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The Ecological Effect of the Proposed Mansbrook Grove Outfall With Particular Reference to Birds on the Adjacent Mudflats of the Orwell Estuary

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1. SUMMARY

Background

- This report presents an appraisal of the potential impact on bird populations and wildlife habitats of a proposed water outfall pipe running from the Ransomes Europark site on the outskirts of Ipswich. It is planned that the pipe should join a small stream approximately 200 m from the shoreline of the Orwell Estuary.

Pipe Construction

- The pipeline route passes through agricultural land and some woodland and damp pasture, the latter part of a County Wildlife Site. A total of 1420 m^2 of grassland will be affected during pipe laying. The significance of this impact is considered to be low. Suffolk Wildlife Trust have suggested that plants be left to regenerate naturally once soil is replaced.

Bird Populations on the Orwell Estuary and the Effects of the Discharge

- The majority of the Orwell Estuary is designated a Site of Special Scientific Interest and with the neighbouring Stour Estuary, is protected as a Special Protection Area and a Ramsar Site due to the importance of its wintering populations of waterbirds. The estuary holds internationally important numbers of Redshank and nationally important numbers of Dark-bellied Brent Goose, Shelduck, Pintail, Ringed Plover, Dunlin and Black-tailed Godwit during winter.

- Analysis of Wetland Bird Survey Low Tide Counts for the Orwell indicated that the Mansbrook Grove area was of some local importance for Pintail. More detailed data indicated that the channel itself held densities of Dark-bellied Brent Goose, Shelduck, Pintail and Redshank similar to those found on other flows within the estuary. The Mansbrook Grove channel was less important for Dunlin and Black-tailed Godwit. The data emphasized the importance of freshwater flows for waterbirds.

- An appraisal by HR Wallingford indicated that the outfall's introduction would approximately double the flow of water into the estuary at Mansbrook Grove. This would lead to a 41% increase in the width and a 26% increase in the depth of the channel and a 12% increase in the flow's velocity. These effects would diminish with distance and hence be of little significance on the lower shore.

- The outfall is not predicted to appreciably increase the nutrient input to the mudflats and thus will not directly benefit algae or invertebrate populations. However, the increased discharge may indirectly benefit some invertebrates, by reducing salinity and maintaining sediment moisture over a wider area and hence may benefit feeding birds.

Recommendations and Possible Mitigation

- It is recommended that land-based construction work should not be undertaken during the breeding season (mid-March to mid-July). Also the discharge to the estuary should not be commissioned during the winter (mid-October to mid-March).
- It is recommended that a Monitoring Programme be set up to record bird numbers on the Mansbrook Grove channel over the five winters subsequent to construction. Comparative counts should be carried out at two control sites within the estuary, a flow of similar size to the present Mansbrook Grove and one similar to its predicted future size.
- It is our assessment that there is a low risk of negative impacts on bird populations. Indeed it is more likely that populations will be enhanced. However, if negative impacts were detected by the Monitoring Programme, then it may be possible to mitigate the effects by splitting the outfall. In our view, this is sufficiently unlikely that no further investigation into this possibility should be undertaken at the present time.

2. GENERAL INTRODUCTION

This report provides an assessment of the potential impact on bird populations and wildlife habitats of a proposed water outfall pipe running from the Ransomes Europark site on the outskirts of Ipswich to Mansbrook Grove on the Orwell Estuary (OS co-ordinates 619800E, 240200N). The sewer is designed to meet the Fox Farm stream, prior to its confluence with the Mansbrook stream, at a point approximately 200 m from the shoreline.

Section 3 of the report gives a description of the pipeline route and an assessment of the potential impact upon terrestrial and freshwater habitats. This was provided by The TA Millard Partnership and incorporates comments from Suffolk Wildlife Trust.

Section 4 provides a review of the status of waterbirds using the Orwell Estuary and an assessment of the likely impact on the birds using adjacent mudflats. To help in this appraisal, HR Wallingford have also provided an assessment of the potential physical impact of the proposed outfall on the hydrodynamics and sediment transport processes and hence on the morphology of the stream channel across the mudflats. The water run-off itself is to be cleaned to reduce concentration of any pollutants to within Environment Agency standards.

The majority of the Orwell Estuary is designated a Site of Special Scientific Interest (SSSI), whilst together with the neighbouring Stour Estuary, the Orwell is designated as a Special Protection Area (SPA) and a Ramsar Site due to the importance of its wintering populations of waterbirds. Levington Lagoon and Trimley Marshes, downstream of Mansbrook Grove, are Suffolk Wildlife Trust reserves.

3. PRELIMINARY ECOLOGICAL APPRAISAL OF ROUTE OF PIPELINE AND OUTFALL

This section was provided by the TA Millard Partnership after comment from Suffolk Wildlife Trust. The BTO has not been involved in any detailed ornithological survey of this area. However, this area does not include any ornithologically important sites and so does not warrant detailed bird survey work.

3.1 Introduction

The on-going development of the Ransomes Europark requires that surface water run-off is collected and discharged in a controlled manner. Current proposals for discharge are to pipe the water from the Ransomes Europark site and discharge it into a small watercourse before entering the River Orwell estuary. This method of disposal is required within the current planning instructions for fixture development of Ransomes Europark.

This section is the result of the walkover survey.

The scheme consists of some 1567 m of buried pipe, which is approximately 100 mm diameter. The piping material will be reinforced precast concrete. The majority of the construction will be through laying pipes in open trenches; some limited areas of tunnelling will be used under roads.

The remainder of this section sets out the findings of the walkover survey, the outline impact assessment and suggestions for potential mitigation where necessary.

3.2 Site Location and Description

The site is located at Nacton, to the south of Ipswich in Suffolk. Ransomes Europark is located just to the north of the A14 trunk road. The proposed pipeline runs generally south-westwards towards the River Orwell estuary (Fig.1).

The pipeline route passes through land dominated by intensive agricultural production with smaller areas of woodland plantation, pasture and across two roads. Table 1 shows the approximate lengths and percentages of each habitat type affected by the proposals.

The majority (70%) of the route crosses agricultural land. This is intensively farmed and at the time of survey (August 1999) was a mix of barley, linseed, wheat and onion. A small area of plantation (12%) is crossed, this is former woodland that has been cleared in the recent past and replanted. The species mix for the replanting appears to be based on Sycamore *Acer pscudoplatanus* with some native species also present. An inspection of the planting indicates that a high percentage of it has failed and will need replacement at some point.

The grassland affected forms part of the local Fox Farms Meadow County Wildlife Site. This is designated for its wetland interest with a mix of damp pasture and wet woodland. The route across this site has been developed in association with Suffolk

Wildlife Trust and is contained with an area of tall ruderals which have developed on the site. The vegetation is dominated by Common Nettle *Urtica dioica*. This vegetation type indicates that the area has been both disturbed and enriched in some way in the recent past. This may be due to animals or possibly a former storage area for animal manure. Whatever the reason, the habitat type is common throughout Britain, within the context of the County Wildlife Site it acts as a detractor and source for invasive species.

The lengths of pipe run indicated in Table 1 provide some indication of the degree of impact of the construction process. In some areas where the pipeline is buried deeply, the width of working trench required will be increased. Once final figures are provided it will be possible to give total areas to be affected by the construction process.

The route passes adjacent to areas of mature trees as well as individual specimens. It has been developed to avoid impacts on mature tree, and to be an acceptable distance from their root systems.

The outfall for the scheme is located at a small stream which passes through the County Wildlife Site. The outfall has been designed to minimise erosion of the existing stream banks. At present scrub is present at the outfall location and this will need to be cleared for construction. Construction Site access for the southern part of the scheme will be through adjacent mature woodland, along an existing unmade road. Suffolk Wildlife Trust comment that details of the exact location and extent of scrub to be cleared, and of the access route to it, are needed before it will be possible to fully understand the potential impact on this area.

3.3 Outline Ecological Impact Assessment

The impact of the development can be divided into two distinct phases - the construction phase and the operational phase. As the pipeline will be a buried service, there will be no ongoing significant impacts during the operational phase. Some access to manholes will be necessary for maintenance but other than manhole covers the presence of the pipeline across the land will not be evident, nor affect species or habitats within the site.

Operational impacts will only be evident at the outfall and along the stream and potentially into the River Orwell estuary. These latter impacts are considered further in the next section.

The significance of an impact depends upon three main factors, firstly the value of the site or individual receptor, secondly the degree of the impact and thirdly the timescale over which the impact will be present. The predicted impacts during the construction phase are set out below for each of the main habitats present.

Arable – This land is intensively managed and the walk over survey did not record any habitats or species of nature conservation value. The ecological value is considered to be low. The amount of land affected is low in comparison with that surrounding the pipeline route, the degree of significance is therefore considered to be low. The construction impact will only be temporary disturbance with the land being returned to agricultural use. The duration of the impact is considered to be short and the impact temporary only.

Plantation – This area of former wooded cover has been recently replanted. The individual trees present within the line of the route are not of nature conservation interest. However, having previously been wooded, the soil within the area may contain seed of ground flora species, which will be of local interest. It is suggested that soil handling in this area is developed so as to protect the seed bank, the structure and chemistry of the soil layers. At present the value of the habitat is considered to be only of local interest. The degree of loss is low and the impact is temporary only. Therefore the significance of the impact is considered to be low.

Grassland – The grassland forms part of a Wildlife County Site and as such is of County significance. However the section through which the pipeline passes is of much lower quality than County value. The work through this section only requires a 10 m wide working area. This gives a temporary landtake of 1420 m^2. The total area of the Wildlife Site as given in the 1994 Suffolk Wildlife Trust survey notes is 7.6 ha. The area affected represents 1.8% of the site as surveyed in 1994. This is seen as a low degree of impact. In addition the duration of the work through this section is estimated to be five working days. In overall terms, with appropriate mitigation as noted below, the significance of the impact is considered to be low, and of local significance only.

In overall terms the scheme as proposed, with suitable mitigation measures and safeguards, does not represent a significant impact on the ecological value.

3.4 Potential Mitigation

The predicted ecological impacts are considered to be low, but these can be reduced further as can any other risks to the environment through careful planning and implementation of the projects.

The handling of soils is an important issue. For the agricultural areas this will be important and it is assumed that such working methods will be developed by an agricultural specialist or using a contractor's standard approved methodology.

Similar safeguards within the non-agricultural areas will reduce impacts. A full environmental management plan should be developed which the contractors will follow. Specific areas to be covered are the handling and replacement of the woodland soils. In addition, within the County Wildlife Site the soils have been enriched somehow. Following completion of the work, it would be beneficial to exclude this enriched top soil and substitute a soil with a low nutrient status. It is suggested by Suffolk Wildlife Trust that this area should then be left to regenerate naturally.

The timing of the works will be an important aspect in reducing the constructional impacts of the development. A construction programme should be developed (in conjunction with the client and engineers) which minimises ecological disturbance. It is usually good practice to minimise work in the spring and summer to avoid disturbance to breeding birds.

3.5 Conclusions and Recommendations

- The result of the walkover survey indicates that the existing ecological value of the route of the pipeline is only of local significance. Predicted impacts are considered to be very low and temporary.

- Risk to the environment and disturbance to species and habitats can be further reduced by the development and implementation of a construction programme and environmental management plan. This recommendation is supported by the Suffolk Wildlife Trust, who comment that it is important that such a plan includes access to the pipeline and safeguards to protect sensitive wetland areas from disturbance during construction.

- The BTO recommends that construction work in this area should not be undertaken during the breeding season (between mid-March and mid-July).

4. AN APPRAISAL OF THE POTENTIAL IMPACTS OF THE OUTFALL UPON BIRDS USING THE ADJACENT MUDFLATS ON THE ORWELL ESTUARY

4.1 The Status of Bird Populations using the Orwell Estuary

Waterbird populations on estuaries and at other wetland sites in the United Kingdom are monitored by the Wetland Bird Survey (WeBS), a scheme run jointly by the BTO, The Wildfowl and Wetlands Trust, Royal Society for the Protection of Birds and Joint Nature Conservation Committee (the last on behalf of English Nature, Scottish Natural Heritage, the Countryside Council for Wales and the Environment and Heritage Service in Northern Ireland). The scheme is based on monthly co-ordinated counts of waterbirds, principally from September to March, and provides an indication of the relative importance of sites across Great Britain and in an international context. The majority of counts at estuarine sites are undertaken at high tide. A wetland site is considered internationally important for a species if it regularly holds at least 1% of the individuals in a population of that species. Britain's wildfowl belong to the north-west European population (Pirot *et al*. 1989) and the waders to the east Atlantic flyway population (Smit & Piersma 1989). A wetland site in Britain is considered nationally important for a species if it regularly holds 1% or more of the estimated British population of that species.

Based on the mean of the five peak winter counts from 1993/94 to 1997/98, the Orwell Estuary is considered to be internationally important for Redshank *Tringa totanus* (Cranswick *et al.* 1999). It is also nationally important for, Dark-bellied Brent Goose *Branta bernicla bernicla*, Shelduck *Tadorna tadorna*, Pintail *Anas acuta*, Ringed Plover *Charadrius hiaticula*, Dunlin *Calidris alpina* and Black-tailed Godwit *Limosa limosa*. Only these species are considered in the following analyses.

4.2 The Importance of the Mudflats at Mansbrook Grove for the Waterbirds of the Orwell Estuary

The relative importance for birds of the drainage channels on the mudflats at Mansbrook Grove was assessed by analysis of low tide count data. Data for the Orwell Estuary were available from the WeBS Low Tide Count scheme for the winters of 1994/95-1996/97 and 1998/99 and also from previous work undertaken by Neil Ravenscroft in 1996/97 and 1997/98 (Ravenscroft 1998). WeBS Low Tide Counts are undertaken monthly from November to February each winter within the period two hours either side of low tide. To determine the relative importance of the mudflats at Mansbrook Grove - part of the Count Section EW016 – the densities of each species using that section were compared to those over all other mudflat sections within the estuary (see Fig. 2). The analysis excluded data from non-tidal habitats, i.e. grazing marsh and freshwater lakes, and from mudflat sections which were only counted intermittently. In total, data were available for 11 months over the four winters. Paired t-tests compared the densities on each of these 11 dates.

The results of this analysis are shown in Table 2. The count section at Mansbrook Grove held a significantly higher density of Pintail ($t_{10} = 3.52$, $P < 0.01$) than the rest of the estuary, but lower densities of Black-tailed Godwit ($t_{10} = 4.62$, $P < 0.001$), Dark-bellied Brent Goose ($t_{10} = 2.94$, $P < 0.05$), Redshank ($t_{10} = 2.69$, $P <$

0.05) and Ringed Plover (t_{10} = 4.76, $P < 0.001$). There were no significant differences in the densities of Dunlin and Shelduck.

Further analysis compared the densities of birds found on the stream corridor at Mansbrook with those found over the total area of 26 other such freshwater flows and two areas of freshwater seepage running into the Orwell estuary (Fig. 3). Data came from 10 counts undertaken by Neil Ravenscroft in the winters (October to March) of 1996/97 and 1997/98. No Ringed Plover were recorded on the stream outfall at Mansbrook Grove in these counts (Table 3). There were also lower densities of Dunlin (Paired t_9 = 2.79, $P < 0.05$) and Black-tailed Godwit (t_9 = 3.07, $P < 0.05$) than on other freshwater flows. Densities of Dark-bellied Brent Goose, Shelduck, Pintail and Redshank were similar to those elsewhere.

4.3 The Importance of Freshwater Flows for Waterbirds on Estuaries

The WeBS Low Tide Count Area at Mansbrook held higher densities of Pintail than the rest of the estuary, but on an estuary scale neither this mudflat nor the stream corridor at Mansbrook itself held higher than average densities of any other species. The data, however, clearly show the importance of freshwater flows for waterbirds. Densities, both at Mansbrook Grove and on all other stream corridors, were greater for all species considered than in the estuary as a whole. The association between wintering waterbirds and freshwater on the mudflats of the Orwell and other East Anglian estuaries has previously been reported upon by Ravenscroft (1998). On the Orwell, Stour and Blackwater, it was found that Shelduck, Wigeon *Anas penelope*, Pintail, Dunlin, Curlew *Numenius arquata* and Redshank all used these stream corridors in greater numbers than would have been expected if birds were distributed evenly across the estuaries. Densities of Shelduck, Grey Plover, Dunlin, Curlew and Redshank were also positively related to the rate of discharge of flows into the Orwell. Four potential reasons were noted for the importance of such flows, particularly for feeding birds. Firstly, freshwater run-off may increase the nutrient input into the mudflat system, increasing algae and invertebrates such as *Hydrobia* that graze upon it. *Hydrobia* are an important food source for Shelduck, Pintail and Dunlin (Olney 1965, Cramp 1977, Cramp & Simmons 1983) and algae such as *Enteromorpha* are important for Wigeon (Cramp 1977). The flows may also provide other detritus for filter-feeding molluscs and surface-feeding polychaetes, such as ragworm *Nereis diversicolor* and the amphipod *Corophium volutator*, important food sources for Curlew and Redshank respectively (Goss-Custard 1969, 1970, Goss-Custard *et al.* 1977). Some of these invertebrates would also benefit from the reduced salinity of the flows. Lastly, the flow of water would keep the mudflat surface wet, which would help to maintain the activity of invertebrates and thus their availability (Yates *et al*. 1993). Ravenscroft (1998) also notes that the freshwater flows may also be of benefit for washing and preening and because the creeks produced may offer shelter from predators.

Associations between the organic inputs into estuaries and the densities of invertebrates and thus waterbirds have been reported in many previous studies. Organic sewage outflows have an obvious impact upon both the species and numbers of invertebrates (Pearson & Rosenberg 1978). Close to the outfalls, smothering and low oxygen levels result in almost no life, but beyond as oxygen levels rise, invertebrates proliferate in the enriched organic levels. In both the Rogerstown

Estuary in Ireland (Fahy *et al.* 1975) and the Lillo-Rilland area of Holland's Delta Region (van Impe 1985), increases in algae and invertebrates such as *H. ulvae*, *C. volutator* and *N. diversicolor* have been linked to increased organic inputs, from sewage and from industrial and agricultural wastes. These increases in turn resulted in increased bird populations. Within the Clyde estuary, Thompson *et al.* (1986) likewise found close relationships between bird and invertebrate densities, but noted that densities of invertebrates fell following improvements to sewage treatment.

4.4 Options for Discharge

There are three main options for the location of this discharge. Firstly, a pipe could be laid to release the discharge at the low tide mark. Previous BTO work at Morecombe Bay has shown that bird densities in the area of such work may remain low for several years due to disturbance to sediments. Secondly a pipe could release the discharge at a point to the west of Mansbrook Grove, where the shore is narrow. Ravenscroft (1998) found that discharge which reached the low tide mark was most beneficial to birds. A pipe to this area would go through a large part of the Fox Farm Meadow Country Wildlife Site, however. Thirdly the discharge could be released into the stream at Mansbrook Grove, as proposed by The T A Millard Partnership, and thus add to the flow here.

4.5 Potential Physical Impacts of the Outfall on the Stream Channel on the Mudflats at Mansbrook Grove

The potential physical impacts of the proposed outfall on the hydrodynamics and sediment transport processes and hence on the morphology of the stream channel across the mudflats were assessed by HR Wallingford. Their report is provided in full in Appendix 1.

In summary, the doubling of the annual peak flow at Mansbrook Grove resultant from the introduction of the outflow would lead to a 41% increase in the width and a 26% increase in the depth of the channel and a 12% increase in the flow's velocity. (The annual peak flow is often a good estimate of the morphologically dominant flow for rivers and streams.) The depth at low discharge would not change significantly. Additionally, the equilibrium slope of the channel would decrease to approximately 89% of its original value. This would increase the sinuosity of the channel. In the uppermost part of the intertidal flat, where the channel is presently braided, the longitudinal extent of the braided zone would be extended slightly.

On the lower mudflat, the influence of the drainage of tidal water is more important and the change in channel shape would be proportionately smaller and at its lowest part of the mudflat is likely to be negligible.

It was not anticipated that the increase in discharge of the Mansbrook and Fox Farm streams would have any impacts in other areas of the estuary.

4.6 Potential Effects on Local Waterbird Populations

Whilst the outfall of water from Ransomes Europark will increase the discharge at Mansbrook Grove it is not likely to appreciably increase the nutrient input to the mudflat. Thus there will be little direct benefit to algae or to invertebrate populations. However, the increased discharge may indirectly benefit some invertebrate species, by reducing salinity and maintaining sediment moisture over a wider surface area and hence may benefit feeding birds. Densities could therefore increase and for some species match those found on larger channels, such as Levington Creek.

The local waterbird populations could also be affected by the change in the channel's physical characteristics. At low tide, Ravenscroft (1998) found that feeding birds at freshwater flows favoured the lower shore where it was presumed that there were higher densities of prey (Yates *et al.* 1993). As it is predicted that the increased discharge would not appreciably alter the channel in this area, bird densities should not be adversely affected. Further up the shore, the increased depth and width of the channel could make feeding within the flow itself more difficult during mid-tide periods. Food availability would not be restricted in areas immediately aside the flows, however, and it is here that invertebrate densities are typically at their highest. The increased depth and width of the channel may also provide increased shelter from the elements and provide more washing and preening sites.

4.7 Conclusions

- It is predicted that the increased discharge will increase the width of the Mansbrook Grove channel by 41%, the depth by 26% and the flow's velocity by 12%.

- It is concluded that these changes present a low risk of causing negative impacts to the internationally important bird populations of the Orwell estuary. Indeed it is considered more likely that they will have a positive impact on the densities of birds using the area.

4.8 Recommendations

- The BTO recommends that the discharge to the estuary should not be commissioned during the winter (mid-October to mid-March).

- To determine whether the increased outflow at Mansbrook Grove affects local bird numbers, it is proposed that a Monitoring Programme should be set up to record bird usage of the site subsequent to construction. Any effects may take time to manifest themselves, particularly if they are driven by storm-flow events. For this reason it is proposed that monitoring should be undertaken for five years. We propose that the following protocol should be adopted which should enable the detection of a 25-50% change in the populations using the area. Monthly counts to be undertaken at hourly intervals over four complete tidal cycles from November to March at three sites: Mansbrook Grove, Freston Brook and Levington Creek. The latter two will act as control sites, Freston Brook having a similar flow to the existing Mansbrook Grove and Levington Creek having a similar flow to that predicted for the future flow at Mansbrook Grove. These data should be analysed in relation to overall change in populations on the Orwell Estuary and national trends in waterfowl populations as shown by WeBS data.

- Monitoring of the discharge should ensure that the run-off is within Environment Agency standards and that pollutants do not affect the mudflats and their food resources. Monitoring should also record discharge rates.

- The BTO believes that it is unlikely that there will be a negative impact to birds from the increased flow. If, however, monitoring detects decreases which are of a sufficient magnitude to require mitigation, then the outfall could be split. This would produce reduced discharges at two sites separated by at least 200 m. This would have the potential benefit of creating additional habitat. Ravenscroft's (1998) study found that just as natural freshwater flows may benefit waterbirds on estuaries, so may artificial pumped outfalls of water. The BTO considers that the risk of needing to undertake this mitigation is low and therefore no further investigation should be undertaken into this at this time.

Acknowledgements

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Habitat Type	Length Crossed	Percentage
Arable	1100	70
Plantation	190	12
Grassland	142	9
Other	135	9
Total	**1567**	**100**

Table 1 Length of pipe run across habitats present.

	Area (ha)		DB	SU	PT	RP	DN	BW	RK
EW016	106	A	0.03±0.02	1.90±0.41	0.81±0.21	0.07±0.03	14.54±3.26	0.19±0.08	1.99±0.37
		B	0.04	1.77	0.85	0.08	14.14	0.21	2.00
Other sections	485	A	0.37±0.12	1.39±0.18	0.18±0.04	0.25±0.03	12.62±2.15	0.63±0.14	3.32±0.19
		B	0.40	1.32	0.18	0.26	11.83	0.61	3.31

Table 2. Mean winter densities (± standard errors) of waterbird species on the WeBS Low Tide Count Section EW016 at Mansbrook Grove in comparison to those on other mudflat sections on the Orwell Estuary. A = mean density using all available counts; B = mean of monthly mean densities. DB = Dark-bellied Brent Goose, SU = Shelduck, PT = Pintail, RP = Ringed Plover, DN = Dunlin, BW = Black-tailed Godwit, RK = Redshank.

	Area (ha)	DB	SU	PT	RP	DN	BW	RK
Mansbrook Grove	0.9	0.89±0.89	12.11±3.94	5.44±3.42	0.00±0.00	30.56±15.81	0.22±0.22	26.44±11.22
Other flows	9.8	0.93±0.74	13.00±2.93	3.85±1.00	2.42±1.42	74.03±14.22	3.93±1.16	44.77±6.26

Table 3. Mean winter densities (± standard errors) of waterbird species at Mansbrook Grove in comparison to those at other freshwater flows running into the Orwell Estuary.

Figure 1 The study site showing the line of the proposed off site sewer from Ransomes Europark to its outfall into Fox Farm Brook at Mansbrook Grove, 200 m from the Orwell Estuary. Also shown is the boundary of the Orwell Estuary SSSI and SPA.

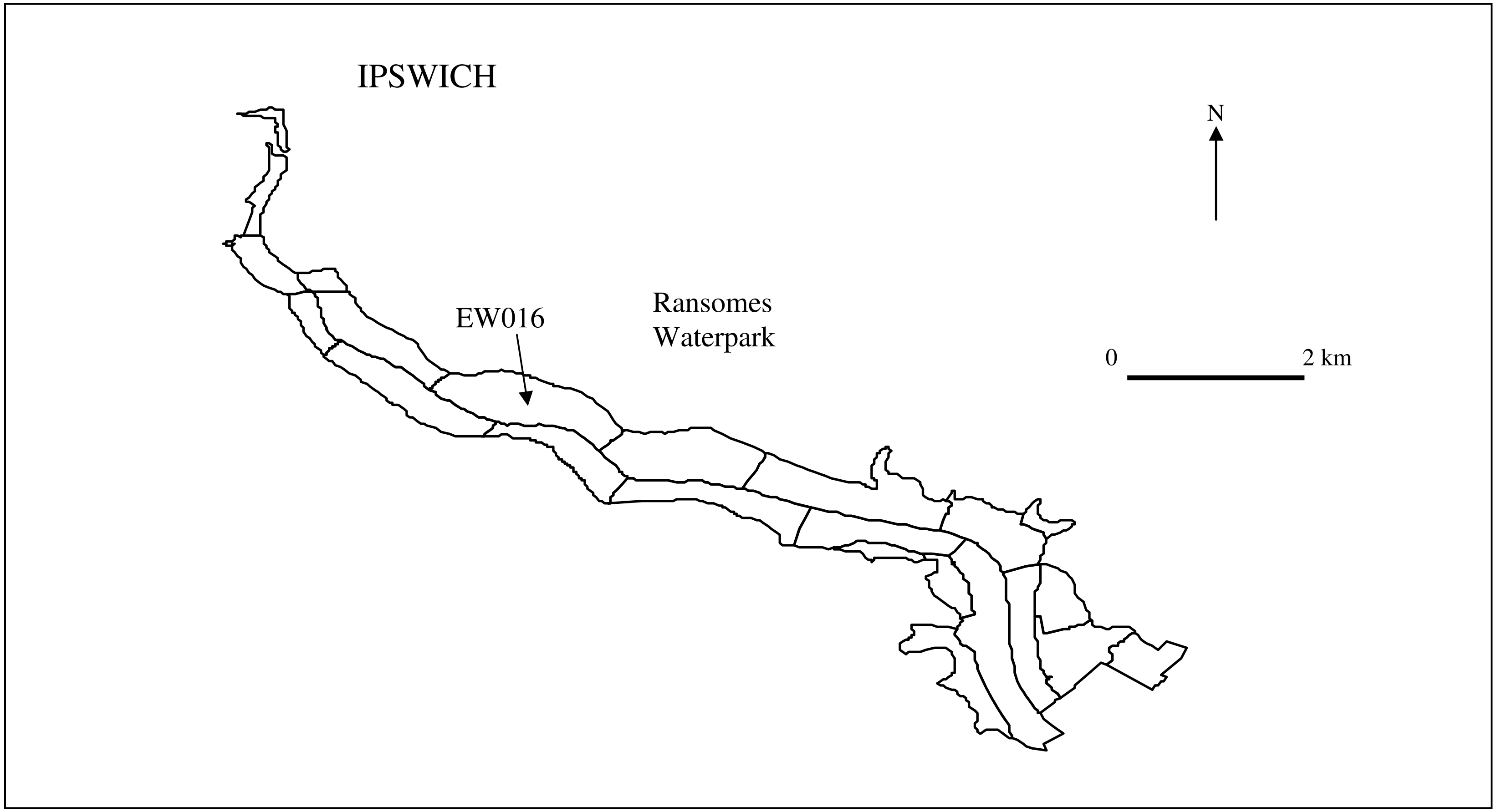

Figure 2 The Orwell Estuary showing Wetland Bird Survey (WeBS) Low Tide Count sections, including EW016 at Mansbrook Grove.

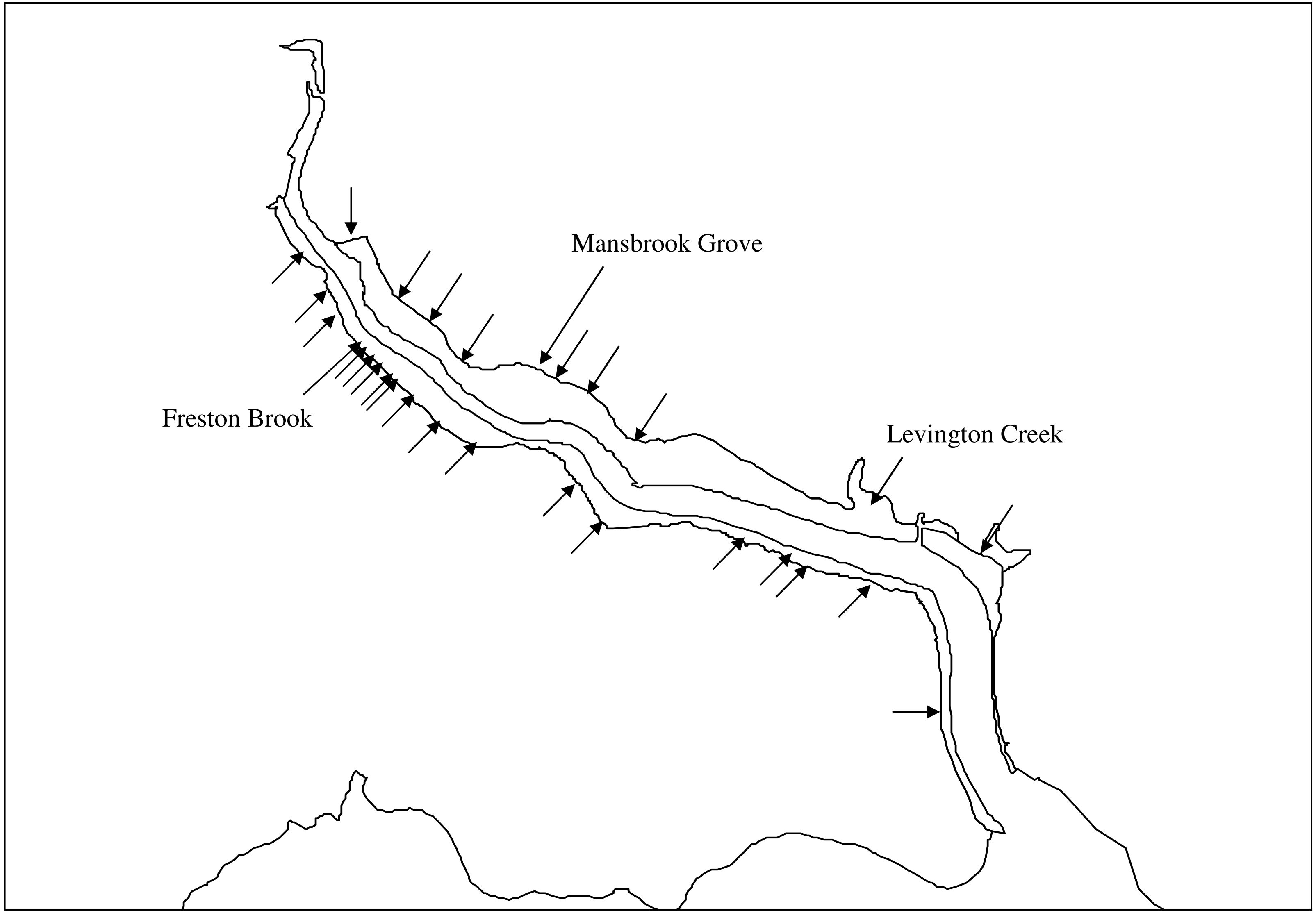

Figure 3 The Orwell Estuary showing freshwater flows counted at low tide.

APPENDIX 1

HR Wallingford (2000) *Effect of the proposed Mansbrook Grove Outfall on the adjacent mudflats of the Orwell Estuary*. HR Wallingford Report DDM4672, May 2000.

Effect of the proposed Mansbrook Grove Outfall on the adjacent mudflats of the Orwell Estuary

Introduction

It is proposed to build an outfall sewer to carry rain water drainage from Ransomes Europark on the outskirts of Ipswich, to meet the Fox Farm stream at a point approximately 200 m from the shoreline of the Orwell (approximate OS co-ordinates 619800E, 240200N).

In this area, the Fox Farm stream runs parallel to the Mansbrook stream, which lies about 50 m to the west. The two streams converge a short distance from the Orwell shoreline and the combined channel flows onto the intertidal flats of the estuary. It is noted that such fresh water sources to estuarine mudflats can provide a particularly valuable feeding resource for wading birds provided that they are free from pollutants and it is desired to investigate whether an increase to the volume of fresh water in this stream will have an adverse effect on its value to the bird populations.

HR Wallingford has been commissioned by the British Trust for Ornithology, whose representative is Dr Nigel Clark, to investigate the physical impact of the proposed outfall on the hydrodynamics and sediment transport processes and hence on the morphology of the stream channel across the mudflats. The study has been carried out by Dr Bill Roberts of the Ports and Estuaries Department. The HR Wallingford job number was DDM4672. The study is not intended to address any other issues associated with the outfall, for example any issues arising from contaminants potentially present in the water.

The British Trust for Ornithology and Dr Neil Ravenscroft have been employed by the TA Millard Partnership, who are responsible for the design of the sewer scheme, to undertake an Appropriate Assessment of the scheme impacts.

Details of the proposed works

The TA Millard Partnership have provided HR Wallingford with calculations of the flows through the outfall sewer for a range of return periods of rainfall events, together with ADAS surface runoff design calculations for the Mansbrook and Fox Farm catchments, to allow an estimate of the existing flow characteristics of the two streams. The following figures have been extracted from the TA Millard calculations.

1 in 1 year flow in sewer: approximately 0.2 m^3/s for 1000 minutes.
1 in 1 year flow in Fox Farm stream: 0.136 m^3/s
1 in 1 year flow in Mansbrook stream: 0.062 m^3/s

Thus the introduction of the outfall will approximately double the annual peak flow of the two combined streams. Note that the annual peak flow is often a good estimate of the morphologically dominant flow for rivers and streams. The 1:100 year flows in the existing streams are approximately 4 times larger than the 1:1 year flow. However, the design of the storage ponds associated with the sewer means that extreme flow events do not greatly increase the peak flow rate in the sewer: rather they increase the duration of the event.

For the purpose of this assessment, a reasonable assumption is that the effective discharge of the stream across the mudflat will be doubled.

Description of the existing mudflat

The Mansbrook and Fox Farm streams flow into an embayment in the north bank of the Orwell Estuary, opposite Woolverstone Marina. The width of the mudflats at this point is between 500 and 700 m. The mudflats of this part of the Orwell display a typical S-shaped cross-section being steep in the upper part, having a wide, nearly flat central section, at or a little below the level of mean water, and sloping more steeply again near the low water line as the intertidal mudflat merges into the relatively steep sided low water channel. No survey data is available for the mudflats at the site of interest, but cross-section shapes were measured in 1991 at Pond Ooze and at Broke Hall, approximately 2 km to the north-west and 2.5 km south-east respectively. These surveys were carried out for the Port of Felixstowe by Harwich Survey Associates.

The uppermost part of the flats, within roughly 50m of the shoreline, can have a slope of up to 1:10 to 1:20, based on the sections measured at Pond Ooze and at Broke Hall. The central part of the mudflat is much flatter, with a minimum slope of around 1:200 at Pond Ooze and 1:500 at Broke Hall. The overall mudflat width at Mansbrook is similar to that at Broke Hall and a minimum vale of mudflat slope of around 1:500 is to be expected for the central area.

The steep, upper part of the mudflat is dominated by the influence of waves. Although the estuary is sheltered from the open sea, locally generated waves can still be significant for the movement of sediment, particularly around high water, when the fetch lengths are at their greatest. The sediment transport processes in the central part of the mudflat are affected both by tidal flows along the estuary, and also by cross-shore directed currents, which can be quite strong for a short period during the flooding and drying of this part of the mudflat. The rate of change of water level is greatest around the time of mean water, and a rough estimate of the cross-shore speed of the wetting and drying currents is given by:

$$U = \frac{\pi R}{T S}$$

where U is the current speed, R is the tidal range, T is the tidal period, and S is the mudflat slope. For this location, the mean spring tidal range is approximately 3.6 m, the tidal period is 45000 seconds and the slope at the central part of the mudflat is

estimated to be 0.002 (=1:500). This leads to an estimate of peak cross-shore current of 0.125 m/s. Note however that this is an average value, and the presence of
drainage gullies may lead to locally higher values. This is discussed in more detail below. The maximum long-shore current at the central part of the mudflat is greater than this, approximately 0.2-0.3 m/s (taken from a calibrated computational flow model of the Orwell Estuary: HR Wallingford, 1996).

In the lowest part of the mudflat, the slope becomes steeper again as the mudflat meets the low water channel. In this area the greatest hydrodynamic forces on the mudflat are caused by the long-shore directed tidal currents.

The site inspection confirmed that the uppermost part of the mudflat in this area is indeed rather steeply sloping, and with a covering of relatively coarse sediment: coarse sand and gravel, overlying sandy clay deposits beneath the surface. As the stream meets the intertidal flat, there is a region where the stream channel is braided, corresponding to the steepest beach-like part of the mudflat. The various channels then form into two separate streams proceeding down the mudflat. It is likely that these streams rejoin at some lower point. The 1:25000 Ordnance Survey map of the area (Sheet 1053) indicates a dendritic network of drainage channels forming into a single substantial channel at the low water line. Most of the branches of this network will be associated with the drainage of tidal water, rather than fresh water input from the shoreline.

The regime description of channel size

The regime method of analysing the size of alluvial channels is largely empirical, originating from measured values of width, depth, speed, slope and discharge of various rivers, streams and man-made canals. However, it offers a simple way of making approximate predictions of channel size and shape. An explanation of these observations has been put forward by a number of authors, for example White *et al.* (1982). In this case, the regime shape of a channel is shown to be the one which carries the imposed discharge and sediment load with the least dissipation of energy (proportional to channel slope). To achieve this state, the channel can vary its width and depth. For a certain chosen width, there is only one value of depth which will satisfy the imposed discharge and sediment load criteria. Amongst the range of possible widths, the theory says that the width (and corresponding depth) leading to the minimum channel slope is the "regime" width and the one which we would expect to find in nature. This can be shown to be equivalent to fixing the discharge and the channel slope, and optimising the width and depth to achieve the maximum rate of sediment transport.

Regime descriptions of channels are usually expressed as power law relationships between the discharge and the other parameters of interest: width, depth, velocity and slope, i.e.

$$B = k_1 Q^b$$
$$D = k_2 Q^f$$
$$U = k_3 Q^m$$

$$S = k_4 Q^z$$

where Q is the discharge, B is the width, D is the depth, U is the current speed and S is the channel slope. k_1, k_2, k_3, k_4, b, f, m and z are coefficients, determined by observations of large numbers of rivers. Note that because the discharge is equal to the speed multiplied by the width times the depth, the coefficients b, f and m must satisfy:

$$b + f + m = 1$$

The most commonly accepted values for the coefficients are:

b = 0.5
f = 0.33
m = 0.17
z = -0.17

Different authors have arrived at different values for the multiplying coefficients k_1-k_4, but these values are not required to consider the proportional change in channel size in response to an increased discharge. In general, a larger sediment load in the stream will lead to a smaller channel size for a given discharge. More mobile bed sediment type generally increases the channel size for a given discharge.

If the valley slope is very much steeper than the equilibrium slope which the river would like to achieve, then the "strategy" of meandering is no longer stable, as the required sinuosity would be too great. In this case, river channels tend to split into several (typically 3) smaller channels. Smaller channels have a higher value of equilibrium slope, and these multiple channels can then flow roughly straight down the valley.

Note that the equilibrium slope for a stream of the approximate size as the one in question will normally be less than the minimum mudflat slope of around 1:500 (White *et al.* 1981), therefore it is to be expected that the channel takes a meandering course. The actual value of the slope depends on the sediment load of the channel, which will be influenced by mobilisation of the intertidal sediments as well as the terrestrial sediment load, so this is difficult to determine without detailed measurements.

In the case addressed here, the situation is more complicated than for a non-tidal stream, because in addition to the fresh water flow down the mudflat, there is also the tidal rise and fall of the water level. The fresh water stream will have an important influence, as it runs at all states of the tide, whereas the tidal flow is only present intermittently. In the uppermost part of the mudflat, the behaviour of the channel will be dominated by the effect of the fresh water stream. In the lower part of the channel, the drainage of tidal water from the mudflat will become an important influence and the form of the channel will become increasingly independent of the fresh water input.

The presence of the stream has created a small valley in the mudflat, which then acts as a focal point attracting drainage from a substantial area of the mudflat. Note that at certain states of the tide, the main flow direction may be across the stream, rather than along it, but because of the relatively large water depth at such times, this cross-flow will have little effect on the stream morphology.

Expected change in channel shape due to the Mansbrook Grove outfall

As described above, we will assume that the dominant discharge at present is 0.2 m^3/s and that this will increase to 0.4 m^3/s after the construction of the outfall. We emphasise again that the actual discharge in the stream will usually be smaller than this, and occasionally larger than this, but the overall effect of the range of flows can be approximated by taking the annual maximum flow as a representative value.

Using these values indicates that doubling the discharge will lead to a 41% increase in width, 26% increase in depth and 12% increase in velocity. Note that all of these values are to be evaluated at the dominant discharge. The depth at low discharge will not change significantly. Also, the equilibrium slope of the channel will decrease to approximately 89% of its original value. This will tend to increase the sinuosity of the meanders of the channel. In the uppermost part of the intertidal flat, where the channel is presently braided, the longitudinal extent of the braided zone can be expected to extend slightly.

In the lower part of the mudflat, the influence of the drainage of tidal water will become progressively more important and hence the change in channel shape arising from the increased fresh water discharge will be proportionately smaller. At the lowest part of the mudflat, the change in channel size is likely to be negligible.

Effects further afield

Note that it is not anticipated that the increase in discharge of the Mansbrook and Fox Farm streams will have any impacts in the Orwell as a whole, other than the local effects on the channel across the mudflats discussed above.

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