4. DISCUSSION

In essence the aim of this study was to establish the existence and extent of any effects to the aquatic dyke vegetation occurring as a result of the saline inundation of the Cantley level in 1993. By surveying the aquatic flora in the summer following the flooding only immediate short-term effects could be scientifically determined. Nevertheless, extrapolating such data has given indications of the long-term impacts on the Cantley grazing marsh dyke system.

To qualify the ecological effects it is necessary to identify the physical effects of the flooding event that they reflect. The major concern is salinity. As previously mentioned, the brackish communities related to increased salinity are valued litle in comparison to the mesotrophic/mesoeutrophic endgroups that were prevalent on the level in 1988/89. Any effects on the vegetation are likely to primarily mirror the elevated salinity at the level. Additionally, river water is of higher nutrient status than the water in the grazing marsh dykes, which are usually protected from the intrusion of eutrophic river water. The input of nutrients into the Cantley dyke system not only from the flood water, but also from the river water used to flush the system, should be considered too. The influence of saline water on the ecology of the marshes, particulary in relation to endgroup deterioration, cannot be examined in isolation.

Consequences like the overall change from freshwater marshes to more oligohaline conditions south of the railway line were directly quantifiable by analysing samples (in this case by measuring conductivity). However, some of the physical effects to the level were apparent without the need for analysis. The deposition of sediments and detritus was observed to be most severe in the western marsh. It is believed that sedimentation may restict the re-growth of some aquatic species. The significant quantities of ochre deposit in the central marsh dykes was again obvious.

It was expected that the aquatic flora would be adversely affected on a wide scale as a result of the flooding. Few dykes were dicovered to be devoid of all aquatic species, and fewer still were directly attributable to the flooding. Over half of these dykes were overgrown or recently cleared. Of the remaining ten, two were on the path of treated effluent from the sewage works (at location: TG 3795 0329) to the pumping station (see **Map 1**) and would therefore be expected to be subject to nutrient enrichment. Four were soak dykes. The system of soak dykes is isolated from the rest of the marsh and can´t be flushed properly because it is blocked off from the pumping station at the mid-point of dyke 24 (referring to the 1993 survey). The highest conductivities were recorded in the soak dykes in 1993.

Nevertheless, species impoverishment has occurred. There has been a decline in the existence of over half the species recorded at Cantley in 1988/89, coupled with decreasing species cover (frequency) for a lesser number of species. This has left a high proportion of macrophyte poor and algae dominated communities throughout the level.

It would be wrong, however, to assume the effects of the flooding were homogenous. There was spatial variation in physical parameters. For instance, the flushing of the marsh following the flood did not affect the dykes equally. Dykes radiating from the main drain will have been better flushed than remote or dead-end dykes. The northern marsh will have been subsequently flushed more thoroughly as a result of the increased gravitational movement of water through this part of the level. Variation of this kind may account for anomalies in the ecological responses to the flooding. An example would be dyke 105 which joins the main drain close to where the flushing water would have entered the level, and was the only dyke surveyed in 1993 to show an improvement in endgroup.

Despite discrepancies, it has been possible to draw valid conclusions about the specific and general effects of the flood. Taking the level in its entirety, the three most floristically impoverished endgroups (characterised by high constancies of algae species) have become dominant. A5b, A7a and A7b are closely related communities in the sense that they support only a limitted number of species able to tolerate high salinity/nutrient status. This may explain the impoverishment of the macrophyte flora which, apart from a limited number of species favouring the changes to habitat, are generally less tolerant of the post-flood environment.

The deterioration of many dykes since 1988/89 when brackish communities were rare can only be accounted for by the saline flooding. Furthermore, the widespread distribution of A7a in 1993 indicates that conditions had been both oligohaline and eutrophic. The decline of mesotrophic/mesoeutrophic A2 and A3a freshwater endgroups would substantiate this conclusion. The relative decrease in freshwater eutrophic communities (A4, A5a, A5b and A6) suggests that the increased salinity has been more important in determining the dyke communities in 1993. The total loss of A1 and A5a infers that the range of different aquatic habitats has been reduced following the flood.

The accuracy and significance of the endgroup data may have been slighlty restrained by the macrophyte impoverishment and the inflexibility of TWINSPAN keying. Subtler results have been highlighted by examining indicator species, the existence of which has been more stable than the endgroups they indicate. Generally, effects to these species reinforce the conclusions drawn from the community data.

In similar fashion to endgroup, the mesotrophic freshwater indicators species suffered most as a result of the flood. Potamogeton natans, Sparganium emersum and Myriophyllum verticillatum all reduced in occurence and frequency between 1988/89 and 1993. Nevertheless, with the exception of Elodea canadensis, all the species characteristic of the A1 and A2 endgroups were present on the marsh, hence the potential for the recovery of these communities does exist. In order for this to happen, however, the species must occur in the same area of marsh, and have recovered to sufficient frequency. In 1993, P.natans and Scirpus fluitans (present at high constancy in A1) did occur together in a small block of marsh in the central level, south of the railway. This block (mid-point: TG 371 042) includes a dyke recorded as A1 in 1989. Although S.fluitans was abundant here in three dykes, P.natans was very rare. There were few other individual macrophytes, and no S.emersum, hence even if the indicator species thrived sufficiently to classify the community as A1, it is unlikely to be characteristic of the endgroup.

The sensitivity of the species outlined above was not duplicated by Hottonia palustris and Sagittaria sagittifolia. Their robust response, coupled with high constancy in the A2 endgroup and their wider distribution across the level in 1993, suggests that A2 communities have a better potential for return. Their patterns of distribution are clear, linked to the central marsh block (mid-point: TG 373 038) and the north-west corner of the marsh (both sides of the railway). This range is similar to that of A2 in 1988/89. This could indicate that the best water quality on the level is still to be found in these areas. Again, it is likely that the communities would still be depleted of key species (eg M.verticillatum).

A combination of several factors may account for this distribution of good water quality at Cantley. Whilst the central marsh between the main drain and the railway would have been well flushed after the flood, it is probable that longer term factors are more important. The central marsh is the furthest removed from the influences of both the river and the arable land to the north and east. Additionally the central block and north-western corner have been consistently under-fertilised with respect to Tier 1 fertiliser levels (which are fully applied to the southern marsh block and fields in the south west). Interestingly, no fertiliser has been applied in about the last twenty years to the corner of three fields in between Hassingham broad and the railway line. These dykes possessed the richest Potamogeton acutifolius communities on the level.

Whilst Hottonia palustris and Sagittaria sagittifolia were slighlty affected, their persistence in conjunction with the stablilty of Hydrocharis morsus-ranae infers that the deterioration of mesoeutrophic conditions was not as severe as the mesoeutrophic degradation. The potential for A3a communities at Cantley whilst limited, still exists in the areas of better water quality. In addition its feasible range is wider than A2 north of the railway.

Although conductivity was lower in the northern peaty marshes, the indications are that the trophic status was generally higher there in comparison to the central marsh (possibly the result of the adjacent arable farming up-slope from the level). The abundance of A5b communities here may have been falsely high as a result of the flood. However, macrophyte species like Ceratophyllum demersum, Utricularia vulgaris and Lemna gibba, which are also indicative of eutrophic conditions, were at their highest occurrence here, being found less within the rest of the level.

C.demersum occurred regulary with H.morsus-ranae in this area of marsh. Whilst most of the A4 communities present here in 1988/89 had degraded to A5b, this indicates that the recovery of A4 in this location is possible.

The habitat for A5a communities has not been lost from Cantley, even though the endgroup was. This is reflected in the widespread occurence of Potamogeton fresii in the central level. As can be seen in **Appendix** I, there are significant numbers of species with high constancies in A5a, and consequentially these communities are characteristically rich in floral species. Given the general macrophyte impoverishment in 1993 along with the reduction in occurence of key species (eg Elodea canadensis), it is hard to envisage A5a returning to its former extent or appearance, in the short-term, even though the potential habitat does exist.

Although there is the possibility of at least a limited recovery of the flora in the long run, the comparison of species data still supports the conclusion that there has been an increase in saline habitats following the flood. All brackish indicator species are distributed mainly south of the railway, corresponding to the higher conductivities. Myriophyllum spicatum was a new species at Cantley in 1993, occurring in a total of 28 dykes (although only four were surveyed in 1988/89). This species is asociated with high salinity and is present at high constancy in A7b. Other indicator species (P.pusillus and Enteromorpha spp) also increased in occurrence. Conversely, Potamogeton pectinatus had declined since 1988/89 and Zanichellia palustris (a species showing its highest constancy in A7a) had become extinct. These species would be expected to flourish in the increased frequency of oligohaline environments. It is feasible, however, that the flood adversely effected these species in another way (eg sedimentation preventing colonization in the summer).

In 1988/89 the Cantley level was an important area for national rarities/scarcities. The flood caused the extinction of no important species. In 1993 the site remains of national importance for P.acutifolius as, despite a general reduction in species cover, the plant still occurs in significant numbers of dykes. P.fresii and P.tricoides have maintained their ranges, although M.verticillatum has been adversely affected. Its occurrence has been radically reduced, however the species occurs in sufficient dykes to ensure its survival in a small area of the level.

In conclusion it can be said that the 1993 flood of the Cantley level caused widespread detrimental effects to the valued floral communities and species of the grazing marsh dyke system. The environmental stress and disturbance to the habitats were both observable and quantifiable. The predominance of floristically poor algae dominated communities, and the increase in salinity in 1993 were particulary notable.

Nevertheless, even though the frequency and occurrence of some characteristc Broadland species declined, it is likely that in the long-term the dyke communities will recover to a limited degree. The conservationally important mesotrophic/mesoeutrophic freshwater communities could potentially reclaim frequencies similar to 1988/89. Their distribution will, however, be limited to the areas of better water quality, and the recovery of their full range and species complement may depend on whether the water quality generally improves at Cantley in successive years. Other factors, like the application of fertiliser, may, in the future, become more significant than residual salinity in determining aquatic endgroup in certain parts of the level.

Putting this in perspective, infrequent saline flooding events may not be as crucial as the influence of trophic status on dyke communities. The conservationally important macrophyte assemblages of Broadland are likely to have arisen in environments where saline flooding was occasional. In a historical context, flood defenses are now superior, and flooding was more frequent in the past. For instance, even during the 1960s in some locations breaching of grazing marsh flood walls occurred at frequencies of every four years. The conductivity isopleths determined for the Cantley level in 1975 (from Doark 1990) show a distribution and range of conductivities similar to those found in 1993. This indicates the occurrence in the recent past of other flood episodes at Cantley from which the aquatic flora has recovered.

Presently, however, with the higher trophic status of river water, and the longer term problems linked to sea level rise, the flooding of areas of Broadland grazing marsh is an important and changing issue. Determining the short-term and long-term ecological effects of recent saline innundations are likely to have significant bearing apon the necessity for efficient flood alleviation in the future.

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APPENDIX I

A summary of the species constancy values for all aquatic endgroups is given below. Only species of particular interest to this report have been included. An indication of the relationship between water quality and endgroup has been added. This relationship is also reflected by the indicator species.

Table 5. Constancy table summarising the percentage occurence of a range of species within every aquatic endgroup. Only constancies exceeding 10% have been indicated.

Species	Endgroup									
	A1	A2	A3a	A3b	A6	A4	A5a	A5b	A7a	A7b
Ceratophyllum demersum			13			86	73	33		13
Elodea cancadensis	27	60	55	10		23	78			
Hottonia palustris	13	63	23	14	14		12			
Hydrocharis morsus-ranae	13	37	39	69		51	20	12		
Myriophyllum spicatum	13	12					12		31	87
Myriophyllum verticillatum	20	65	13				33			
Potamogeton acutifolius										
Potamogeton fresii							53			
Potamogeton natans	93	84	74	24	14		17			
Potamogeton pectinatus							33		36	83
Potamogeton pusillus							25	17		22
Sagittaria sagittifolia		60	32			16	35			
Sparganium emersum	53	60	19	14			27			
Zannichellia palustris									28	

(Source: Doarks and Leach 1990)

Figure 13. The relationship between water quality and aquatic endgroup.