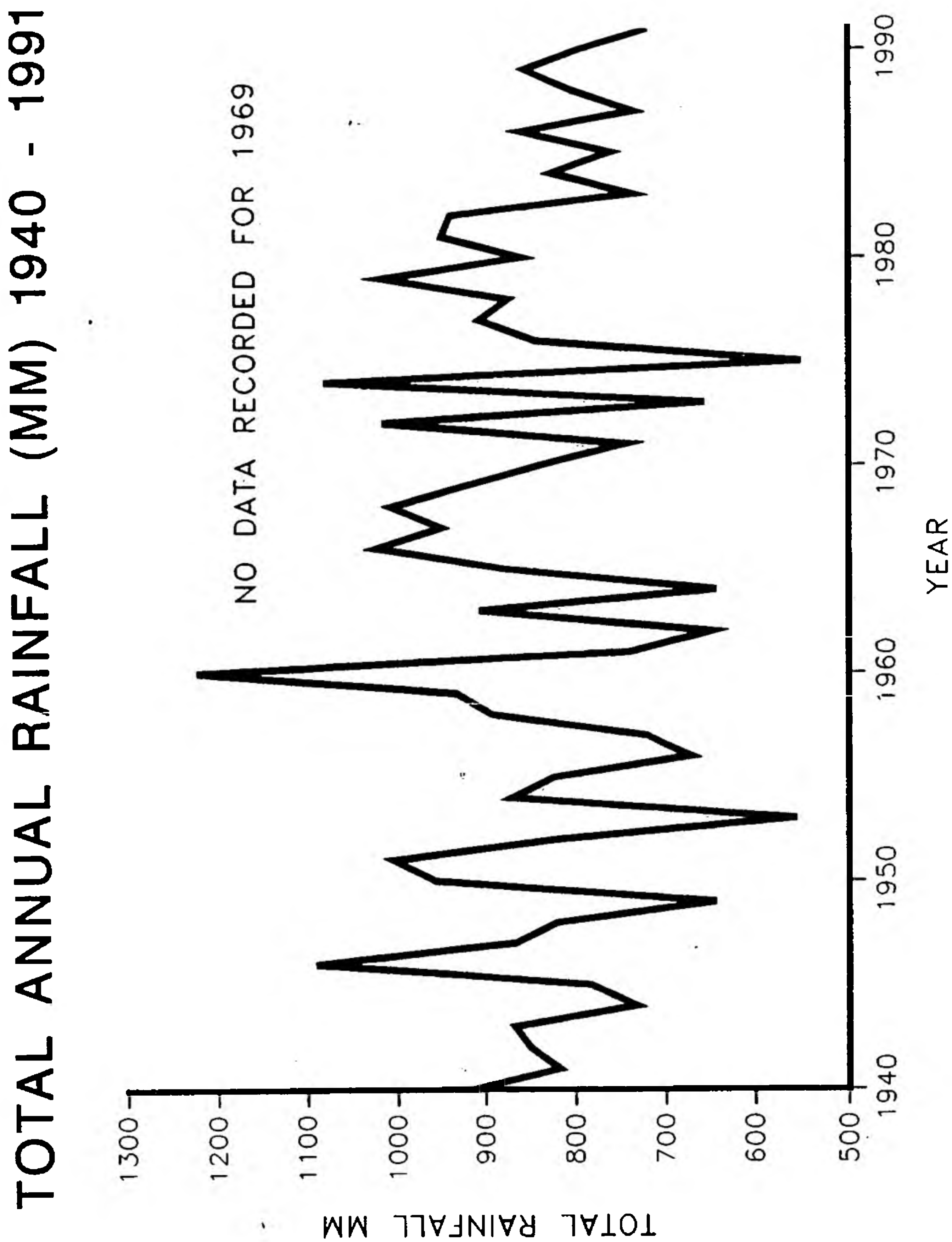


Table 1 -
Theoretical and actual flow measurements of inputs and outputs of the Exminster Marshes

Site	Flow (Cumecs)			
	Theoretical ADF	Q95	Archive	Measured
Alphin Brook	0.364	0.058	*	*
Matford Brook	0.098	0.033	0.01615	*
	*	*	0.01164	*
Exminster Brk	0.075	0.024	0.00837	0.0124
	*	*	0.09000	*
SX 9485 8815	0.009	0.003	*	NF
SX 9550 8690	0.017	0.006	*	NF
Crablake Brook	*	*	0.00236	NF
	*	*	0.00287	NF
Combined Alphin and Matford Brook				
11:05	*	*	*	0.043
11:20	*	*	*	0.052
11:30	*	*	*	0.051
11:45	*	*	*	0.049
12:10	*	*	*	0.051
Turf Lock	0.563$	0.124$	*	0.475

Where
* signifies that data was not available
NF that no flow was measurable
$ No ADF/Q95 data was available for Turf Lock figures given refer to summations of known inputs.

Theoretical data produced 06 1992
Archive data measured (gauged) in 1989/90
Measured data measured (gauged) 06 1992, with the exception of Alphin Brook as shown.

Time BST	Downstream Pipe	Upstream Pipe
8.15	NF	NF
8.45	NF	NF
9.15	NF	NF
9.45	NF	NF
10.00	NF	SF
10.15	NF	FF
10.30	SF	FF
11.00	SF	FF
11.30	SF	FF
12.00	SF	FF
12.30	SF	FF
13.00	SF	FF
13.30	SF	FF
14.00	SF	FF
14.30	NF	SF
14.45	NF	SF
15.00	NF	SF
15.30	NF	NF
16.00	NF	NF

Table 2- Operation of the Alphin Brook Outfall

Where NF = no flow
SF = slight flow
FF = full flow

Table 3 - Water level differences associated with the site's sluices

i) Sluice A - Water level difference <10cm
Water flowing through holes in this poorly maintained sluice rather than over the top.

ii) Sluice B - Water level difference 60cm
Water flowing through holes or underneath rather than over the top.

iii) Sluice C - At low tide it maintains a water height difference of approximately 20cm.

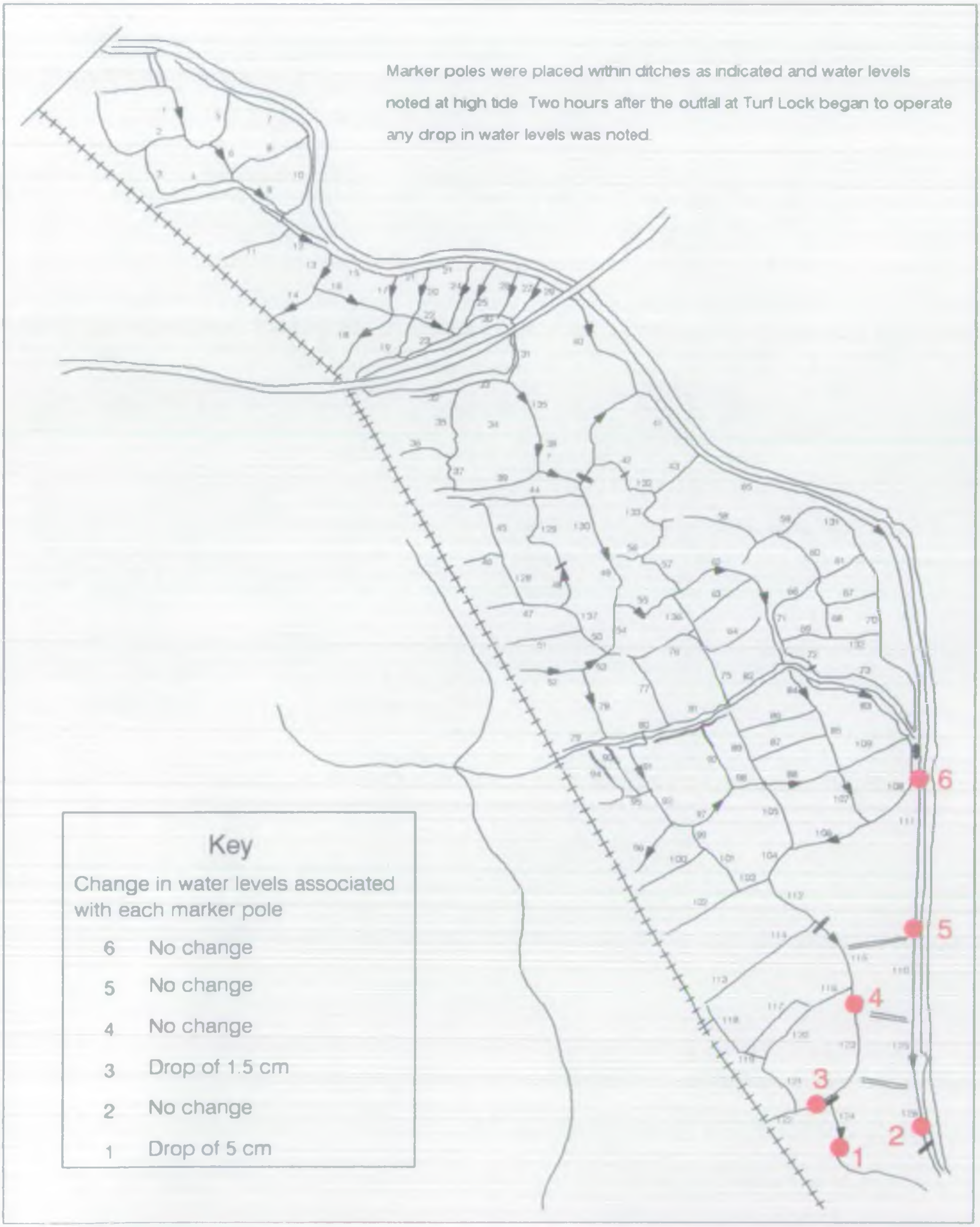
This is a pipe rather than a traditional sluice.

iv) Sluice D

- Low tide:	Sluice height	100cm
	Water height	95cm upstream 70cm downstream
- High tide:	Sluice height	100cm
	Water height	102cm upstream 102cm downstream

v) Sluice B - Water level difference approximately 30cm.
Water flowing through holes in the sluice rather than over the top.

Figure 7 - Water backup at the southern end of the marshes



APPENDIX 2

Ditch sampling and numbering system	Fig 8
Changes in twinspan and groups	Fig 9 - 11
Ditch maintenance programme 91/92	Fig 12
Distribution of dry ditches 1988	Fig 13
Twinspan classifications	Table 4
Ditch flow type	Table 5
Ditch freeboard classes	Table 6
Rare plant data	Table 7a - b
Site report card	
Description of Aquatics and emergent	
Twinspan and groups	

Figure 8 - Ditches sampled in 1992 and the ditch numbering system

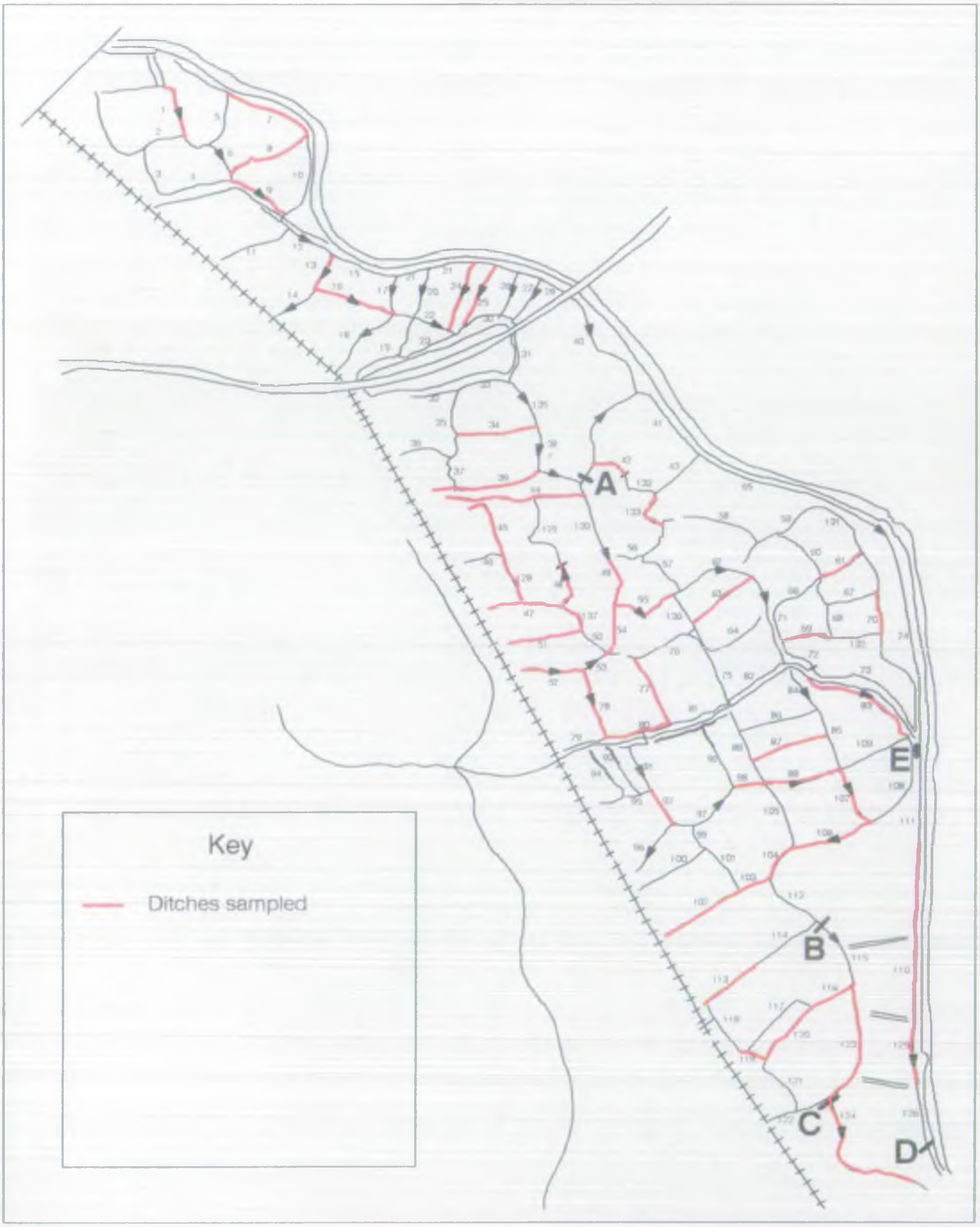
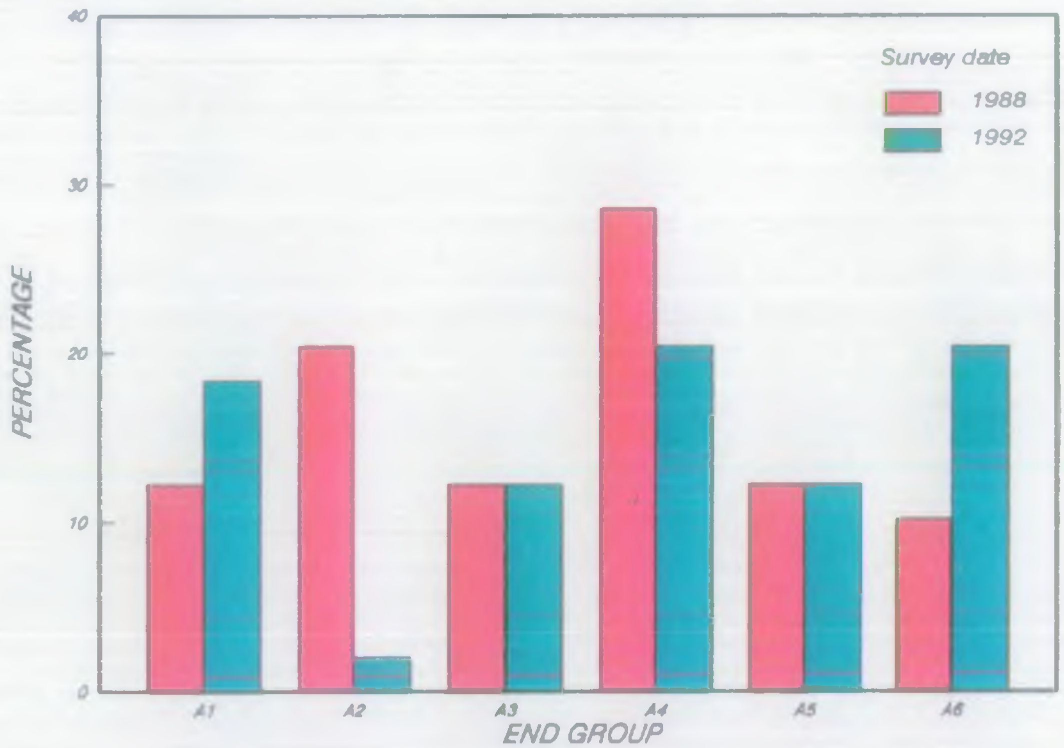


FIGURE 9
OVERALL CHANGES IN TWINSPAN END GROUPS

9a OVERALL CHANGES IN AQUATIC END GROUPS



9b OVERALL CHANGES IN EMERGENT END GROUPS

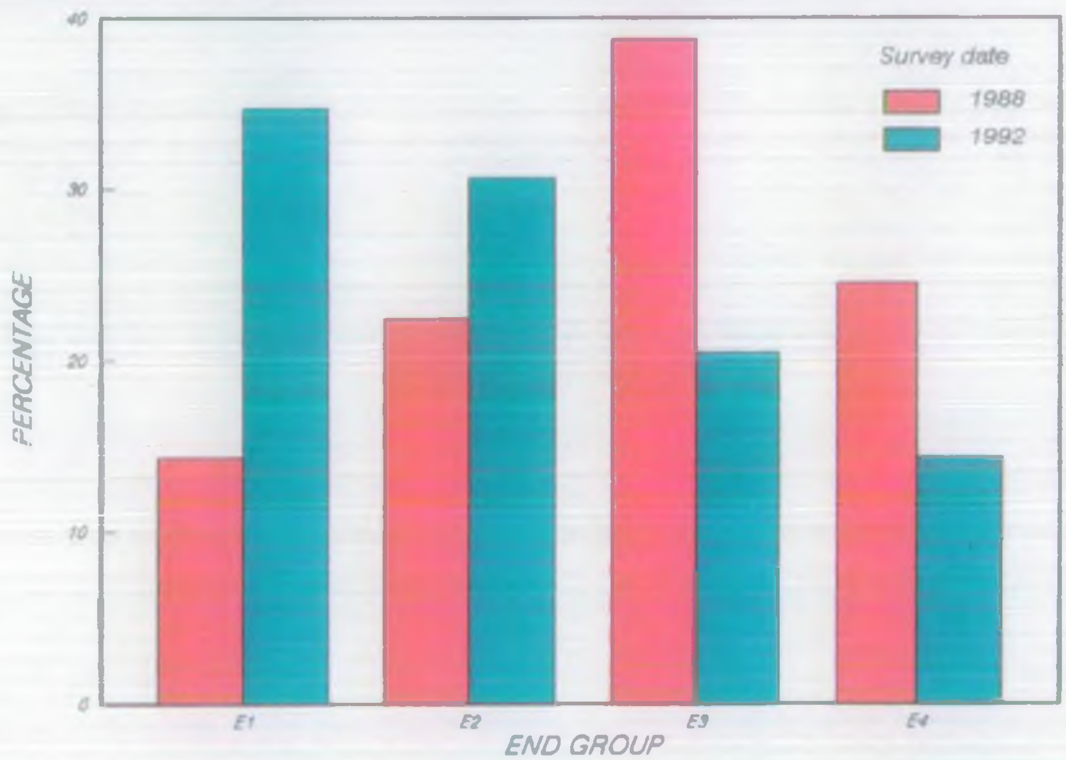
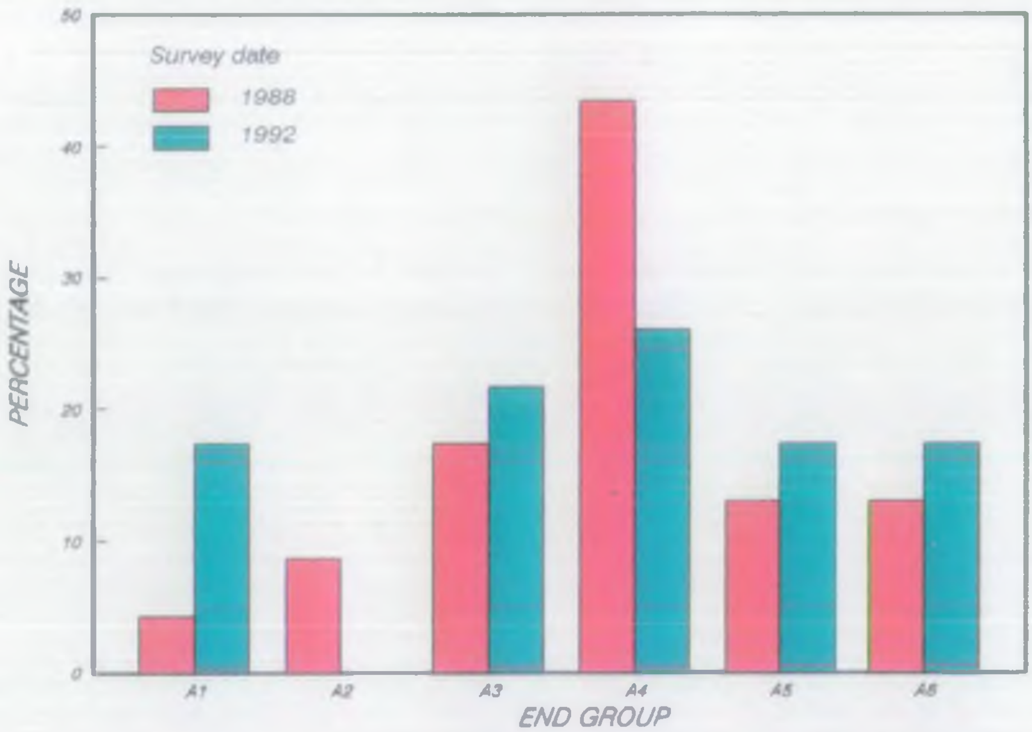


FIGURE 10
CHANGES IN AQUATIC END GROUPS - MANAGED Vs UNMANAGED

10a CHANGES IN AQUATIC END GROUPS - MANAGED DITCHES



10b CHANGES IN AQUATIC END GROUPS - UNMANAGED DITCHES

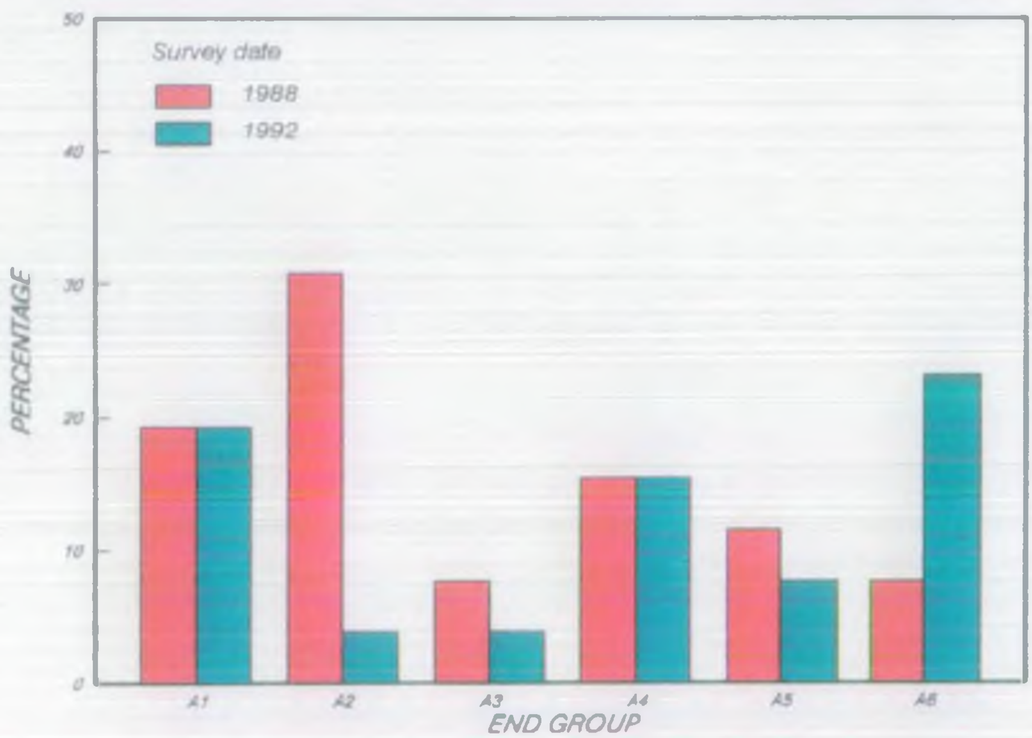
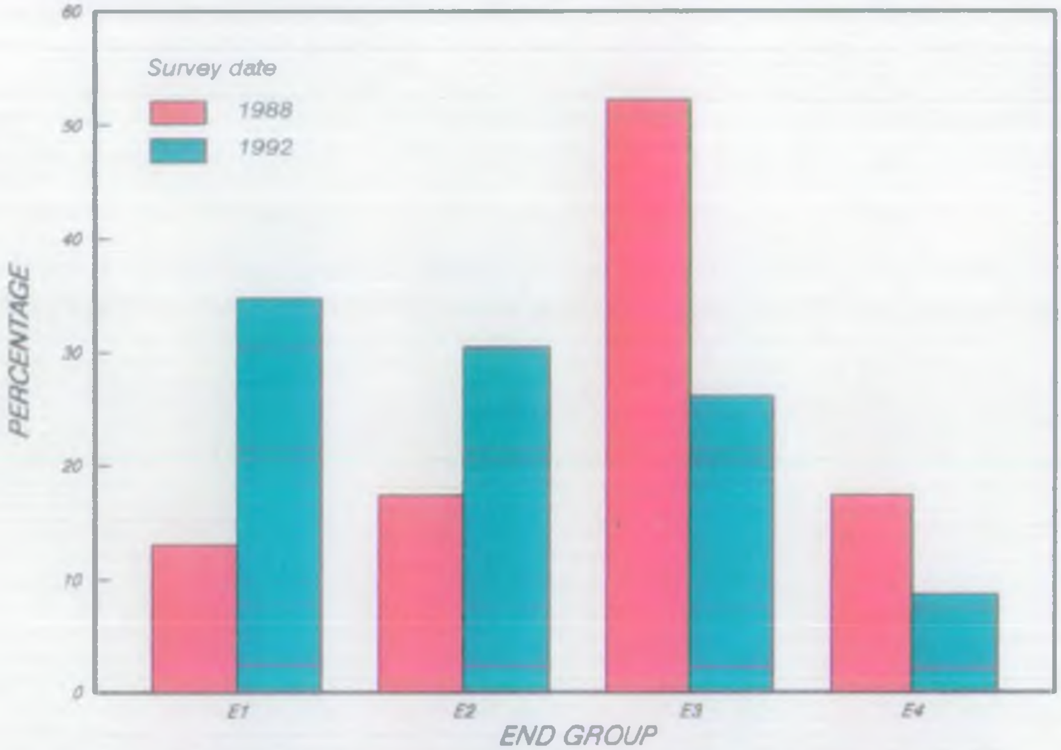


FIGURE 11
CHANGES IN EMERGENT TWINSPAN END GROUPS
MANAGED Vs UNMANAGED

11a CHANGES IN EMERGENT END GROUPS - MANAGED DITCHES



11b CHANGES IN EMERGENT END GROUPS - UNMANAGED DITCHES

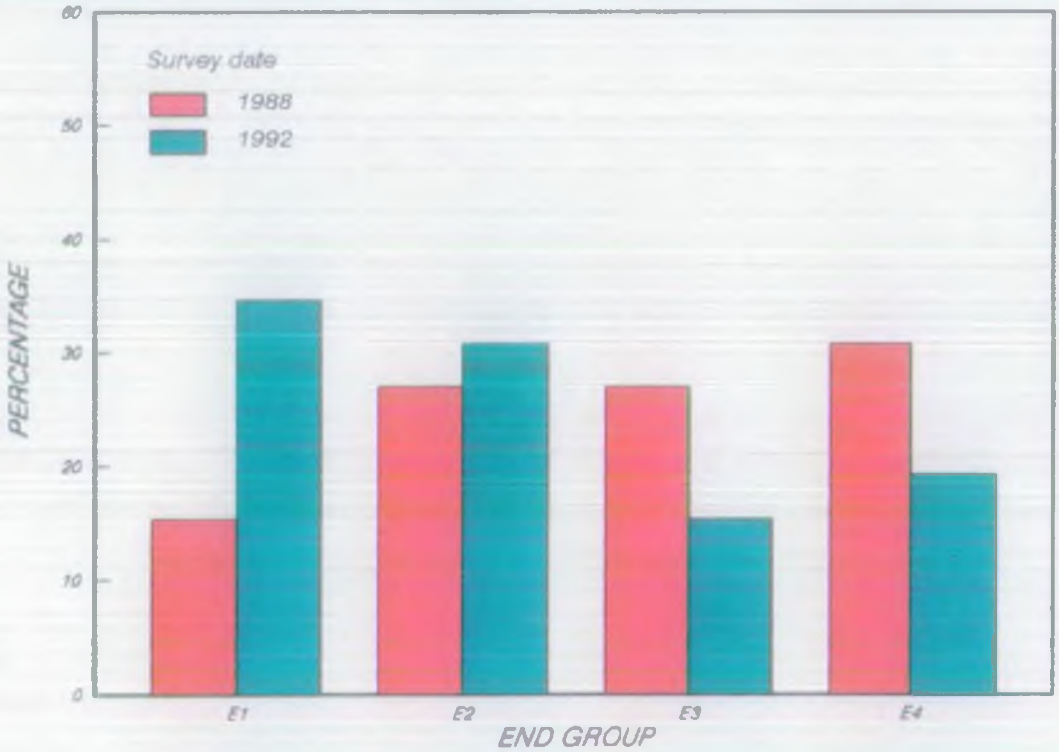


Figure 12 - Ditches maintained during Winter 1991/92

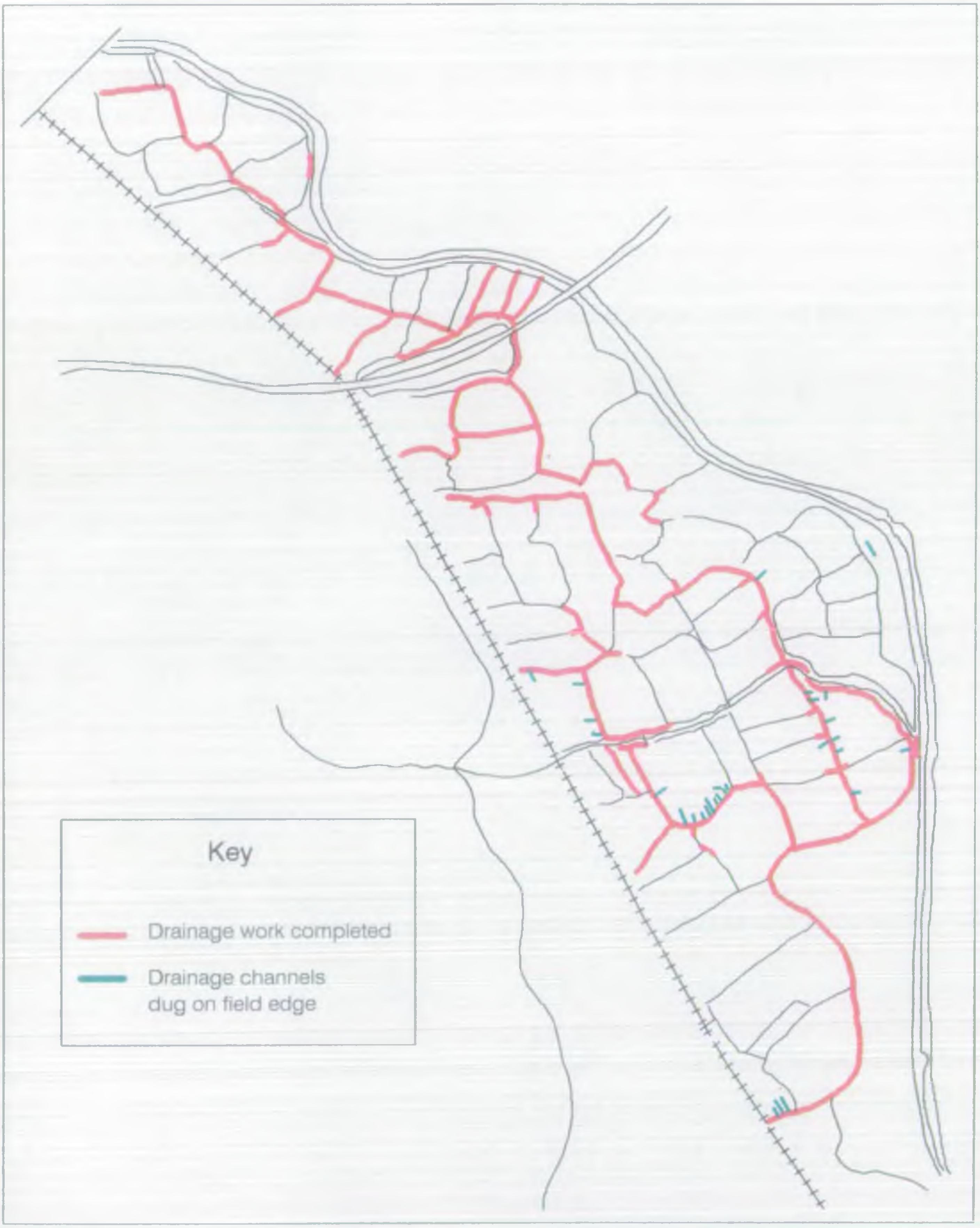
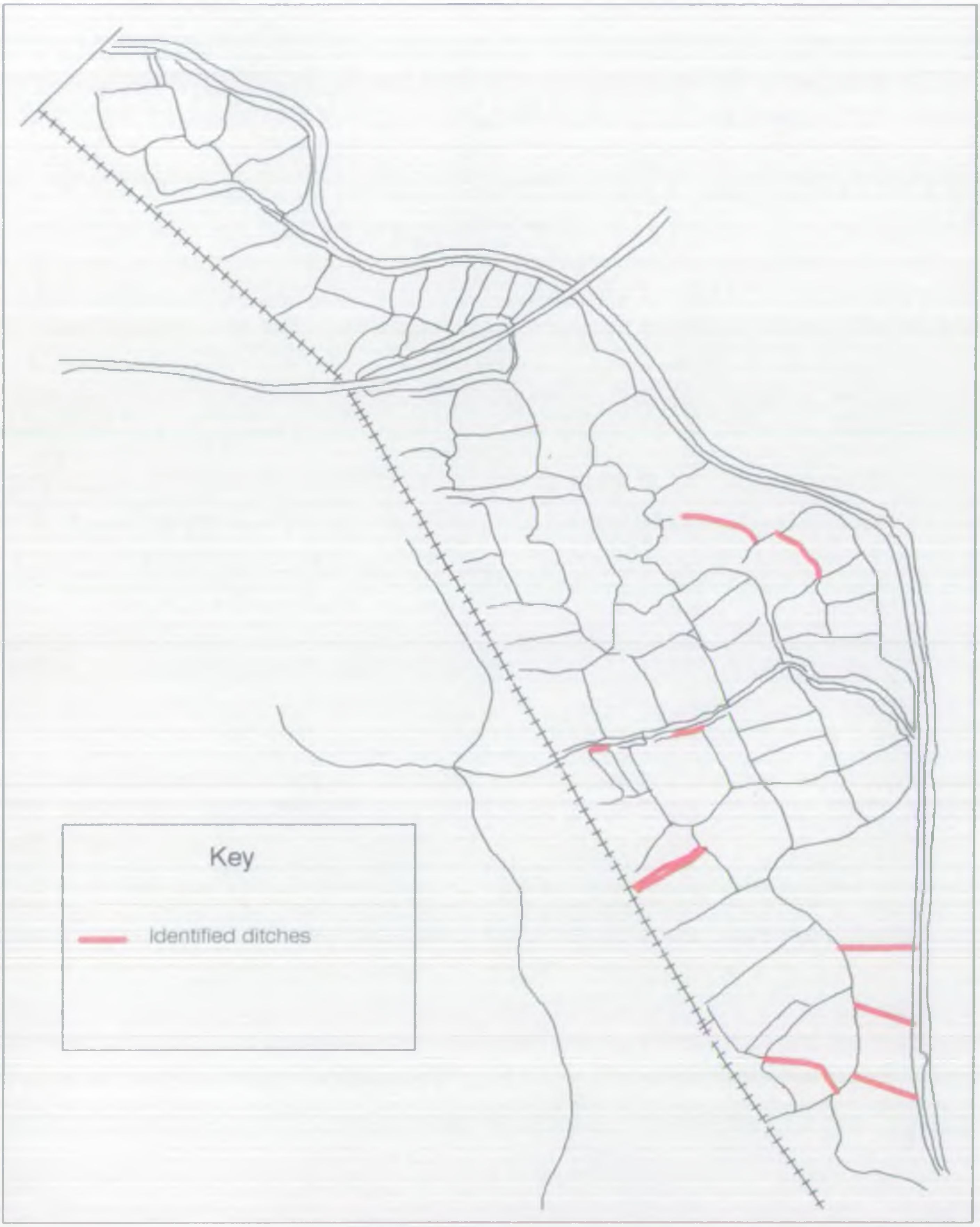


Figure 13 - Dry ditches identified in the 1988 NCC report



Ditch	TWINSPAN class. '88	'92	Freeboard '88	'92	Flow
1	A4 / E3	A3 / E3	B	C	F
9	A4 / E2	A4 / E2	B	B	F
13	A4 / E2	A3 / E3	B	B	F
16	A4 / E3	A3 / E2	A	B	F
24	A4 / E1	A3 / E1	A	A	F
25	A4 / E3	A4 / E1	B	A	F
34	A2 / E3	A1 / E3	B	A	NF
42	A4 / E1	A1 / E1	A	A	NF
44	A3 / E2	A1 / E2	B	B	NF/F
49	A3 / E3	A6 / E2	B	B	F
52	A6 / E3	A6 / E3	A	A	F
55	A4 / E4	A5 / E2	C	C	F
78	A6 / E3	A4 / E2	C	C	F
80	A6 / E4	A5 / E1	B	B	F
83	A3 / E4	A4 / E4	C	C	F
92	A5 / E3	A4 / E1	C	B	F
98	A2 / E3	A3 / E2	A	B	F
104	A4 / E3	A6 / E3	B	C	F
106	A5 / E3	A6 / E4	C	C	F
107	A3 / E3	A5 / E1	B	B	F
123	A5 / E4	A5 / E1	B	C	F
133	A4 / E1	A1 / E1	B	C	NF
137	A1 / E2	A4 / E3	B	B	F

Table 4- TWINSPAN Classifications of sampled Ditches, Measurements of Freeboard and Flow

Table 3a - Managed Ditches

Ditch	TWINSPAN class. '88	'92	Freeboard '88	'92	Flow
7	A2 / E4	A6 / E2	B	B	F
8	A4 / E3	A4 / E1	B	A	NF
39	A1 / E3	@ / E3	B	B	NF
45	A1 / E2	A1 / E2	B	A	NF
47	A1 / E2	A1 / E2	B	B	NF
48	A1 / E2	A4 / E2	B	A	F
51	A1 / E2	A1 / E1	A	A	NF
54	A4 / E3	A5 / E3	C	C	O
61	A6 / E4	@ / E4	C	*	NF
63	* / E3	@ / E2	B	B	F
69	A2 / E1	A6 / E1	B	B	NF
70	A6 / E1	@ / E4	C	*	NF
71	A2 / E1	A2 / E4	C	C	NF
77	A2 / E2	A4 / E2	C	C	F
87	A2 / E2	A6 / E4	B	C	NF
88	A3 / E4	A6 / E4	B	C	F
102	A2 / E1	@ / E1	B	C	NF
103	A3 / E3	A5 / E1	C	B	O
110	A2 / E3	A3 / E2	C	C	F

Table 4b -Unmanaged Ditches

- Ditch numbering is consistent with that used in figure 8
- * refers to ditches not classified in the 1988 NCC report
- @ indicates a ditch containing no aquatic vegetation
- A refers to a freeboard of 0–50cm
  B refers to a freeboard of 51–100cm
  C refers to a freeboard >100cm
- F indicates the ditch possessed a measurable flow
- NF indicates the ditch possessed no measurable flow

113	A5 / E4	@ / E1	C	B	O
116	A5 / E4	A6 / E1	C	C	F
119	A2 / E2	A1 / E1	B	C	F
120	A4 / E4	A6 / E3	B	C	F
124	A5 / E4	@ / E1	C	C	F
125	* / E4	A4 / E2	C	C	F
128	A4 / E3	A1 / E3	B	A	NF

Table 4b - continued

* - Data not available

F - Ditch with flow

NF- Ditch with no flow

O - Overgrown ditch

@ - No aquatic vegetation, ditch dominated by emergents

NF/F- Ditch containing two equal sections, one with flow and one without.

Flow Type	Overall No.	Overall %	Managed No.	Managed %	Unmanaged No.	Unmanaged %
Flow	30	61	19	83	11	42
No Flow	15	31	3	13	12	46
Some Flow	1	2	1	4	0	0
Overgrown	3	6	0	0	3	12

Table 5-Analysis of flow types for ditches sampled. Shows for all ditches sampled and within the managed and unmanaged subsets the proportions of each flow class. Similarly the number of ditches in 88/92 that were classified as that flow class

a)OVERALL

Freeboard Class	No. in 88	%	No. in 92	%
A	6	12	10	21
B	27	55	17	36
C	16	33	20	43

b)MANAGED

Freeboard Class	No. in 88	%	No. in 92	%
A	5	22	5	22
B	13	57	10	44
C	5	22	8	35

c)UNMANAGED

Freeboard Class	No. in 88	%	No. in 92	%
A	1	4	5	21
B	14	54	7	29
C	11	42	12	50

Table 6-Analysis of freeboard classes for ditches sampled. Shows for all ditches sampled (a) and within the managed subset (b) and unmanaged subset (c) the proportions of each freeboard class. Similarly the number of ditches in 88/92 that were classified as that freeboard class

Spp	B 1988	A 1992
Azolla filiculoides	3	0
Oenanthe pimpinelloides	1	0
Lysimachia vulgaris	3	0
Butomus umbellatus	3	3
Hydrocharis m-ranae	10	8
Potamogeton trichoides	2	0
Carex pseudocyperus	4	2

Table 7a - Rare plant data showing overall results for 88/92

	Managed		Unmanaged	
spp	B	A	B	A
Azolla filiculoides	3	0	0	0
Oenanthe pimpinelloides	1	0	0	0
Lysimachia vulgaris	2	0	2	0
Butomus umbellatus	2	2	1	1
Hydrocharis m-ranae	4	3	7	5
Potamogeton trichoides	0	0	2	0
Carex pseudocyperus	2	1	2	1

Table 7b-88/92 rare plant datapresented for the managed and unmanaged ditches

A - Number of ditches in which a species was recorded (92 data).

B - 88 data, refers to the number of ditches sampled in 92 that in 88 had that species recorded.

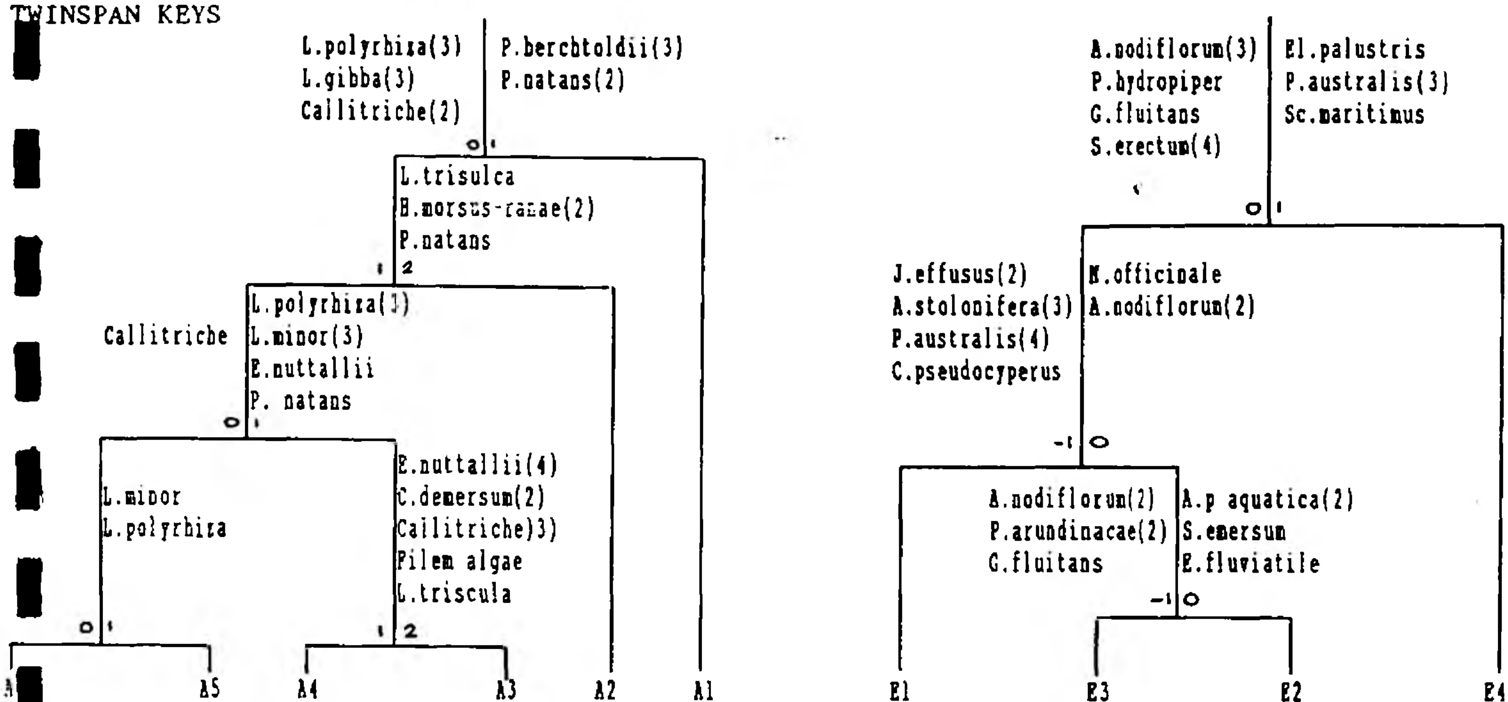
Date:____________ Time:____________ Ditch no:________

Wind Direction:__________ Weather:________________

Strength:__________

Water Depth:	0	10	50	100	200cm
Width:	0	1	2	3	4m
Freeboard:	0	20	50	100	200cm
Bank Slope: A	0	15	30	55	70°
B	0	15	30	55	70°

TWINSPAN KEYS



RARE BOTANICAL SPECIES.

Species	D	A	F	O	R	Comments	Species	D	A	F	O	R	Comments
Azolla filiculoi..							Botumus umbellatus						
Oenanthe lachenalii							Hydrocharis m-ranae						
Oenanthe pimpin..							Potamogeton trich..						
Lysimachia vulgaria							Carex pseudocyperus						

DRAGONFLIES.

Southern Hawker
Common Hawker
Migrant Hawker
Emperor Dragonfly
Golden ringed Dragonfly
Hairy Dragonfly
Downy Emerald
Black tailed Skimmer
Keeled Skimmer
Broad bodied Chaser

Four spotted Chaser
Black Darter
Ruddy Darter
Red-veined Darter
Common Darter
Banded Demoiselle
Beautiful Demoiselle
Emerald Damselfly
White legged Damselfly
Large red Damselfly

Small red Damselfly
Blue tailed Damselfly
Common tailed Damselfly
Azure Damselfly
Southern Damselfly
Others.

BIRDS.

Heron
Water Rail
Snipe
Common Sandpiper
Redshank
Kingfisher

Sand Martin
Reed Bunting
Sedge Warbler
Reed Warbler
Cettis Warbler
Chiff-Chaff

Lapwing
Moorhen
Coot
Others

Appendix 2 - Description of Aquatic and Emergent TWINSPAN End Groups

Aquatic

A1- Distinguished by the constancy of Potamogeton natans, usually at high cover, and associated with Elodea nuttallii and Lemna minor.

A2 - A5 Generally characterised by constant Lemna minor, Lemna polyrhiza and Callitriche agg.(usually Callitriche stagnalis), but are generally differentiated on the basis of their other constituents:

A2- has Potamogeton natans, Hydrocharis morsus-ranae and Lemna trisulca;

A3- has Elodea nuttallii, filamentous algae and Ceratophyllum demersum;

A4- a species-poor Lemna Spp. ditch with an abundance of Elodea nuttallii;

A5- a species poor Lemna Spp. ditch without an abundance of Elodea nuttallii

A6- ditches containing Callitriche agg. and little else.

Emergent

These four end groups were considered to be rather poorly defined, all having constant Sparganium erectum and frequently Phalaris arundinacea, but still having certain distinguishing features:

E1- has Phragmites australis at high constancy and with constant Agrostis stolonifera and Glyceria fluitans, and with a number of middle and low constancy species not recorded in the other groups, eg Juncus articulatus, Carex pseudocyperus, Hydrocotyle vulgaris and Lycopus europaeus

E2- has little or no Phragmites australis but is defined by the high constancy of Alisma plantago-aquatica and Equisetum fluviatile and only moderate frequency of Glyceria fluitans and Apium nodiflorum,

E3- has little or no Phragmites australis but Glyceria fluitans, Apium nodiflorum and Phalaris arundinacea as constants

E4- has Phragmites australis at high constancy but only with Sparganium erectum and little else

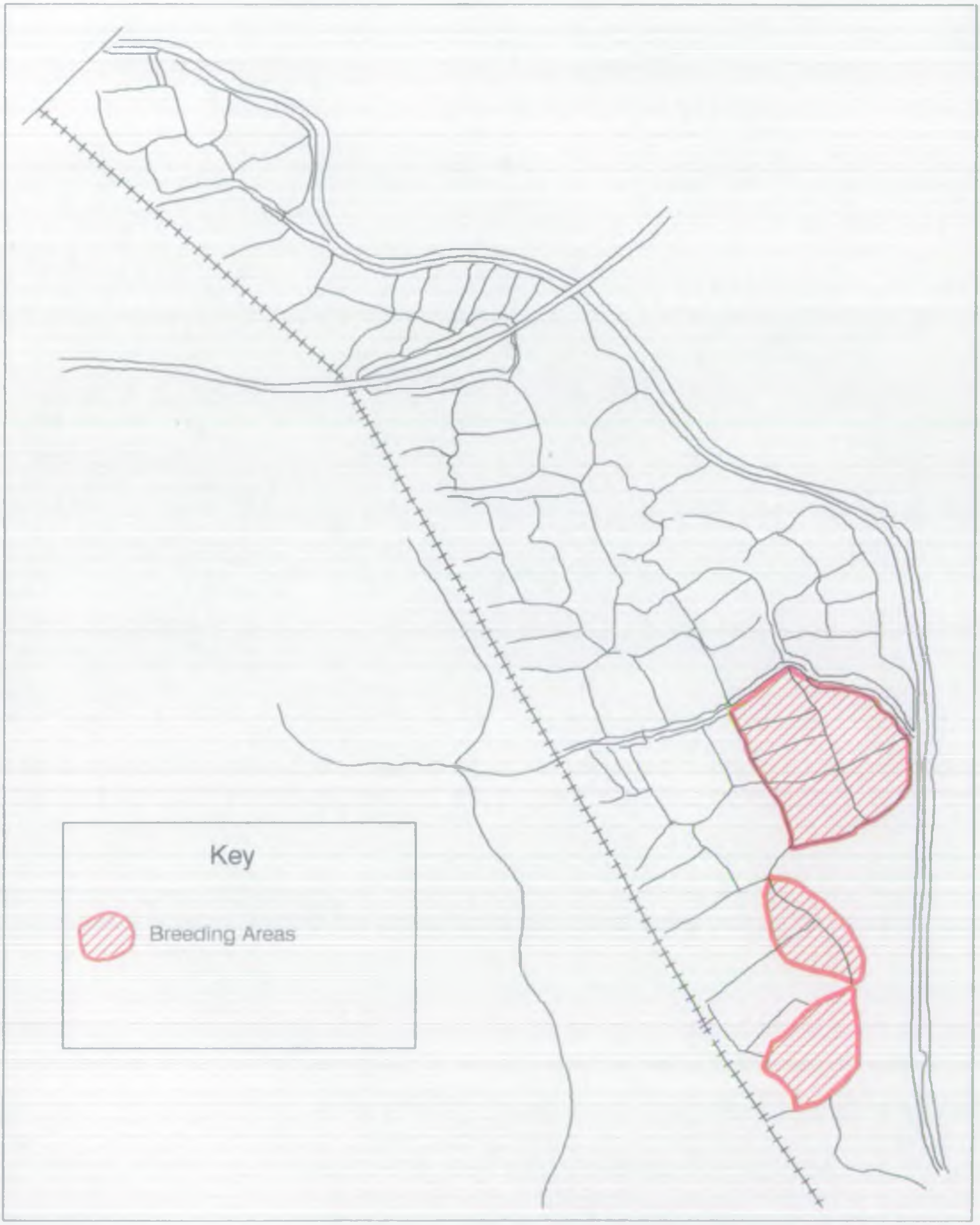
A more complete list of the species found can be found in the NCC report.

APPENDIX 3

Redshank breeding areas

Fig 14

Figure 14 - Redshank breeding areas 1989 - 92



APPENDIX 4

Recommendations

Figure 15 - Position of suggested sluices

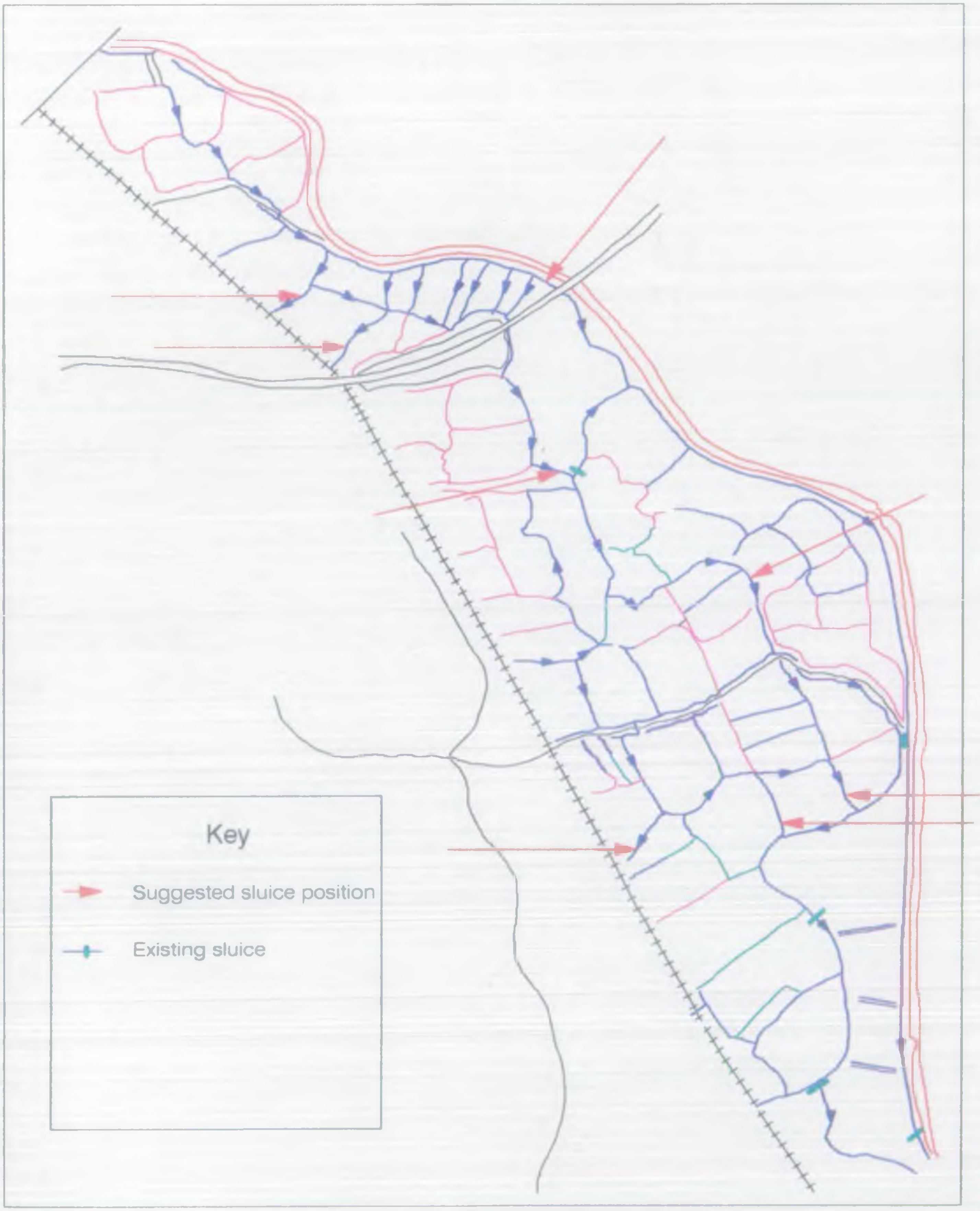
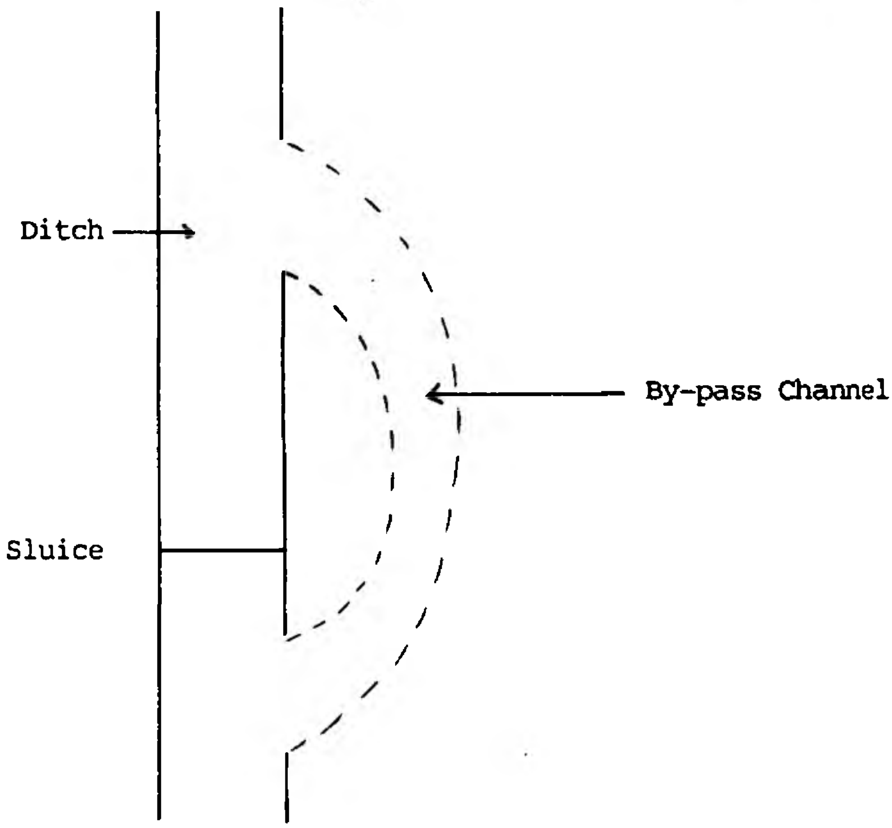


Figure 17 - Suggested low level by-pass channel



In cross section

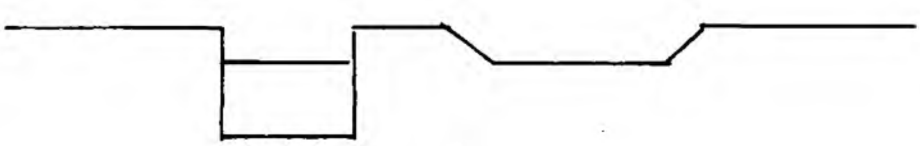


Figure 17a - Suggested ditch maintenance initiated winter 1992/93
Primary ditches to be maintained on a yearly cycle

Figure 17b - Suggested ditch maintenance initiated winter 1992/93
Secondary ditches to be maintained in years one and two of a six yearly cycle

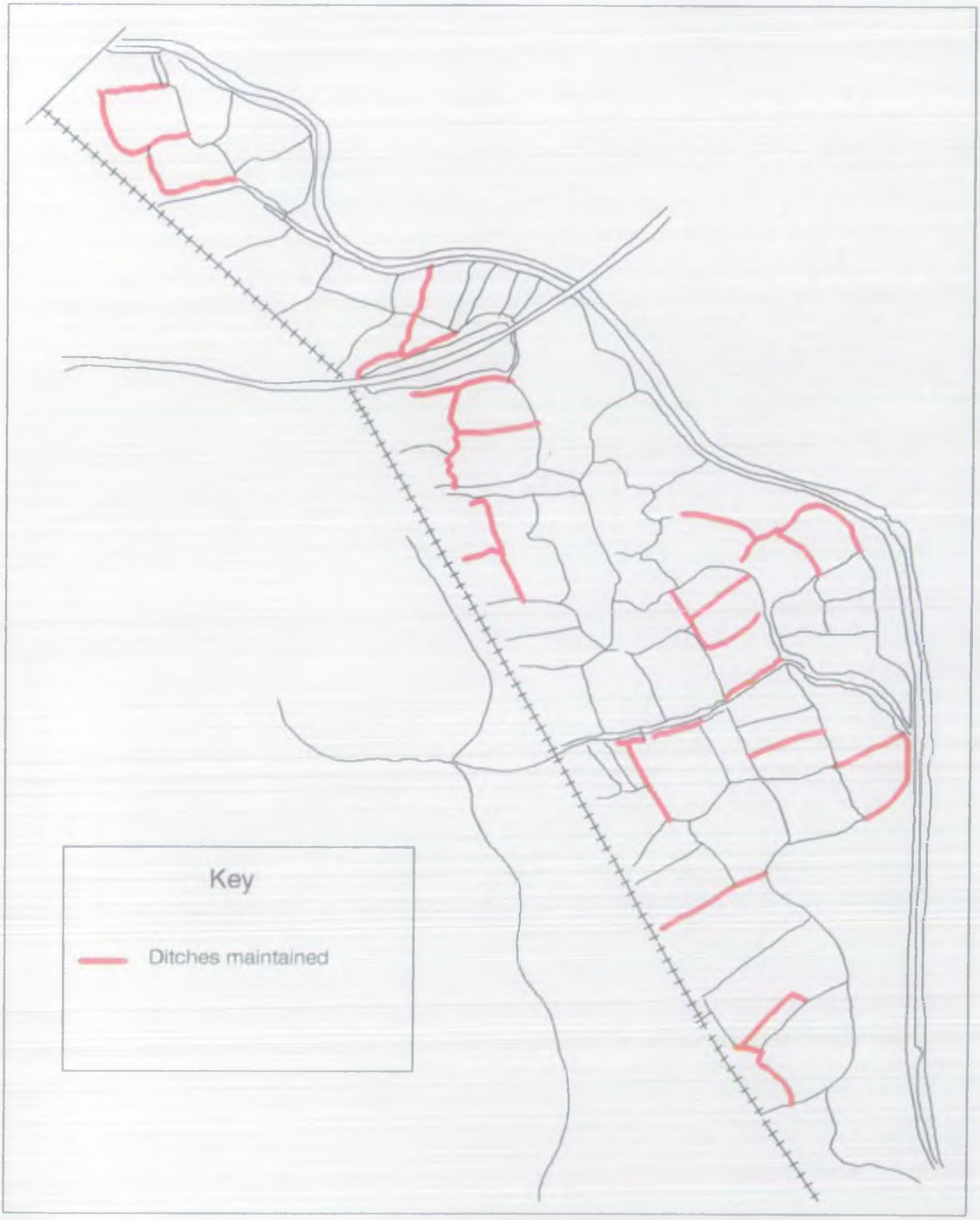


Figure 17c - Suggested ditch maintenance initiated winter 1992/93
Secondary ditches to be maintained in years three and four of a six yearly cycle

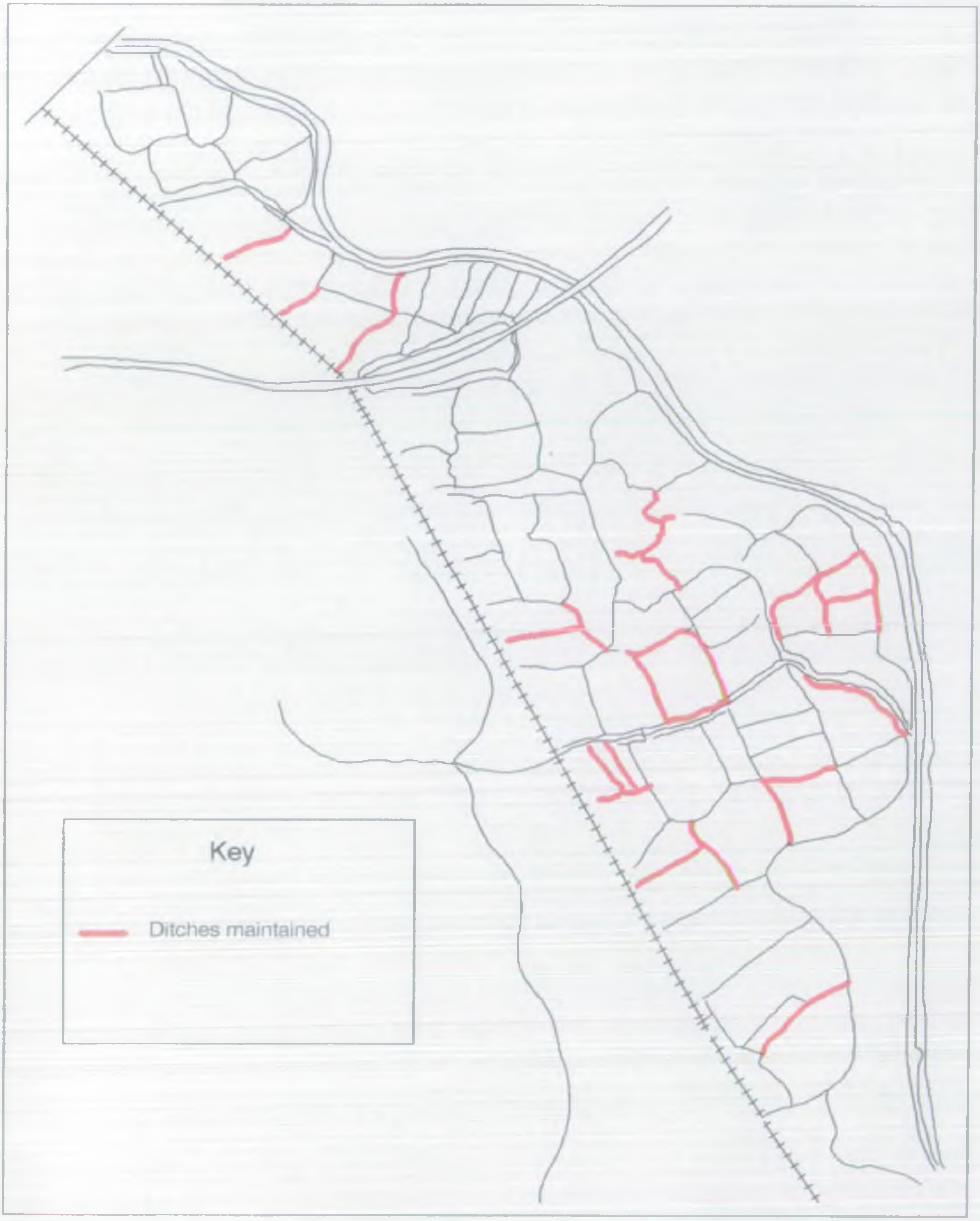


Figure 17d - Suggested ditch maintenance initiated winter 1992/93
Secondary ditches to be maintained in years five and six of a six yearly cycle

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