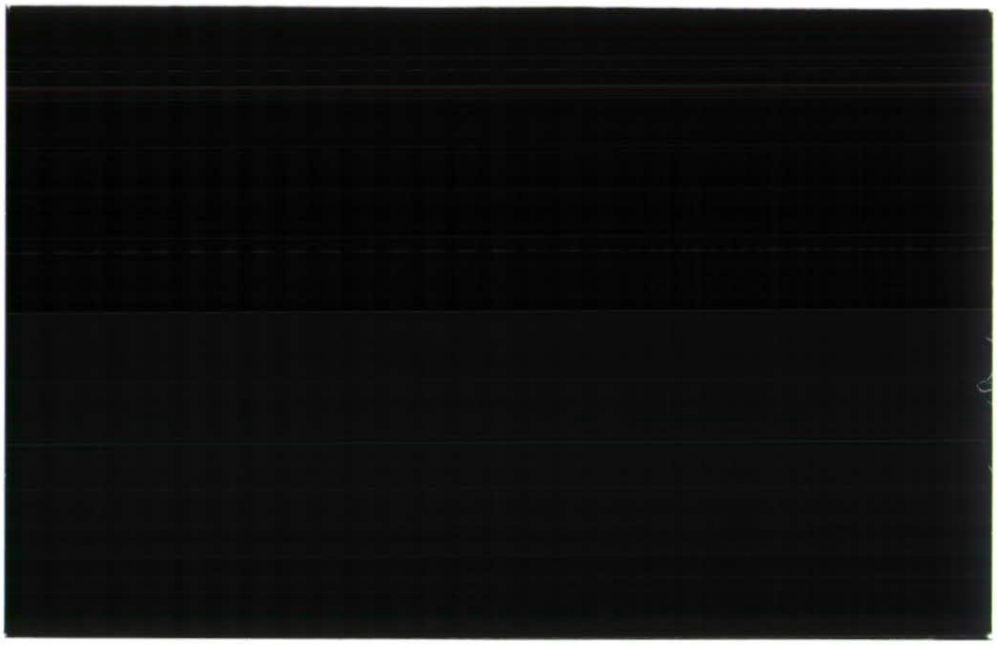
Institute of Hydrology



Natural Environment Research Council

1996/056

Water Quality and Environmental Issues of the Medway

B.N.Austin and F.M.Law

September 1996

Addendum :

Fishes of the River Medway estuary
Mike Ladle, Institute of Freshwater Ecology

Observations on the Fish Populations of an East Coast Estuary
J.R.Wharfe *et al*, Southern Water Authority, Kent

Centre for Ecology and Hydrology
Wallingford
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Water Quality and Environmental Issues of the Medway

Report to SAUR UK and GU 3/09/96

B.N. Austin and F.M. Law, NERC Institute of Hydrology

1. The broad setting

The Medway catchment comprises a mixture of chalk, clay with alluvial gravels and sandstone complexes. As a result it has a number of very flashy tributaries. Three reservoirs have been built on the catchment since 1950. Bewl Water is the largest and supplies mainly the Medway towns, although it also supports a wider system. Bewl is filled principally by pumping from the Teise and the Medway (at Smallbridge and Yalding respectively) and supplies water to Bewl Water and Burham treatment works. In the latter case this is by augmenting Medway flows by dry weather releases so that the intake just below Springfield Mill, on the Medway east of Maidstone, can always operate. The tidal limit of the Medway is at Allington sluices between Springfield and the M20 bridge. The Medway estuary remains modest in width until Rochester is reached (Figure 1). In times of drought, water may be transferred from Bewl reservoir, via a new pipeline, to Robertsbridge for repumping up to Darwell reservoir which serves Hastings.

Most of the water from Weir Wood and Bough Beech reservoirs is exported from the catchment. Weir Wood, near the head of the catchment fills naturally, while Bough Beech, like Bewl, is filled by pumping (Figure 2). Abstraction volumes allowed are governed by a daily and annual limits as well as by the minimum residual naturalised[1] flow (MRF) in the river as measured at Teston on the Medway.

Quality of the water in the Medway will dictate, in the long term, the amount of water that will be allowed to be abstracted from the river. River quality issues dealt with in this report cover the reaches between Tonbridge at the head of the Medway Navigation and Rochester; the largest effluent and industrial returns lie below Maidstone. Below Rochester the tidal mixing and related processes are of a different order than those considered here.

2. Aim of the Report

A sound integrated catchment management plan involves the identification of point sources of pollution, but looks at their effect as a whole on the seasonal and sustainable quality and ecology of the river. Understanding and controlling the effects of industrial discharges and treated effluents leads to more sensible use of existing water. This results in a reduced need to exploit distant supplies or build new reservoirs. It is envisaged that increased growth and demand for water in a catchment as large as the Medway can be met by sensible management of existing resources.

This report outlines the water quality issues which may arise in light of increasing pressure on water supplies in the Medway catchment. It seeks to highlight the problems that must be tackled so that the present protection afforded by the Teston residual flow rule of 275 Mld--which is 30% of the long term mean flow -- can be relaxed to release additional yield while

[1] The flow is not fully naturalised, but a simple formula allows for major influences.

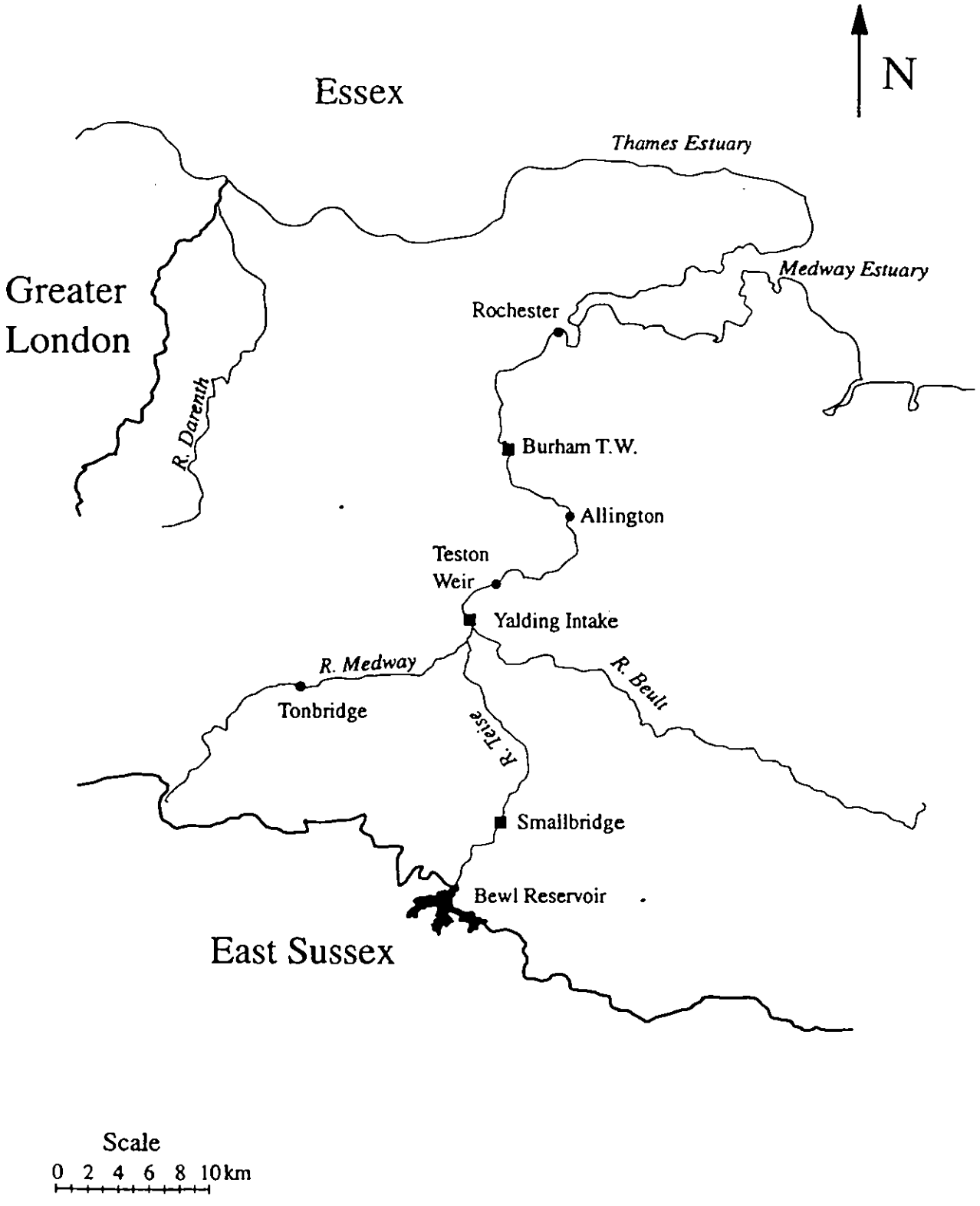


Figure 1 The Lower Medway

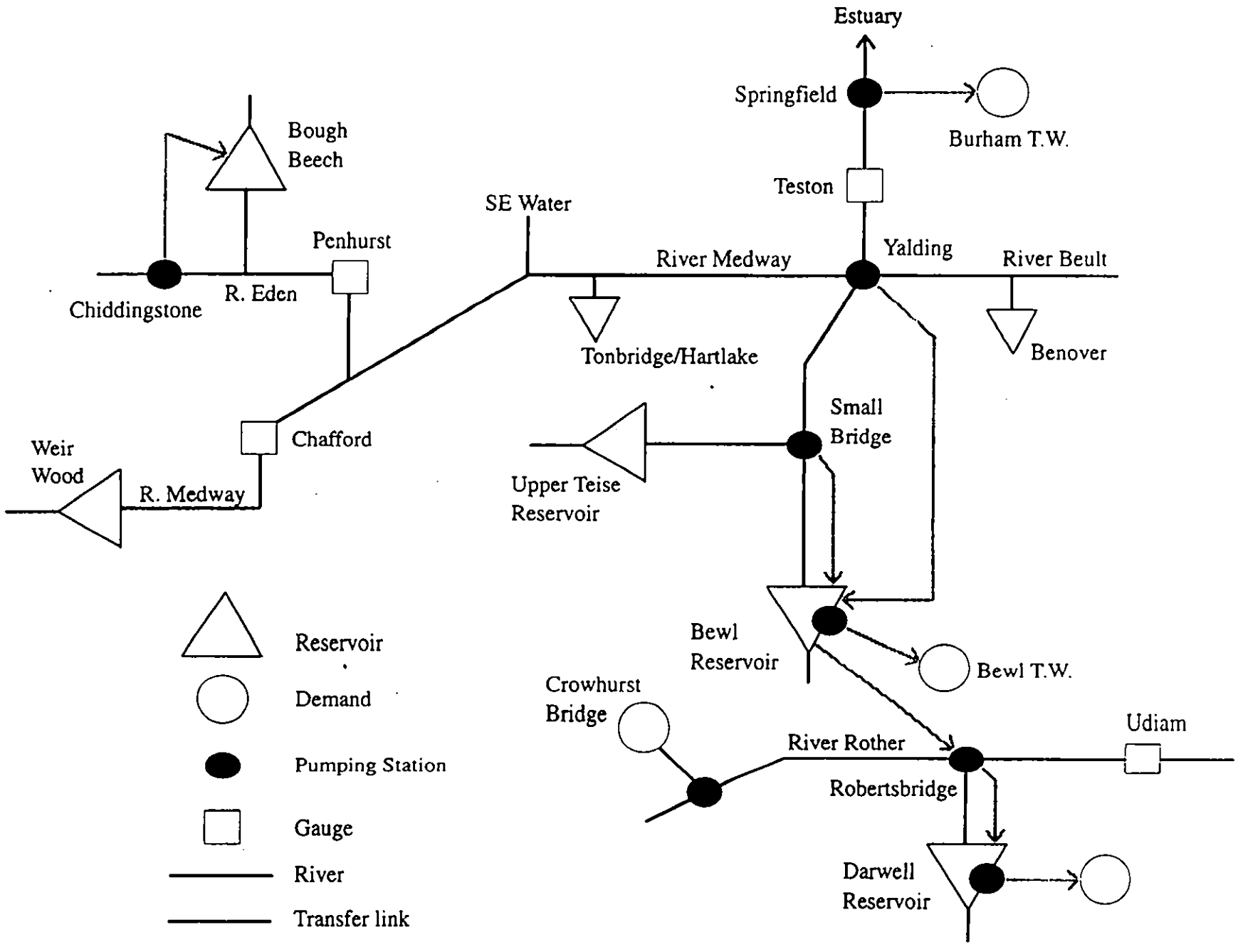


Figure 2 System diagram for the Medway and Darwell schemes

causing no disadvantage to the ecology and fisheries.

3. Background

The National Water Council (now defunct) set Water Quality Classes for rivers to control the nature, volume and composition of effluents. The four broad classes are based mainly on chemical criteria and are as follows:

Table 1: Water Quality Classes for Rivers

IA	Good	Exceptional water quality typical of upland river or chalk streams
IB	Good	Good water quality typical of clean lowland streams
II	Fair	Water quality typical of lowlands stream containing well treated effluent
III	Poor	Water in need of improvement
IV	Polluted	

For most catchments the objective class has been IB. Where streams provide low dilution of treated effluents, class II may be appropriate.

It is unrealistic to expect the quality of water in the Medway ever to be pristine while it is used to dispose of treated effluents. It is however possible to maintain a level of quality which is ecologically acceptable. There are more than 180 sewage treatment works in the Medway catchment, of which 54 discharge more than 70 m^3/day (see appended tables).

The Medway resource optimisation strategy of the joint companies to meet forecasted demands is presented for convenience in Figure 3). It takes into account reduction in leakage targets, peak and average demands as well as possible long-term effects of water conservation on demands. It shows how construction of new reservoirs can be delayed by restructuring and by the reduction of the controlling residual flow around 2005 if water quality targets are not compromised.

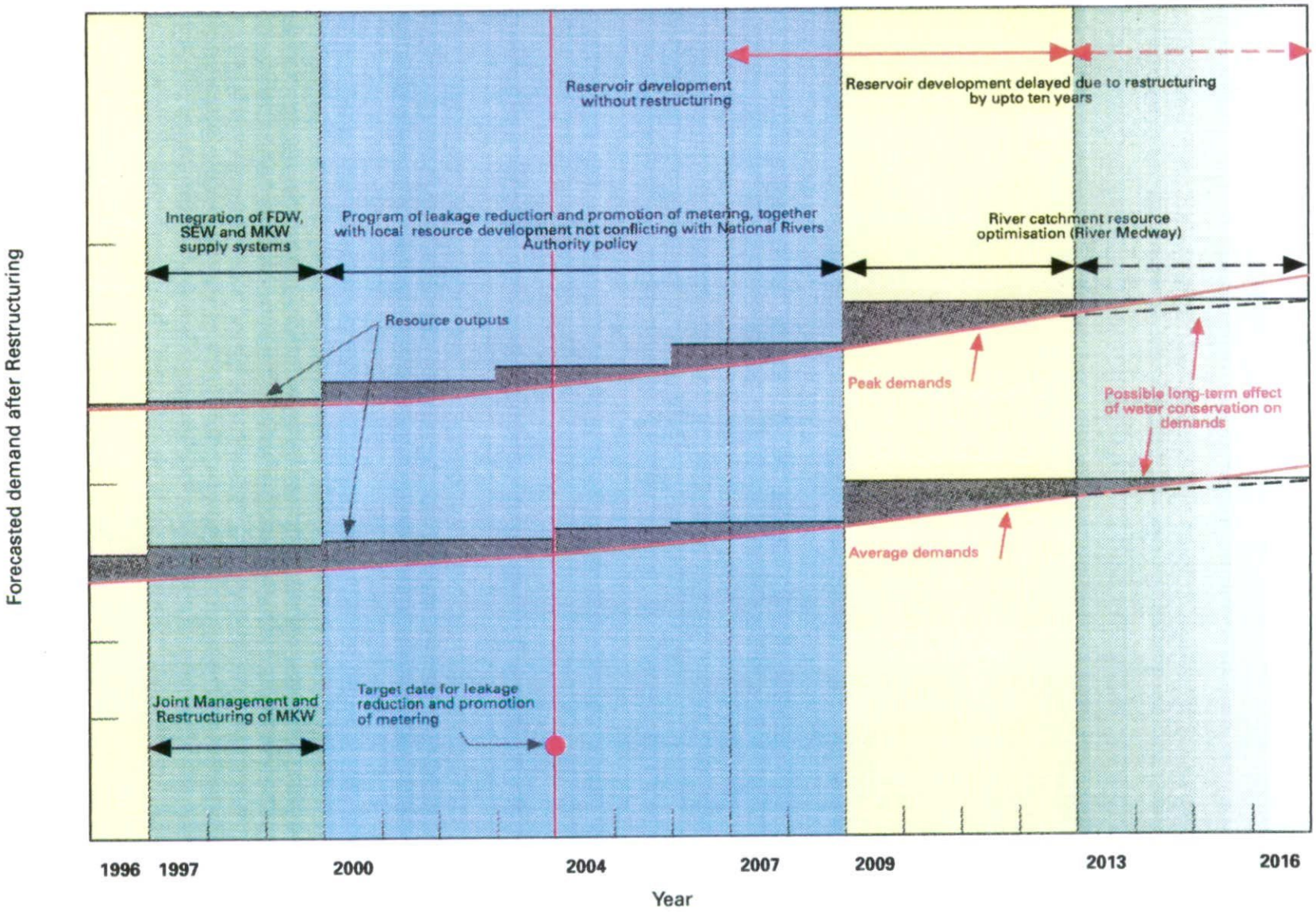
4. Baseline of river quality

Medway water is tested for many contaminants on a regular basis by a number of agencies, but principally the EA. A small but key part of this data is held in the Harmonised Monitoring Scheme by the Department of the Environment. The more important indicators of quality are measured more regularly and are Biochemical Oxygen Demand (BOD), dissolved oxygen (DO) and level of nitrates and chlorides. Each is associated with different types of catchment, industry and treatment works.

In 1979 the NRA commissioned the Water Research Centre (WRC) to construct a model to examine the effect of change in natural and imposed conditions on the quality of water in the Medway estuary. It was developed to examine the options available to meet water quality objectives and to suggest ways of developing the Medway water resource. The principle indicator in is DO with a suggested minimum level of 10% in the upper estuary on a 95%ile basis. The calibrating survey was for May-July 1979 (see Gascoine and Jury Figure 2 attached, which shows the sag in oxygen status below Allington which then applied).

Figure 5 is a time series from the Harmonised Monitoring Scheme for site 07001 above Allington, covering the BOD and conductivity parameters. Similar results are available for

Resource Optimisation Strategy
1997 to 2013-2016



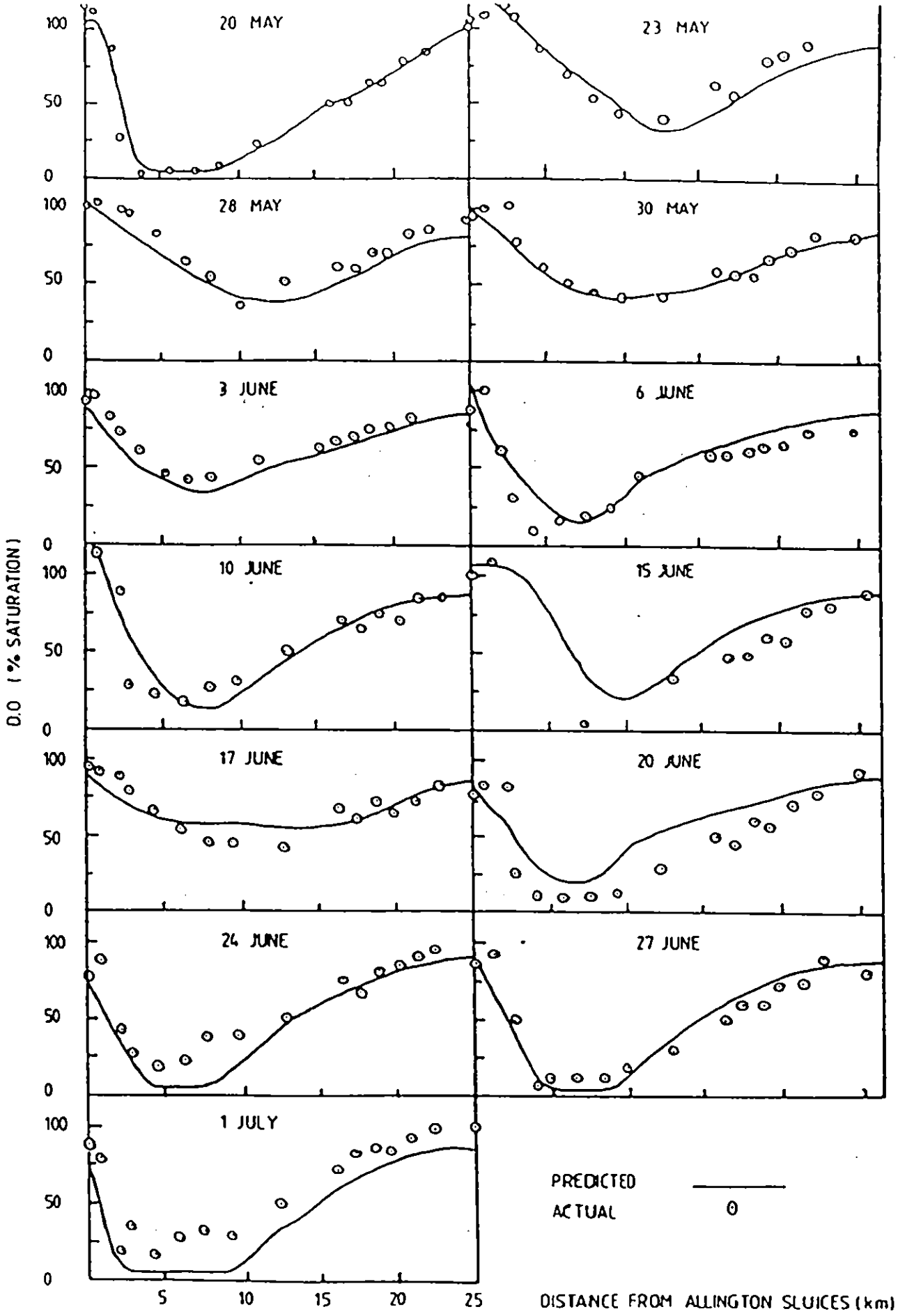


Fig. 2. Observed and calculated distributions of DO for intensive 6-week survey in May-July 1979

(from Gaspine and Jury, 1984)

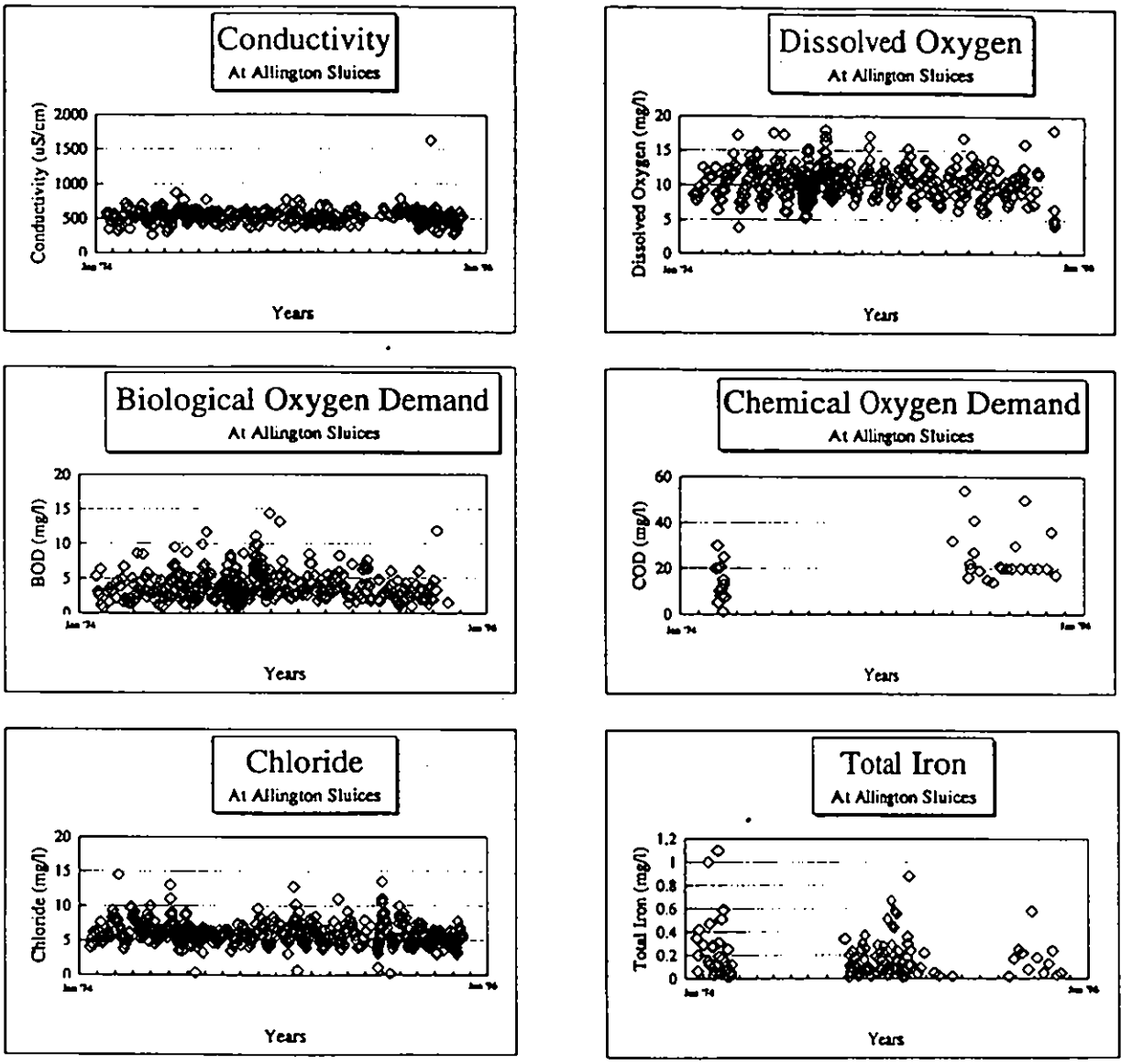


Figure 5 - Water Quality Indicators on the Medway at Allington.

station 07002 on the lower Eden tributary;earlier Eden results for 1963-69 can be found in Shinner and Davison 1971. At first sight the baseline of current water quality in the basin is not improving significantly. The quality rating given in the Medway Catchment Management Plan is predominantly Class IB.

The lack of clear improvement, despite the various sewage treatment works extensions that have been built across the basin, may be due in part to the general period of lower flows in recent years. However it may also be a consequence of the population growth that is having to be handled; conductivity should reflect growing effluent returns, all else being equal.

The successes due to improved paper mill effluents from the new factories immediately below Allington sluices are limited to the upper estuary and no conventional data source is available to us to quantify that.

The EA has provided us with a list of effluent discharge consent sites which is appended. This can be compared with the 1964 list from the Kent Rivers Hydrological Survey.

5. Recent river quality improvements

The Medway catchment comprises rural, urban and industrial areas and thus many different forms, quantities and frequencies of pollution to the river occur. BOD readings are a measure of the levels of organic materials in the water. Recent technological development in effluent treatment plants has made it possible to significantly reduce the BOD in treated water. This, together with increasingly stringent licence limits enforced by the EA has meant that some industries have drastically improved the quality of their effluent. Aylesford Newsprint for example, one of the largest industries on the Medway, have reduced the BOD in their effluent to 7% of the 1994 level per tonne of production (production quadrupled in the same period and licence limits of BOD in the effluent dropped by a factor of 2.5 - see Figure 4). Aylesford Newsprint produce 19 Mld of effluent. There are several other paper plants on the Medway upper estuary.

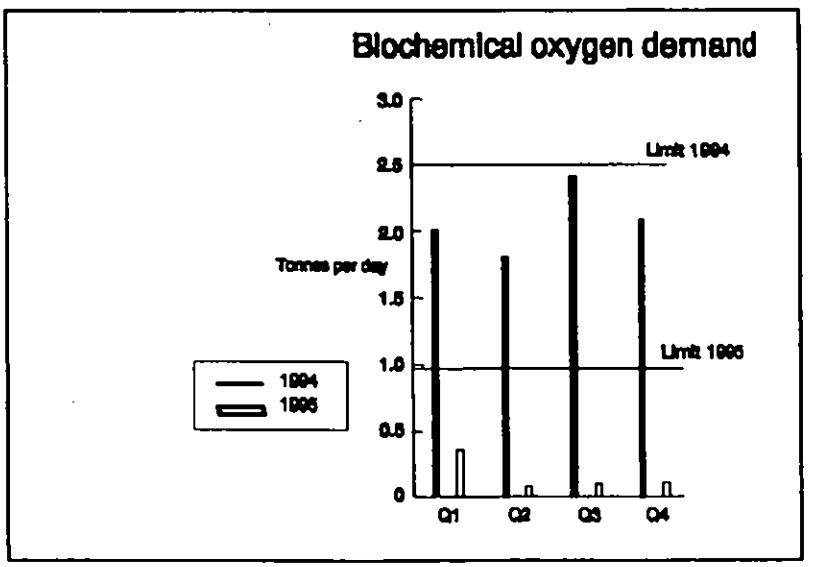


Figure 4 Biochemical Oxygen Demand in treated water from Aylesford Newsprint.

There is no reason to assume that future innovations in wastewater treatment technology together with further EA restrictions will not continue this trend in the future.

The NRA/EA Catchment Management Plans (CMP) are designed to promote the overall vision of the NRA to a specific catchment and are usually based on a 10 year planning horizon. Recommendations are reviewed in light of changing circumstances.

The Medway CMP highlights water quality objectives and performance in the past few years on the Medway and its tributaries:

Table 2: Objectives and achievements of the Medway CMP.

Class	Objective (km)	Achieved in 1991(km)
IA	23.7	37.2
IB	312.2	219.6
2	60.1	124.5
3	0.2	11.6
4	-	3.3

Other indicators of river quality for the period 1974-1995 are shown in Figure 5.

The WRC model described in the previous section recommended that in order to drop the MRF at Teston, reduction in loadings at the estuary must take place. There have been many changes in both the quantity and quality of loading on the estuary since the model was built. It is time that the model is reviewed and rerun with these changes built in and river quality modelled again. This should be coupled with a comparable quality model (eg. QUASAR) of the Tonbridge to Allington locked reaches. However the best test of long term quality of a river is the presence of aquatic species. Refer to Annex for a description of fish population trends.

6. Development issues

Substantial growth is expected in the Medway towns, but provision of houses is only expected for local needs. Several new distribution centres, high technology industries, office development and research organisations are expected, due at least in part to improvements in the A20 and M20 and development of the Channel Tunnel Rail Link. New roads and railways result in an increased risk of accidental spillage while the increased housing will result in increased demands for water and higher effluent returns to the river.

There are extensive mineral workings along the Medway with alluvial deposits providing virtually all the coarser sands and gravels. Major new reserves have been discovered downstream of Tonbridge and gravel extraction will no doubt continue there. Comprehensive minerals plans exist. Siltation risks to the river will continue to have to be controlled.

A large number of vessels from tankers and passenger ferries to sailing boats and canoes use the Medway Estuary for transport and recreational purposes; Medway Ports Ltd publishes a

map of estuary features and facilities. Recreational navigation of the river up to Tonbridge is believed to be increasing, with consequent bank wash erosion risks. Conflict may arise between use of the river for informal recreation and the need to protect and conserve the river corridor. Tourism and recreation on and around the Medway is increasing faster than the rate of population increase in the area. The buffer strips along the river bank have high conservation value and one of the CMP management proposals involves encouraging Government agencies to structure agricultural grant schemes to favour the development of these buffer zones.

7. River improvement objectives of local communities

It is important to manage any river and to restore degraded ecosystems so that they can sustain themselves naturally. The CMP on the Medway was designed to promote community awareness and participation in the management of the local environment. The Medway River Project (MRP) was encouraged by the NRA (Southern Region). The specific objectives were:

- Manage and enhance the landscape and wildlife of the Medway
- Maintain and enhance the access and recreational use of the Medway
- Promote local community awareness of, and involvement in the enhancement of the Medway's environment.
- Encourage landowners to take a positive role in enhancing the Medway and the surrounding countryside.

A number of industries and private owners of land were approached with proposals to develop and implement a management plan for conservation of land with great potential for habitat. One of there areas is now the Yalding Fen Educational Nature Reserve. Originally purchased by ICI as a buffer between the chemical plant and the general public, it is unique on the Medway. Countryside Stewardship and Hedgerow Incentive grants have been used to secure conservation of similar significant areas of land along other stretches of the Medway. When the MRP was established in 1988 it was unique. Now there are three in Kent.

8. Options for yield and quality improvements

If it is necessary to increase abstraction from the Medway, this needs to be done without deterioration of the quality of the water remaining. There are two possible approaches: increasing the quality of the water or changing the abstraction regime. The quality of the water may be improved through tighter statutory discharge consents or through mechanical means such as an emergency bubbler system (as on the Thames). Alternatively some major effluents could be treated with hydrogen peroxide. Alternatively temporary treatment plants might be built on outfalls from factories unable or unwilling to improve effluent quality. Such measures would improve the quality of the water in the Medway and improve the chance of being able to drop the MRF for abstraction at Yalding and Springfield.

Another approach might be to change the abstraction patterns now controlled by licences at Yalding and Smallbridge. Adjustment of seasonal pumping rates and/or relaxing the daily and annual limits to allow greater exploitation of the peak flows (or those of poor quality) might increase the yield from Bewl while preserving or increasing the quality of the water in the Medway and Teise. This merits further investigation using the quality models recommended earlier.

9. Opportunities for both Water Companies

The Medway Catchment Management Plan makes it plain that there are water quality improvements to be made but that financial stringency limits the pace of achievement. It is understood that EA Southern had sought £50m for low flow alleviation and water quality related schemes but that this was refused by government in 1994/95. This gives the companies some scope for negotiation with EA about making contributions towards reaching SWQOs on the Medway in return for the granting of a licence. Complications may exist about the EA water resources account balancing requirement but good will towards river improvements should exist if the companies feel able to contribute multi-million pound sums.

To reinforce this, it could be useful to become corporate sponsors of the Medway River Project and of the Millennium Project proposed by Maidstone Council; the latter is intended to open up the riverside as a stronger public attraction. It is not obvious at present that either of these projects is associated in the public eye with a major commercial sponsor. To invest in consortia of interests which have the river as a focus must be persuasive that the companies are taking sustainable development seriously. Conversely to under-invest in the Medway will send the opposite message.

A complicating feature is Southern Water's responsibility to run all the public system effluent treatment plants. For financial reasons they can only be expected to invest in extensions or better management practices that just observe their discharge consent. Your companies could adopt a policy of offering to take certain Southern Water effluents (eg. Tonbridge / Maidstone) and give them a final "polish" before discharge to a reach that was critical to fishery interests as well as to Joint Resource Company future abstraction.

Kent CC planners are known to have a keen interest in the recreation potential of lakes created on the alluvial gravels between Tonbridge and Yalding. Rather than the Joint Resource Company suggesting a site, it may be better to get the County Council to indicate one or more which would be likely to receive planning permission (taking into account local resident and ownership views over visitor numbers etc). The JRC could them work up that design to include water quality improvement features and could do so with more confidence than the associated licences and statutory permissions would be forthcoming. The River Medway Project consortium would also need to be involved so that no substantial group remained that wished the associated abstraction licence to be refused.

10. Overview

This report points to the issues relating to river quality along the Medway that must be considered in any endeavour to increase yield from the river. As steps to being allowed a Medway licence it is recommended the companies:

- Carry out a rapid water quality transect survey of the river between Rochester and Tonbridge so that the companies have access to the data at that point in time. Preferably this would happen before the end of the dry period of 1996 and be repeated at the end of the next wet season for contrast.

- Remodel the river between Tonbridge and Rochester for key quality parameters to take into account the many recent changes. This would reveal the sensitivity of the quality of the water in the main river and upper estuary under current conditions and the

effects of the lower residual flows that we believe are justified and sustainable.

- Examine the benefit/cost of offering to 'polish' the Tonbridge and Maidstone effluents.
- Weigh up the value of a major sponsorship of river Medway improvements.

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Appendix of 1996 consented PLC Sewage and Trade disharges provided by EA Southern Area Office, and of the comparable 1964 list from the Kent Rivers Hydrological Survey (HMSO)

PLC SEWAGE DISCHARGES

HYDROREF	SITE	NGR	
A1/004/1	GRAIN SEA OUTFALL	TQ89907608	
A2/007	HOO SEWAGE WORKS	TQ79257166	
A2/008	STOKE STW	TQ84147516	
A3/003	WHITEWALL CREEK STW	TQ75526975	
B7/031	CUXTON STW	TQ72006705	
B8/031	HARVEL STW		
C2/002/1	HAM HILL STW	TQ71196133	*
C3/003/1	DITTON STW	TQ71705906	*
C4/003	HALLING STW	TQ71026443	
D1/002	LOWER HALSTOW STW	TQ85706780	
D2/065/1	MOTNEY HILL SEWAGE WORKS	TQ83156900	
D4/003	AYLESFORD STW	TQ71665933	*
D5/004	WOULDHAM STW	TQ71126475	
E1/007	BEARSTED STW D	TQ79425450	
E2/008	LEEDS STW	TQ82375366	
E2/010	HARRIETSHAM STW	TQ86765200	
E3/005	COXHEATH STW	TQ75605226	
F1/004/1	WATERINGBURY STW	TQ69635281	
F2/003	EAST PECKHAM STW	TQ68104910	
F3/007/1	HADLOW STW	TQ63204920	
F3/007/2	HADLOW STW - STORM OVERFLOW	TQ63204920	
G1/009	LINTON STW	TQ75154901	
G1/018	CHAINHURST STW	TQ73134766	
G2/002	ULCOMBE STW	TQ84324804	
G2/005	HEADCORN STW	TQ81804420	
G2/013	SUTTON VALENCE STW	TQ80934809	
G3/005	FRITTENDEN STW	TQ81024173	
G3/009/1	STAPLEHURST STW	TQ79484467	
G4/007	BIDDENDEN STW	TQ84803871	
G4/008	SISSINGHURST STW	TQ79683790	
G4/015/1	CRANBROOK STW	TQ78443620	

HYDROREF	SITE	NGR
O1/008	MARK BEECH S.T.W.	TQ47324270
O1/009	COWDEN STW	TQ46654018
O1/019	BLACKHAM STW	TQ50333950
P4/002	REDGATE MILL STW	TQ55253248
Q1/010/1	LINGFIELD STW	TQ38864505
Q1/010/2	LINGFIELD STW	TQ39004495
Q2/008	FELBRIDGE STW	TQ36434093
Q3/007	EDEN VALE	TQ39254038
R1/003/1	WEST HOATHLY STW	TQ37453349
R2/012	LUXFORD LANE STW	TQ404 363
R3/003/1	FOREST ROW STW	TQ45553558
R3/003/2	FOREST ROW STW	TQ45553556
R3/003/3	FOREST ROW STW	TQ45753570
R3/004	HARTFIELD STW	TQ48403619
R5/002/1	ST JOHNS STW	TQ49853318
R5/002/2	ST JOHNS STW OFS	TQ49903308
R5/006	NUTLEY STW	TQ44052868
Count:	79	

HYDROREF	SITE	NGR
H2/004/1	SMARDEN STW	TQ87684226
H3/006	HIGH HALDEN STW	TQ88903770
H4/002	EGERTON STW	TQ90624713
H4/007/1	BETHERSDEN STW	TQ92384025
I1/002	CHERRY GARDENS STW	TQ73303824
I1/004	SMITHS LANE STW	TQ71853820
I1/006	HORSMONDEN STW	TQ72024030
I3/015	PADDOCK WOOD STW	TQ67744583
J2/006/1	WHITEGATES STW	TQ63103414
J2/006/2	WHITEGATES STW	TQ63103414
J2/009	FRANT STW	TQ60133359
J2/053	BEST BEECH STW	TQ61503152
J3/003/1	LAMBERHURST STW	TQ67893621
J3/007	SPINDLEWOOD	TQ67303087
J4/003	KILNDOWN STW	TQ70703505
J4/008/1	UNDERHILL STW	TQ72213720
K1/002/1	TONBRIDGE STW	TQ59704630
K2/005/1	PEMBURY STW	TQ64544270
K3/002/1	TUNBRIDGE WELLS NORTH STW	TQ60294260
L1/017	PENSHURST STW	TQ53164385
M1/027/1	TUNBRIDGE WELLS SOUTH STW	TQ52693742
M2/002	BIDBOROUGH STW	TQ55864246
M2/005	SPELDHURST STW	TQ55494212
M2/016	FORDCOMBE STW	TQ52334043
N1/015	GODSTONE STW	TQ36705038
N2/004	ST. GEORGES COTTAGES	TQ39204778
N2/037/1	OXTED & LIMPSFIELD(POINT A)	TQ39825012
N2/037/2	OXTED & LIMPSFIELD STW	TQ39825010
N4/005	EDENBRIDGE STW	TQ45424649
N6/003	CHIDDINGSTONE CASTLE	TQ50204547
N7/010	CHIDDINGSTONE HOATH	TQ50004249

TRADE DISCHARGES.

HYDROREF	SITE	NGR
A1/002/1	GRAIN POWER STATION	TQ898275
A1/002/2	GRAIN POWER STATION	TQ895765
A1/005/1	B.P. WHITE OILS	TQ859875
A1/005/2	B.P. WHITE OILS	TQ859875
A1/006/1	BRITISH GAS GRAIN	TQ857175
A1/006/3	FORMER BP OIL REFINERY	TQ879573
A1/011	TRANSMANCHE LINK	TQ872074
A1/013/4	B.P. SEPARATOR	TQ874673
A1/013/5	B.P.ACIDIC EFFLUENT	TQ874673
A1/031/2	MEDWAY POWER LTD,(FORMALLY A.E.S.MEDWAY)	TQ870074
A2/017/1	FEB LTD. (FORMERLY B. P. AQUASEAL)	TQ812873
A2/050	HOO ISLAND	TQ784970
A3/026	MEDWAY TUNNEL WEST APPROACH WORKS	TQ.75706
A3/031	WHITEWALL ROAD	TQ
A3/034	SCOTLINE TERMINAL (MEDWAY) LTD	TQ751068
A5/005	WESTMINSTER DREDGING CO	TQ714577
A5/007/1	BRETT MARINE AGGREGATES	TQ718475
B1/002	FISHER CONTROLS LTD	TQ734768
B2/005	CEGB CABLE TUNNEL	TQ670574
B3/020	MARINE GRAVEL WORKS	TQ668574
B3/021	TURNPIKE FILLING STATION	TQ640171

B4/028/1	BLUE LAKE (FORMERLY KNOWN AS PORTLAND PIT)	TQ617074
B4/028/2	BLUE CIRCLE, NORTHFLEET EASTERN QUARRY	TQ617673
B5/014	NORTHFLEET EASTERN/WESTERN QUARRY	TQ605275
B6/094	SOUTHFLEET	TQ598724
C1/002	RYARSH PLACE FARM HOUSE	TQ672 59
C1/009	ADDINGTON SAND PIT	TQ652059
C1/012/1	TROSLEY P.S.	TQ640859
C2/003/1	SMURFIT TOWNSEND HOOK LTD - NO.7	TQ711761

HYDROREF	SITE	NGR
C2/003/2	SMURFIT TOWNSEND HOOK COOLING - NO.12	TQ711761
C2/004	AYLESFORD NEWSPRINT - NO. 12 (FORMERLY REEDS)	TQ715859
C2/018/1	RYARSH PUMPING STN	TQ666560
C2/043	SCA EUROLINER NO. 15 (FORMERLY REEDS)	TQ716059
C2/058	KIMBERLEY CLARKE, LARKFIELD, AYLESFORD	TQ717159
C3/002/1	ARC PREMIX	TQ743358
C3/029	ESSO	TQ728658
C4/004	RUGBY CEMENT COMPANY	TQ705065
C4/009	RUGBY CEMENT CW	TQ705 65
C4/010	HOLBOROUGH CEMENT	TQ705162
C4/011	HOLBOROUGH CEMENT	TQ705762

C4/027	VANTAGE POINT	TQ704062
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D1/003	WESTMINSTER DREDGING	TQ869569
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D1/012/1	REDLAND BRICKS LTD,FUNTON	TQ874667
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D2/007/1	MEDWAY TUNNEL EAST APPROACH WORKS	TQ760269
76		
D2/007/2	MEDWAY TUNNEL PROJECT	TQ7604 6
975		
D2/009/1	ST.MARY'S ISLAND	TQ762070
45		
D2/010/1	AKZO CHEMICALS NO.2	TQ779469
70		
D2/011	AKZO CHEMIE NO1	TQ778069
40		
D2/085	MEDWAY TUNNEL.EAST APPROACH WORKS	TQ760269
76		
D3/075	BLAW KNOX CONSTRUCTION	TQ735067
60		
D4/049	AYLESFORD SAND PIT	TQ728058
80		
D5/002	SCA EUROLINER - ISLAND SITE (FORMERLY REEDS)	TQ714859
90		
D5/010/1	BURHAM WATER TREAT	TQ715660
95		
D5/010/2	BURHAM WATER T'MENT	TQ715661
13		
D5/010/3	BURHAM WATER T'MENT	TQ717560
93		
D5/024	FARLEIGH COACHES	TQ712562
68		
E1/005	WHATMAN PAPER LIMITED	TQ753656
90		
E1/021/1	HOCKERS LANE P.S.	TQ789057
10		

HYDROREF	SITE	NGR
---	---	---
E1/021/4	HOCKERS LANE P.S.	TQ788057
10		

E1/094	M20 MOTORWAY SERVICE STATION		TQ825 55
E3/006	HAYLE MILLS		TQ756 53
F1/007/1	TREBOR SHARPS LTD		TQ757053
F1/007/2	TREBOR SHARPS LTD		TQ757055
F1/007/3	TREBOR SHARPS LTD		TQ757055
F1/007/4	TREBOR SHARPS LTD		TQ757055
F1/007/5	TREBOR SHARPS LTD		TQ757055
F1/007/6	TREBOR BASSETT		TQ757055
F2/002	J. CLUBB LIMITED		TQ679048
F2/004/1	ZENECA AGROCHEMICALS	DISCHARGE TO SOAKAWAY LAGOON	TQ687050
F2/004/2	ZENECA AGROCHEMICALS	DISCHARGE FROM SOAKAWAY LAGOON	TQ687050
F2/064	ARNOLD (BRANBRIDGES)		TQ673148
F3/003/1	BRYMOR LTD (B)		TQ658048
F3/003/2	BRYMOR LTD D		TQ658048
F3/003/3	BRYMOR LTD NO.1		TQ659048
F3/003/4	BRYMOR LTD NO.3.		TQ658948
F3/003/5	BRYMOR LTD NO.4		TQ659148
F4/065	BROADFIELD FARM PACKHOUSE		TQ617053
G1/014	CHARLTON FARM		TQ778548
G1/023/2	BOUGHTON BOTTOM FARM		TQ771148
G1/134	STAPLEHURST TRANSITS		TQ774046
G2/012	NUBAL ELECTRONICS		TQ812247

G2/160	BABYLON TILES	TQ802046
G4/006	QUISTWENS CHEMISTS	TQ779236
G4/180/1	CHEQUER TREE FARM	TQ347079
H3/007/2	PLUCKLEY TIP	TQ914543
H3/108	REDLAND BRICKS LTD.	TQ918543
H4/027	NINN FARM	TQ978842

HYDROREF	SITE	NGR
H5/011	CHILMINGTON GREEN	TQ982740
J1/030	TANGIERS PUMPING STATION	TQ586736
J3/033	LUCKS FARM	TQ654633
K2/011	REDLANDS GRAVEL	TQ651847
K2/018	STONECASTLE FARM	TQ656046
K2/019	STONECASTLE FARM	TQ651847
K2/023	PEMBURY WATERWORKS	TQ626642
K2/062	MATFIELD BOREHOLE	TQ649541
K2/070	STONECASTLE FARM WHETSTED	TQ644047
K3/035	LAND AT NORTH FARM LANE	TQ602542
L2/011/1	TONBRIDGE PUMPING STATION	TQ588046
L2/011/2	TONBRIDGE PUMPING STATION	TQ588246
L2/011/5	TONBRIDGE TREATMENT WORKS	TQ588546

L2/020	GREAT HOLLANDEN FARM	TQ56 51
M2/054	HAYESDEN WATER PUMPING STATION	TQ560344
M2/110	SANDY SHAW - NEW BOREHOLE	TQ519341
N1/014/1	GODSTONE WATERWORKS - OUTLET E	TQ353352
N1/035	GODSTONE RESERVOIRS	TQ345752
N2/009	INTERNATIONAL RECTIFIERS	TQ405860
N2/079	SAFEWAYS FOOD STORE	TQ395052
N4/009/3	TESTERS OF EDENBRIDGE	TQ451844
N4/013/2	DELAWARE FARM - REVOKED	TQ459545
N4/022	WEST HAXTED FARM	TQ425045
N5/068	HOW GREEN FARM	TQ474046
N6/011	LODGEWOOD COTTAGES - NO. 8	TQ478446
N6/012	SMARDEN FARM	TQ501346
N6/014	GRAVEL PITS	TQ488046
N7/008/3	BOUGH BEECH TREATMENT WORKS	TQ491447
N7/018	HATCHLANDS FARM	TQ512551

HYDROREF	SITE	NGR
N7/037	FACTORY PREMISES	TQ516246
O1/030/3	SAINTS HILL WATER TREATMENT WORKS	TQ523941
O1/030/4	SAINTS HILL WATER TREATMENT WORKS	TQ523341
O1/031	SAINTS HILL BOREHOLE SH2	TQ521040

O1/114	LAND NEAR SANDFIELD ROAD	TQ518641
P1/043/1	GROOMBRIDGE WATER PUMPING STATION	TQ528036
P1/043/2	GROOMBRIDGE TREATMENT WORKS	TQ529036
P1/050	NEW BOREHOLE AT ERIDGE	TQ540634
P3/037	ARC PREMIX	TQ520929
P3/049	LODGELANDS	TQ538028
P3/066	Q8 SERVICE STATION	TQ543132
Q2/011	V.G.SCIENTIFIC	TQ372039
Q2/015/1	KOLMAR COSMETICS	TQ375039
Q2/015/2	KOLMAR COSMETICS	TQ375039
Q2/016	V.G. SEMICON LIMITED	TQ372039
Q2/017	TANTOFEX (ENG) LTD	TQ374039
Q21014/2	GODSTONE WATER WORKS - OUTLET J	TQ353352
Q3/010	HACKENDEN WATER	TQ397639
Q3/011	HACKENDEN WATER	TQ397639
R1/015	TURNERS HILL GARAGE	TQ338536
R2/039	WEIRWOOD RESERVOIR	TQ408835
R3/007/1	FOREST ROW WATERWORKS	TQ327035
R5/034	WYCH CROSS RESERVOIR	TQ420031
R5/110	BUCKHURST FARM	TQ502035
S1/002/1	MOORHOUSE TILE WORKS	TQ425053
S1/002/2	MOORHOUSE TILEWORKS	TQ425 53

S1/002/3	MOORHOUSE TILE WORKS	TQ424653
S1/002/5	MOORHOUSE WORKS	TQ431053
S1/012	CHARMANS FARM	TQ456 55

HYDROREF	SITE	NGR
S1/045	WESTWOOD WATERWORKS	TQ424954
S2/070	ARC SOUTHERN - PREMIX PLANT	TQ504358
S3/017	WEST END GARAGE	TQ553058
S3/029	TILCON GRAVEL	TQ537 57
S3/082/1	KEMSING WTW	TQ569557
T1/025	FOXCROFT	TQ588064
T2/002	HORTON KIRBY PAPER	TQ564069
T2/008	OLD MILL FARM	TQ557 71
T2/135/1	HARTLEY PUMPING STATION	TQ616566
T2/154	HARTLEY WATER PUMPING STATION	TQ615766
T3/009	100 HYTHE STREET	TQ541074
T3/010/1	WELCOME FOUNDATION	TQ544 74
T3/010/2	WELCOME FOUNDATION LTD	TQ541075
T3/010/3	WELCOME FOUNDATION	TQ541075
T3/010/4	WELCOME FOUNDATION	TQ544874
T3/010/5	WELCOME FOUNDATION	TQ544974

03/010/6	WELCOME FOUNDATION	TQ545274
03/012	WIGGINS TEAPE LTD	TQ539075
03/014	C.E.G.B.	TQ473073
03/010	LOWER HOOK FARM	TQ429063
03/002	PATEREX LTD	TQ471067
03/002/1	RICHARD KLINGER LTD	TQ475370
	RICHARD KLINGER LTD	TQ476070
03/004	I.T.T.SITE	TQ476071
03/005/1	COCACOLA SCHWEPPES	TQ475070
	COCACOLA SCHWEPPES	TQ475 70
03/005/2	COCACOLA SCHWEPPES	TQ475070
	COCACOLA SCHWEPPES	TQ475 70
03/005/3	COCACOLA SCHWEPPES	TQ471070
03/006/1	DAVID EVANS	TQ511074
03/011	C.E.G.B.	TQ441 73

HYDROREF	SITE	NGR
03/011	C.E.G.B.	TQ441073
03/012	C.E.G.B.	TQ472 73
03/013	C.E.G.B.	TQ497272
03/014	C.E.G.B.SANDY LANE	TQ473073
	C.E.G.B.	TQ473073

03/050	CRAYFORD PUMPING STATION	TQ522274
	CRAYFORD PUMPING STATION	TQ522274

Count: 183

Kent Rivers Hydrological Survey

Section 11 — Schedule

No.	Name	Place	Grid Reference	Amount Taken	Amount Returned	Remarks
1	Uckfield R.D.C.	West Hoathly	TQ 376336		0.018	R. Medway trib.
-	Soakaways				0.006	T
2	North West Sussex Water Board	Weir Wood Reservoir	TQ 40-35-	3.000		Surface catchment
3	Mid-Sussex Water Company	Forest Row	TQ 424355	0.600		R. Medway (s)
4	Mid-Sussex Water Company	Forest Row	TQ 426353	0.280		B
5	Convent of Notre Dame	Wych Cross	TQ 430319		0.003	R. Medway trib.
6	Uckfield R.D.C.	Forest Row	TQ 455356		0.060	R. Medway
7	Uckfield R.D.C.	Hartfield	TQ 483364		0.023	R. Medway
8	East Grinstead U.D.C.	Ashurst Wood	TQ 432382		0.073	R. Medway trib.
9	War Department	Warren Camp	TQ 496300		0.009	R. Medway trib.
10	Uckfield R.D.C.	Crowborough	TQ 490332		0.040	R. Medway trib.
11	Buckhurst Estate	Hartfield	TQ 490350	0.001		Sp
12	Buckhurst Estate	Hartfield	TQ 48-35-		0.002	Stream
13	Mid-Sussex Water Company	Maynards Gate (a)	TQ 542299)			B
14	Mid-Sussex Water Company	Maynards Gate (b)	TQ 544304)	0.160		Sp
15	Mid-Sussex Water Company	Maynards Gate (c)	TQ 545305)			B
16	Mid-Sussex Water Company	Maynards Gate (d)	TQ 548313)			Sp
17	Uckfield R.D.C.	Crowborough	TQ 553323		0.300	R. Medway trib.
18	Mid-Sussex Water Company	Groombridge	TQ 528364	0.760		B
19	British Transport Commission	Tunbridge Wells	TQ 578384	0.036		B
20	British Transport Commission	Tunbridge Wells	TQ 57-38-		0.006	R
21	British Transport Commission	Tunbridge Wells	TQ 578384	0.048		B
22	Royal Tunbridge Wells B.C.	Southern S.W.	TQ 546379		1.200	R. Medway trib.
23	Tonbridge R.D.C.	Groombridge	TQ 527376		0.004	R. Medway trib.
24	Uckfield R.D.C.	Groombridge	TQ 527374		0.020	R. Medway trib.
25	Tonbridge R.D.C.	Ashurst	TQ 506391		0.001	R. Medway
26	Godstone R.D.C.	Dormans Land	TQ 428406		0.001	R. Medway trib.
27	Sevenoaks R.D.C.	Cowden	TQ 467402		0.012	R. Medway trib.
28	Uckfield R.D.C.	Blackham	TQ 500400		0.002	R. Medway trib.
-	Soakaways				0.060	T
29	Sevenoaks R.D.C.	Fordcombe	TQ 521406		0.013	R. Medway trib.
30	Tunbridge Wells M.C.	Tubbs Hole	TQ 513415	-		Sp & B Stand by
31	Tunbridge Wells M.C.	Saints Hill	TQ 524414	0.660		B
32	Kent C.C.	Speldhurst	TQ 563409		0.009	R. Medway trib
33	Tunbridge Wells Hospital Management Committee	Speldhurst	TQ 566414		0.004	R. Medway trib.
34	Tonbridge R.D.C.	Speldhurst	TQ 566418		0.074	R. Medway trib.
35	Tunbridge Wells M.C.	Modest Corner	TQ 569421	0.150		Sp
36	Tonbridge R.D.C.	Bidborough	TQ 563423		0.020	R. Medway trib.
37	Southborough U.D.C.	Southborough	TQ 561423		0.200	R. Medway trib.
38	Middlesex C.C.	Penshurst	TQ 432427		0.011	R. Medway
39	East Surrey Water Company	Duckpit Wood	TQ 371526	0.120		B
40	Titsey Estate Company	Oxted	TQ 406552	0.008		B
41	Godstone R.D.C.	Oxted and Limpsfield	TQ 396502		0.450	R. Eden
42	Godstone R.D.C.	Bletchingly	TQ 344511		0.075	R. Eden trib.
43	East Surrey Water Company	North Park	TQ 343521	0.425		B
44	East Surrey Water Company	Flower Lane	TQ 359526	0.460		B
45	Godstone R.D.C.	Godstone	TQ 365506		0.090	R. Eden trib.
46	Godstone R.D.C.	Tandridge	TQ 371501		0.006	R. Eden trib.
47	Godstone R.D.C.	Crowhurst	TQ 392478		0.001	R. Eden trib.
48	Godstone R.D.C.	South Godstone	TQ 363478		0.053	Eden Brook trib.
49	War Department	Hobbs Barracks	TQ 365412		0.024	Eden Brook trib.
50	Mid-Sussex Water Company	Hackenden	TQ 396394	0.080		B
51	East Grinstead U.D.C.	Eden Vale	TQ 392403		0.690	Eden Brook trib.
52	Godstone R.D.C.	Dormans Park	TQ 391413		0.007	Eden Brook trib.
-	Soakaways				0.190	T
53	Home Office	Court Lees School, Horne	TQ 353444		0.010	R. Medway trib.
54	Home Office	Court Lees School, Horne	TQ 367446		0.007	Eden Brook trib.
55	Godstone R.D.C.	Lingfield	TQ 389450		0.200	Eden Brook trib.
56	East Surrey Water Company	Paines Hill	TQ 414516	0.250		Sp
57	Whitmores (Edenbridge) Ltd.	Edenbridge	TQ 45-46-	0.033		R. Eden
58	Sevenoaks R.D.C.	Edenbridge	TQ 452460		0.275	R. Eden

Section 11

Schedule

No.	Name	Place	Grid Reference	Amount Taken	Amount Returned	Remarks
59	Sevenoaks R.D.C.	Crockhan Hill	TQ 442506		0.002	R. Eden trib.
60	Four Elms Packers Ltd.	Crockhan Hill	TQ 44-50-		0.019	Stream
61	Sevenoaks R.D.C.	Chiddingstone Castle	TQ 501456		0.006	R. Eden trib.
62	Wisdens Ltd.	Chiddingstone Causeway	TQ 516467		0.003	R. Eden trib.
63	Sevenoaks R.D.C.	Chiddingstone Causeway	TQ 516466		0.001	R. Eden trib.
64	Sevenoaks R.D.C.	Chiddingstone Heath	TQ 501426		0.003	R. Eden trib.
65	Sevenoaks R.D.C.	Penshurst	TQ 530438		0.014	R. Medway
66	Sevenoaks R.D.C.	Leigh	TQ 545461		0.028	R. Medway trib.
67	Tunbridge Wells M.C.	Hayaden	TQ 561448	0.120		S
68	Smith, Kline & French Laboratories Ltd.	Tonbridge	TQ 570467	0.016		S
69	Smith, Kline & French Laboratories Ltd.	Tonbridge	TQ 57-46-		0.014	Stream
70	Sevenoaks R.D.C.	Sevenoaks Weald	TQ 535507		0.027	R. Medway trib.
71	Tonbridge R.D.C.	Philpots	TQ 544467		0.003	R. Medway trib.
72	Sevenoaks R.D.C.	Charcott	TQ 524473		0.004	R. Medway trib.
73	Sevenoaks R.D.C.	Little Hawden	TQ 571469		0.004	R. Medway trib.
74	Tonbridge R.D.C.	Hildenborough	TQ 578489		0.054	R. Medway trib.
-	Soakaways				0.150	?
75	British Transport Commission	Tonbridge	TQ 590460	0.500		Tunnel Drainage
76	British Transport Commission	Tonbridge	TQ 59-46-		0.425	R. Medway
77	Sevenoaks & Tonbridge Water Company	Tonbridge	TQ 589467	0.105		S
78	The Distillers Company Ltd.	Tonbridge	TQ 597461		0.014	Botany Stream
79	Whitefriars Press Ltd.	Tonbridge	TQ 593464		0.001	R. Medway
80	The Distillers Company Ltd.	Tonbridge	TQ 597461		0.002	R. Medway
81	British Flint & Cerium Manufacturers Ltd.	Tonbridge	TQ 59-46-	0.008		Botany Stream
82	British Flint & Cerium Manufacturers Ltd.	Tonbridge	TQ 59-46-		0.008	Botany Stream
83	Tonbridge U.D.C.	Tonbridge	TQ 600463		0.900	Botany Stream
84	Central Electricity Generating Board	Tunbridge Wells	TQ 589403	0.020		Sp
85	South Eastern Gas Board	Tunbridge Wells	TQ 593413	0.110		Stream
86	South Eastern Gas Board	Tunbridge Wells	TQ 593413		0.110	R. Medway trib.
87	South Eastern Gas Board	Tunbridge Wells	TQ 593413	0.003		R. Medway
88	South Eastern Gas Board	Tunbridge Wells	TQ 593413		0.003	R. Medway
89	Royal Tunbridge Wells B.C.	Northern S.W.	TQ 597418		1.050	R. Medway trib.
90	National Spastics Society	Dene Park	TQ 596503		0.003	R. Medway trib.
91	Tonbridge R.D.C.	Crockhurst Street	TQ 620450		0.002	R. Medway trib.
92	Optilon Ltd.	Ightham	TQ 592581		0.003	R. Bourne trib.
93	Malling R.D.C.	Crouch	TQ 613559		0.100	R. Bourne
94	Malling R.D.C.	Plaxtol	TQ 612540		0.020	R. Bourne
95	Malling R.D.C.	Shipbourne	TQ 597525		0.001	R. Bourne
96	Tonbridge R.D.C.	Hadlow	TQ 632492		0.080	R. Bourne
97	Gerrish & Gwyn Ltd.	East Peckham	TQ 654481		0.005	R. Bourne
98	Tunbridge Wells Hospital Management Committee	Tunbridge Wells	TQ 618415		0.055	Stream (e)
99	Kent College	Pembury	TQ 627427		0.006	R. Medway trib.
100	Tunbridge Wells M.C.	Pembury	TQ 628427	1.450		Sp & S
101	Tonbridge R.D.C.	Five Oak Green	TQ 624453		0.024	R. Medway trib.
102	Arnolds Ltd.	Tonbridge	TQ 573506	0.025		Stream
103	Arnolds Ltd.	Tonbridge	TQ 57-46-		0.025	Stream
104	Malling R.D.C.	East Peckham	TQ 673486		0.003	R. Medway trib.
105	Tonbridge R.D.C.	Pembury	TQ 644427		0.120	R. Medway trib.
106	Malling R.D.C.	East Peckham	TQ 664487		0.012	R. Medway trib.
107	Uckfield R.D.C.	Frant	TQ 592374		0.001	R. Teise
108	Uckfield R.D.C.	Frant	TQ 594378		0.007	R. Teise
109	Tunbridge Wells M.C.	Tangier	TQ 585367	0.060		Sp
110	Wellcome Veterinary Research Station	Frant	TQ 601363	0.014		S
-	Soakaway				0.011	T
111	Uckfield R.D.C.	Bells Yew Green	TQ 608364		0.002	R. Teise trib.
112	Uckfield R.D.C.	Frant	TQ 601336		0.025	R. Teise
113	Uckfield R.D.C.	Wadhurst	TQ 615317		0.003	R. Teise trib.

No.	Name	Place	Grid Reference	Amount Taken	Amount Returned	Remarks
114	Uckfield R.D.C.	Wadhurst	TQ 627325		0.002	R. Teise trib.
115	Uckfield R.D.C.	Wadhurst	TQ 631341		0.060	R. Teise trib.
116	Tonbridge R.D.C.	Lamberhurst	TQ 679362		0.021	R. Teise
117	Battle R.D.C.	Ticehurst	TQ 693312		0.048	R. Teise trib.
118	Uckfield R.D.C.	Cousley Wood	TQ 654334		0.006	R. Teise trib.
-	Soakaways				0.050	T
119	Cranbrook R.D.C.	Kilndown	TQ 707352		0.005	R. Teise trib.
120	Mid-Kent Water Company	Goudhurst	TQ 712368	0.750		W
121	Cranbrook R.D.C.	Goudhurst	TQ 723373		0.017	R. Teise trib.
122	Cranbrook R.D.C.	Goudhurst	TQ 722378		0.009	R. Teise trib.
123	Cranbrook R.D.C.	Goudhurst	TQ 733382		0.011	R. Teise trib.
124	Tonbridge R.D.C.	Horsmanden	TQ 706402		0.030	R. Teise
125	Tonbridge R.D.C.	Petteridge	TQ 666414		0.007	R. Teise trib.
126	Tonbridge R.D.C.	Matfield	TQ 661415		0.010	R. Teise trib.
127	Tonbridge R.D.C.	Brenchley	TQ 681415		0.015	R. Teise trib.
128	Tonbridge R.D.C.	Horsmonden	TQ 696412		0.005	R. Teise trib.
129	Tonbridge R.D.C.	Brenchley	TQ 696425		0.003	R. Teise trib.
130	Tonbridge R.D.C.	Paddock Wood	TQ 679453		0.074	R. Teise trib.
-	Soakaways				0.215	T
131	West Ashford R.D.C.	Pluckley	TQ 924453		0.003	R. Beult trib.
132	West Ashford R.D.C.	Pluckley Thorne	TQ 923448		0.003	R. Beult trib.
133	West Ashford R.D.C.	Bethersden	TQ 923403		0.023	R. Beult
134	Tenterden R.D.C.	High Halden	TQ 889377		0.029	R. Beult trib.
135	West Ashford R.D.C.	Smarden	TQ 878423		0.014	R. Beult
136	West Ashford R.D.C.	Smarden Bell	TQ 866425		0.002	R. Beult
137	West Ashford R.D.C.	Egerton	TQ 907473		0.006	R. Beult trib.
-	Soakaways				0.100	T
138	Hollingbourne R.D.C.	Headcorn	TQ 829442		0.076	R. Beult
139	Cranbrook Laundry Co. Ltd.	Cranbrook	TQ 781368	0.001		B
140	Cranbrook R.D.C.	Cranbrook	TQ 782362		0.091	R. Beult trib.
141	Benenden School	Benenden	TQ 800339		0.015	Cranbrook Ponds
142	Tenterden R.D.C.	Biddenden	TQ 847388		0.024	R. Beult trib.
143	James Day & Sons Ltd.	Cranbrook	TQ 778400	0.003		Stream
144	James Day & Sons Ltd.	Cranbrook	TQ 77-40-		0.001	Stream (e)
145	Cranbrook R.D.C.	Frittenden	TQ 813418		0.006	R. Beult trib.
-	Soakaways				0.057	T
146	Shaw, Otto L.	Redhill School	TQ 836493		0.002	R. Beult trib.
147	Maidstone R.D.C.	Staplehurst	TQ 788445		0.054	R. Beult trib.
148	Home Office	East Sutton Park	TQ 830493		0.002	R. Beult trib.
149	Hollingbourne R.D.C.	Sutton Valence	TQ 809482		0.040	R. Beult trib.
150	Maidstone R.D.C.	Linton	TQ 753491		0.009	R. Beult trib.
151	Maidstone R.D.C.	Marden	TQ 737447		0.043	R. Beult trib.
152	Maidstone R.D.C.	Hunton	TQ 718496		0.003	R. Beult trib.
153	Maidstone R.D.C.	Yalding	TQ 692504		0.028	R. Medway
154	Plant Protection Ltd.	Yalding	TQ 687502	0.041		Medway Canal
155	Plant Protection Ltd.	Yalding	TQ 68-60-		0.041	R. Medway
156	Malling R.D.C.	Hereworth	TQ 661539		0.001	R. Medway trib.
157	Maidstone R.D.C.	Wettlestead	TQ 686533		0.004	R. Medway
158	Malling R.D.C.	Wateringbury	TQ 690533		0.005	R. Medway trib.
159	Whitbread & Co. Ltd.	Wateringbury	TQ 691531		0.079	R. Medway
160	Maidstone R.D.C.	Barming	TQ 724540		0.046	R. Medway
161	Maidstone Waterworks Company	Farleigh	TQ 734536	0.300		Sp (e)
162	Maidstone R.D.C.	Coxheath	TQ 749521		0.153	R. Medway trib.
163	A. E. Reed & Co. Ltd.	Tovil, Maidstone	TQ 754545	0.391		Stream
164	A. E. Reed & Co. Ltd.	Tovil, Maidstone	TQ 75-54-		0.027	Stream
165	H. Allnutt & Son Ltd.	Maidstone	TQ 752547	0.027		R. Medway trib.
166	H. Allnutt & Son Ltd.	Maidstone	TQ 752547		0.008	R. Medway trib.
-	Soakaway				0.011	T
167	A. E. Reed & Co. Ltd.	Maidstone	TQ 750548	0.245		R. Medway trib.
168	A. E. Reed & Co. Ltd.	Maidstone	TQ 75-54-		0.197	R. Medway
169	British Transport Commission	Maidstone	TQ 756554	0.044		Sp
170	British Transport Commission	Maidstone	TQ 75-54-		0.012	R. Medway
171	Foster Clark Ltd.	Maidstone	TQ 75-55-		0.006	R. Medway
172	Wm. Hobbs & Sons Ltd.	Maidstone	TQ 76-55-	0.001		B
173	Central Electricity Generating Board	Maidstone	TQ 757555	2.329		R. Medway

No.	Name	Place	Grid Reference	Amount Taken	Amount Returned	Remarks
174	Central Electricity Generating Board	Maidstone	TQ 75-56-		2.300	R. Medway
175	Hollingbourne R.D.C.	Harrietsham	TQ 868521		0.021	R. Len
176	Leeds Castle Estate	Leeds	TQ 834532		0.001	R. Len
177	Hollingbourne R.D.C.	Leeds	TQ 823537		0.025	R. Len
-	Soakaways				0.200	T
178	Mid-Kent Water Company	Thurnham	TQ 817559	0.670		B
179	Maidstone R.D.C.	Bearsted	TQ 795545		0.150	R. Len
-	Soakaways				0.130	T
180	Maidstone Waterworks Company	Hockers Lane	TQ 788572	0.270		B
181	Hollingworth (Turkey Mill) Ltd.	Maidstone	TQ 774553	0.070		Sp
182	Hollingworth (Turkey Mill) Ltd.	Maidstone	TQ 77-55-		0.010	R. Len
183	Edward Sharp & Sons Ltd.	Maidstone	TQ 756559		0.300	R. Medway
184	Len Ltd.	Maidstone	TQ 763557	0.011		R. Len
185	South Eastern Gas Board	Maidstone	TQ 757558	0.042		R. Medway
186	South Eastern Gas Board	Maidstone	TQ 75-55-		0.002	R. Medway
187	Fremlins Ltd.	Maidstone	TQ 758558	0.065		Sp
188	Fremlins Ltd.	Maidstone	TQ 758558	0.019		B
189	Fremlins Ltd.	Maidstone	TQ 758558	0.036		R. Medway
190	Fremlins Ltd.	Maidstone	TQ 758558		0.030	R. Medway
191	Courage & Barclay Ltd.	Maidstone	TQ 756559	0.049		R. Medway
192	Courage & Barclay Ltd.	Maidstone	TQ 756559	0.002		Sp
193	Courage & Barclay Ltd.	Maidstone	TQ 75-56-		0.049	R. Medway
194	Tilling & Stevens Ltd.	Maidstone	TQ 75-55-		0.001	R. Medway
195	W. & R. Balston Ltd.	Maidstone	TQ 75-56-	0.153		W
196	W. & R. Balston Ltd.	Maidstone	TQ 75-56-		0.094	R. Medway
-	Soakaway				0.001	T
197	Maidstone Waterworks Company	Boxley	TQ 778593	0.520		B
198	Maidstone Waterworks Company	Boarley	TQ 763593	0.300		Sp (e)
199	Maidstone Waterworks Company	Cossington	TQ 745603	0.400		Sp (e)
200	Maidstone Waterworks Company	Cossington	TQ 748600	0.120		B
201	Maidstone Waterworks Company	Forstal	TQ 741588	0.620		B
202	Shedleys Ltd.	Maidstone	TQ 729570	0.005		B
203	Blue Cap Foods (Kent) Ltd.	Ditton	TQ 709580		0.072	R. Medway trib.
204	South Eastern Tar Distillers Ltd.	Millhall	TQ 717590		0.144	R. Medway
205	Malling R.D.C.	Ditton	TQ 717591		0.400	R. Medway
206	Maidstone B.C.	Aylesford	TQ 717592		3.000	R. Medway
207	A. E. Reed & Co. Ltd.	Larkfield	TQ 715597	1.797		Sp
208	A. E. Reed & Co. Ltd.	Larkfield	TQ 715597	3.564		B
209	A. E. Reed & Co. Ltd.	Larkfield	TQ 715597	13.334		R. Medway including cooling water
210	A. E. Reed & Co. Ltd.	Larkfield	TQ 71-59-		18.123	R. Medway S
211	Malling R.D.C.	Eccles & Burham	TQ 722601		0.073	R. Medway S
212	Mid-Kent Water Company	Trosley	TQ 641596	1.660		B
213	Malling R.D.C.	Malling	TQ 675588		0.110	R. Medway trib.
214	South-Eastern Metropolitan Regional Hospital Management Board	Leybourne Grange Housing Estate	TQ 690593		0.002	R. Medway trib.
215	Mid-Kent Water Company	Ryarsh	TQ 667607	0.002		B
216	Malling R.D.C.	Ryarsh	TQ 668602		0.002	R. Medway trib.
217	South-Eastern Metropolitan Regional Hospital Management Board	Leybourne Grange	TQ 679597		0.125	R. Medway trib.
218	South-Eastern Metropolitan Regional Hospital Management Board	West Malling	TQ 680598		0.118	R. Medway trib.

No.	Name	Place	Grid Reference	Amount Taken	Amount Returned	Remarks
219	Malling R.D.C.	Birling Park	TQ 683606		0.001	R. Medway trib.
220	Unspecified			1.918		S
221	Malling R.D.C.	Snodland	TQ 706615		0.102	R. Medway
222	Unspecified abstraction			5.500		S. (e)
-	Unspecified Returns				5.000	R (e) S
223	South Eastern Gas Board	Snodland	TQ 70-62-		0.001	R. Medway S
224	Strood R.D.C.	Halling	TQ 706640		0.060	R. Medway S
225	Mid-Kent Water Company	Halling	TQ 711647	0.710		S
226	Malling R.D.C.	Wouldham	TQ 711647		0.002	R. Medway S
-	Soakaways				0.200	T
227	Rugby Portland Cement Co. Ltd.	Halling	TQ 703651	0.192		S
228	Rugby Portland Cement Co. Ltd.	Halling	TQ 703651	0.425		Sp
229	Rugby Portland Cement Co. Ltd.	Halling	TQ 70-65-		0.607	R. Medway
230	Cuxton Water Committee	Cuxton	TQ 688674	1.720		W
231	Cuxton Water Committee	Cuxton	TQ 691668	0.620		S
232	Strood R.D.C.	Cuxton	TQ 717671		0.030	R. Medway S
233	Medway Water Board	Nashenden	TQ 734655	1.000		S
234	Unspecified			0.190		S
235	Medway Water Board	Strood	TQ 729693	0.665		S
236	Winget Ltd.	Strood	TQ 73-68-		0.015	R. Medway S
237	Bourne & Hillers Creameries Ltd.	Rochester	TQ 73-69-	0.030		S
238	Unspecified			0.087		S
239	Unspecified				0.160	R. Medway (e) S
240	Woodfield Rochester Ltd.	Rochester	TQ 745696		0.003	R. Medway S
241	Medway Water Board	Snodhurst	TQ 749650	0.560		S
242	British Transport Commission	Rochester	TQ 755670		0.010	R. Medway S
243	British Transport Commission	Chatham	TQ 755676	0.005		W
244	Medway Water Board	Capstone	TQ 779655	0.860		S
245	Medway Water Board	Luton	TQ 777664	1.450		S
246	Strood R.D.C.	Whitewall Creek	TQ 751700		0.270	R. Medway S
247	Navy Works Department	Chatham	TQ 76-70-	0.005		S
248	Navy Works Department	Chatham	TQ 76-70-	1.102		S
249	Navy Works Department	Chatham	TQ 76-70-	0.056		S
250	Gillingham Electric Laundry Ltd.	Gillingham	TQ 775692	0.030		S
-	Soakaway				0.009	T S
251	Novadel Ltd.	Gillingham	TQ 778694	0.200		W
252	South Eastern Gas Board	Gillingham	TQ 782692	0.055		S
253	South Eastern Gas Board	Gillingham	TQ 782692	0.049		S
254	South Eastern Gas Board	Gillingham	TQ 78-69-		0.092	R. Medway S
255	Strood R.D.C.	Hoo	TQ 792721		0.108	R. Medway S
256	Berry Wiggins Ltd.	Kingsnorth-on-Hoo	TQ 806726	0.104		S
257	Berry Wiggins Ltd.	Kingsnorth-on-Hoo	TQ 80-72-		0.123	R. Medway S
258	Medway Water Board	Rainham Mark	TQ 803662	0.275		S
259	Kent Co-operative Society Ltd.	Chatham	TQ 807653	0.036		S
260	Rochester, Chatham & Gillingham Joint Sewerage Board	Motney Hill	TQ 820685		6.000	R. Medway S
261	Medway Water Board	Hartlip	TQ 821627	2.965		S
262	Medway Water Board	Gore	TQ 83-65-	0.600		S
263	Eastwoods Ltd.	Lower Halstow	TQ 846656	0.012		S
264	Swale R.D.C.	Lower Halstow	TQ 856676		0.107	R. Medway S
-	Soakaways				0.045	T S
265	Eastwoods Ltd.	Lower Halstow	TQ 859672	0.011		Stream
266	Eastwoods Ltd.	Lower Halstow	TQ 856676		0.011	Stream S
267	Strood R.D.C.	Lower Stoke	TQ 838754		0.011	R. Medway S
268	South Eastern Gas Board	Isle of Grain	TQ 864755		0.230	Colemouth Creek S
269	B.P. Refinery (Kent) Ltd.	Isle of Grain	TQ 877740	C.847		S
270	B.P. Refinery (Kent) Ltd.	Isle of Grain	TQ 87-74-		1.286	Medway estuary S

Section 11

Schedule

No.	Name	Place	Grid Reference	Amount Taken	Amount Returned	Remarks
271	Central Electricity Generating Board	Northfleet	TQ 632744		0.560	R. Thames (e) S
272	Associated Electrical Industries Ltd.	Northfleet	TQ 63-74-		0.175	R. Thames S
273	Medway Water Board	Luddesdon	TQ 663661	1.363		B
274	Medway Water Board	Meopham	TQ 636691	2.070		B
275	Medway Water Board	Hazella	TQ 637712	0.400		B
276	Kent Co-operative Society Ltd.	Gravesend	TQ 627712	0.063		B
-	Soakaway				0.002	T S
277	Truman Hanbury Buxton & Co. Ltd.	Gravesend	TQ 64-73-		0.011	R. Thames S
278	Medway Water Board	Gravesend	TQ 651732	0.460		B
279	Central Electricity Generating Board	Gravesend	TQ 657742	5.000		R. Thames (e) X
280	Central Electricity Generating Board	Gravesend	TQ 657742	0.002		B
281	Central Electricity Generating Board	Gravesend	TQ 657742	0.178		B
282	Central Electricity Generating Board	Gravesend	TQ 657742	0.194		B
283	Central Electricity Generating Board	Gravesend	TQ 65-74-		5.000	Canal (e) X
284	Gravesend B.C.	Denton	TQ 666739		1.650	R. Thames S
285	Medway Water Board	Crutches Lane	TQ 707704	0.110		B
286	Medway Water Board	Higham Strood Tunnel	TQ 726713	0.100		B
287	Medway Water Board	School Hill	TQ 714722	0.245		B
288	British Uralite Ltd.	Higham	TQ 704738	0.127		B
289	British Uralite Ltd.	Higham	TQ 706739		0.027	R S
290	British Uralite Ltd.	Higham	TQ 70-73-		0.025	R S
-	Soakaway				0.055	T S
291	Alpha Cement Ltd.	Rochester	TQ 723754	0.288		B
292	Unspecified			0.699		B
293	Strood R.D.C.	Cliffe	TQ 740755		0.009	R. Thames S
-	Soakaways				0.390	T S
294	Strood R.D.C.	High Halstow	TQ 779755		0.023	R. Thames S
295	Strood R.D.C.	All Hallows	TQ 848770		0.010	R. Thames S
296	Strood R.D.C.	Grain	TQ 892764		0.019	R. Thames S
			Total	65.821	52.241	

Key

(e) Estimated quantity
av Average for a year
G Gain from outside area
L Loss to outside area
S Loss to sea
W Taken from well
B Taken from borehole

Sp Taken from spring
P Taken from or discharged to gravel pit
R Taken from or discharged to river
T Discharged to septic tank or soakaway
Res Catchment reservoir
X Saline water used for cooling and omitted from the Balance Sheet.

Water Use Balance Sheet

Into Supply	m.g.d.	Disposals	m.g.d.
Water taken	65.821	Water returned	17.617
Transferred from Section I	8.513	Lost to Thames estuary	34.724
		Discharged to Thames Estuary	4.320(e)
		Lost to Area 41	4.763(e)
		Transferred to Section III	2.925
		Transferred to Section V	3.057
		Lost in use	7.028
	74.334		74.334

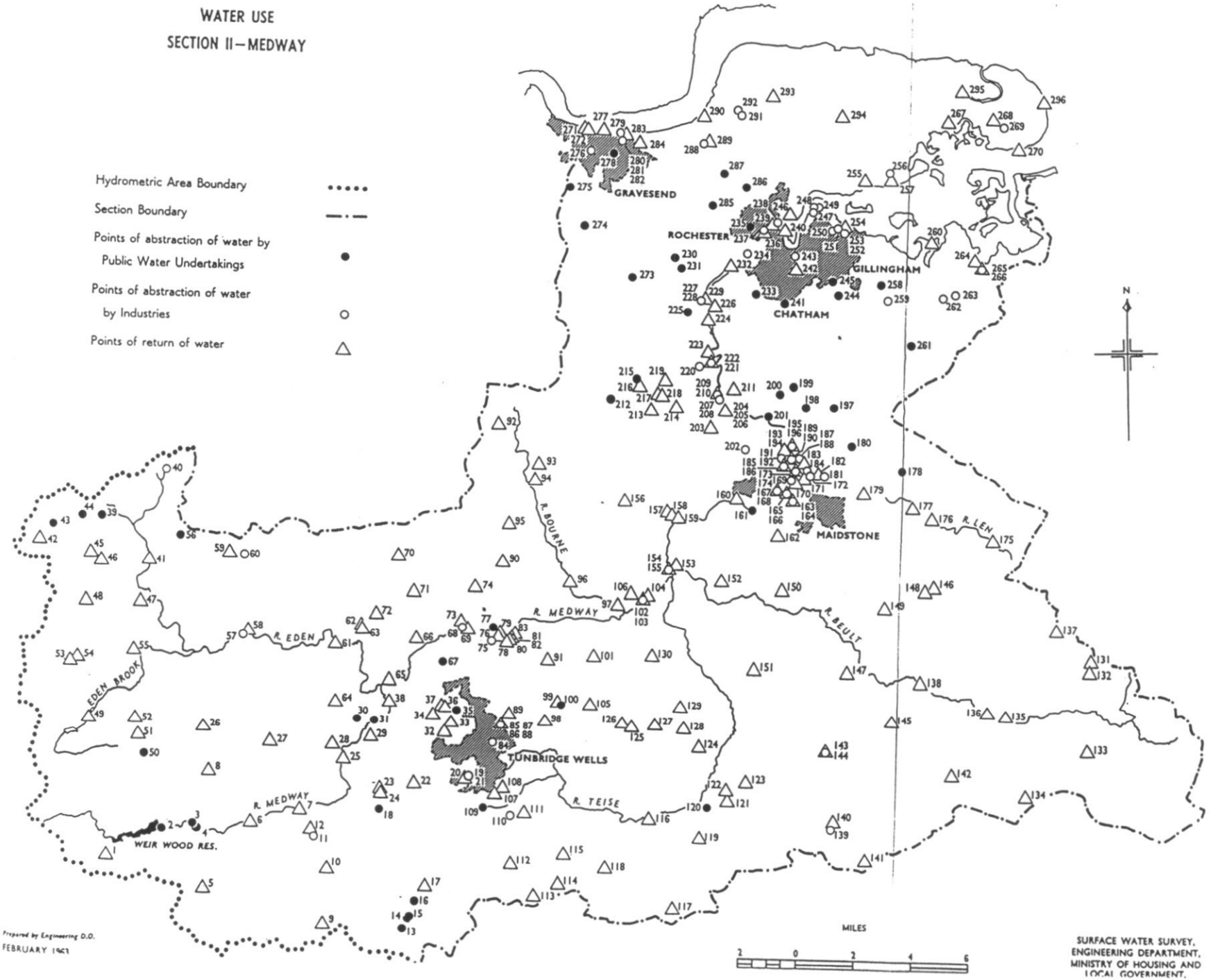
Abstractions m.g.d.

Surface Water		Ground Water		Total
Water Undertakings	Industry	Water Undertakings	Industry	
6.670	19.112	23.796	16.344	
25.882		40.139		65,821

Returns m.g.d.

To Surface		To Ground		Lost to Thames		Total
Domestic	Industry	Domestic	Industry	Domestic	Industry	
11.238	4.909	1.370	-	8.873	25.851	
16.147		1.370		34.724		52.241

WATER USE
SECTION II—MEDWAY



Prepared by Engineering D.O.
FEBRUARY 1963

SURFACE WATER SURVEY,
ENGINEERING DEPARTMENT,
MINISTRY OF HOUSING AND
LOCAL GOVERNMENT.

ANNEX: FISHES OF THE MEDWAY ESTUARY

by DR MIKE LADLE FBA/IFE, WAREHAM

The note that follows represents the current experience of its author.

His information on salmon was drawn to Dr Ladle's attention by a fisheries officer of EA Southern. It comes from analysis of fish trapped on the screens of Kingsnorth power station, well down the Medway estuary. The original source was:-

Wharfe, J.R., Wilson, S.R. and Dines, R.A. (1984) " Observations on the Fish Populations of an East Coast Estuary" in the Marine Pollution Bulletin series.

The 18th century historian of Kent, Edward Hasted, noted that the Medway had never been noted as a salmon river.

Fishes of the River Medway estuary.

Dr Mike Ladle

Fish species worthy of consideration:- All the following species could be expected to be occur in the Medway estuary, although the list is not comprehensive. They have been divided into three categories for the purposes of a clearer understanding of their roles in estuaries:-

Firstly there are essentially marine fishes, such as the bass and the thick-lipped mullet which may spend a substantial part of their lives as adults or juveniles feeding and growing in brackish water situations.

Secondly there are the catadromous species such as the flounder and the eel which *must* breed in the sea but are capable of migrating into totally fresh water, in order to feed, either in the warmer months of the year or throughout most of their adult lives.

Lastly there are anadromous fish like the salmon and the twaite shad which breed *in fresh waters* and spend most of their lives feeding at sea. Of necessity many of these species must negotiate the estuary on at least two occasions in their lives. Details of the roles of these fish in a typical estuarine situation such as that found in the River Medway are given below. A chart has been appended to indicate the times of year when each species is likely to be most susceptible to deterioration in water or sediment quality conditions.

Bass (*Dicentrarchus labrax*), A slow growing species of considerable commercial importance and, in recent, years under threat from over fishing. probably spending its two or three first years of life in the estuary. Although the larger bass exhibit an annual offshore migration in winter the young fish tend to remain inshore throughout the first three years of life. Estuarine situations are widely regarded as nurseries for these fish. The juveniles enter the estuary in late spring-early summer and spend much of their time in drainage runnels on the surface of the mud flats, often in regions where there is surface vegetation such as *Spartina* grass. Fish of 10-30cm in length will often migrate up to and just above the tidal limit. Although the adult fish are essentially predators of fish and crabs the young fish feed to a large extent on isopods and amphipods and are probably dependent on these small crustaceans for their early growth and survival. **Any factor which is likely to influence the water levels, salinity, turbidity, water quality or macrofaunal communities of the estuarine waters could affect bass recruitment success.**

Thick-lipped mullet (*Chelon labrosus*) This species inhabits inshore fully marine and lower estuarine situations mainly in the warmer months of the year (March to October). It grows slowly and often seems to exhibit erratic recruitment with strong year classes only at infrequent intervals. The thick-lipped mullet is a popular sport fish with specialist anglers and is also caught commercially. This species is generally regarded as a poor food fish and consequently the prices are low. Fish of all ages and sizes are likely to occur in estuaries but the smaller (younger) fish appear to be more marine. Essentially a particle feeder these mullet are capable of extracting fine particulate matter from the surface of the sediment, from the water column and from the surface of the water (neuston). The fish are strong swimmers and often enter very shallow waters in order to

feed. Since the fine organic particles which they ingest have a very large relative surface area it is likely that the fish are susceptible to pollutant contamination of sediments.

Black goby (*Gobius niger*) One of the larger species of goby this fish is common in estuaries and low salinity areas. **Like the other gobies the eggs are laid in sheltered places on the shore and guarded by the male fish, this renders the eggs susceptible to water quality problems in shallow water or contamination within the sediments.** The black goby feeds on small crustaceans and crabs as well as polychaete worms, molluscs and juvenile fishes.

Common goby (*Pomatoschistus microps*) and Sand goby (*Pomatoschistus minutus*) Both of these small species are abundant in estuarine situations and form an important element of food for predatory fish and birds. Both species migrate into deeper water in the winter months but in summer they live in very shallow water well up the shore. These gobies breed between March and August. As in the black goby the eggs are brooded by the male fish and **thus susceptible to estuarine pollution**. Both species feed on small crustaceans and the larvae of crustaceans.

Sandeel (*Ammodytes tobianus*) These small fish are a vital element of the food chain for many other species. Sandeels are now heavily exploited for preparation of fish meal. Although they are not exclusively estuarine they often spend the hours of darkness buried in the clean sand of river mouth bars. During daylight sandeels feed on planktonic crustaceans in open water near the surface of the sea, returning at dusk to their resting places. Although the eggs are demersal, being shed on sand in the summer months, the larvae and post larvae of these fish are planktonic.

Five bearded rockling (*Ciliata mustela*) This common fish of the intertidal area is frequently present in estuaries. The eggs are produced in deeper water in winter and early spring and the eggs and larvae drift freely in the sea. This rockling eats crustaceans and small fishes.

Flounder (*Platichthys flesus*) An abundant estuarine flatfish the flounder is widespread around the coasts of Britain. The fish spend most of their life on the sea bed in estuarine situations only migrating offshore to breed in late winter to early spring after which both adults and juveniles return to water of low salinity. The juveniles swim upstream in the summer months and may enter fresh water and remain there until winter before dropping back to the tidal reaches. The flounders often feed intertidally swimming over sandy and muddy bottoms as the tide encroaches on estuarine flats. Most of the food of flounders consists of molluscs, worms and crustaceans but the larger fish will also eat other fish. Flounders spend a large proportion of their time close to the sea bed within estuaries.

Many other species of flatfish including sole, plaice, turbot, brill and dabs spend the fry stage in estuarine situations and they may be abundant in intertidal pools of sand flats in the summer months.

Thin-lipped mullet (*Liza ramada*) are abundant in many south coast rivers. Although it closely resembles the thick-lipped mullet in form this species is much more tolerant of fresh waters and the adult fish are found in estuaries and well up into fresh water rivers and lagoons from March to October. Breeding takes place in the sea and the fish seem to enter rivers after the fry stage and the larger fish may be more tolerant of the physiological stresses imposed by migration from salt to fresh water.. The thin-lipped mullet feeds chiefly on diatoms and tiny particles of detritus and indeed its upstream migrations tend to occur in spring and in Autumn when diatom blooms occur in

many rivers.

Eel (*Anguilla anguilla*) The eel is a catadromous fish which spends most of its life in rivers and lakes. The majority of eels which remain in estuarine situations are males and do not grow as large as the females. All eels undergo long migrations and pass through the estuarine habitats both as juveniles (elvers) and as adults on their way to the spawning grounds. Physical or chemical obstructions to the migration of these fish can have disastrous effects on the population and there is believed to be a general decline in the numbers of European eels at the present day. Eels breed in the deep ocean sea near the Sargasso sea and migrate three or four thousand miles in order to do so. The eel is a valuable food and sport fish feeding on a wide variety of animal foods including fish, crustaceans, worms and molluscs.

Twaite shad (*Alosa fallax*) By far the most common of the two British species of shad the twaite which used to be abundant in many rivers now appears to be virtually restricted to the Rivers Severn and Wye. These fish enter rivers in May in order to spawn on stones, in the lower reaches of the fresh water just at or above the tidal limit. However, the twaite shad is now said to occur in considerable numbers in the estuary of the River Medway. If this is indeed the case it probably indicates an improvement in water quality in the estuary of the Medway. The downstream migration of the larvae of these fish through estuaries is clearly fraught with danger. A small species, the twaite provides good sport for anglers but because it tends to enter rivers only during the close season for coarse fish its presence probably remains undetected in most rivers where it does occur. The twaite shad feeds on small, free swimming, fishes and crustaceans.

Allis shad (*Alosa alosa*) This species is much rarer than the twaite shad (probably for the same reasons) and has similar habits but because it is difficult to distinguish the two no comment will be made.

Smelt (*Osmerus eperlanus*) Has similar habits to the shads and although it was once abundant in the estuaries and was a popular food fish, it is now quite scarce. Smelt are said to be present in the estuary of the River Medway. The eggs are shed onto gravel or among submerged plants, in fresh water, to which they adhere. The adult Smelt live close to river mouths and all life stages are thus likely to be susceptible to estuarine pollution.

Salmon (*Salmo salar*) and sea trout (*Salmo trutta*) These species can be considered together as they have similar life histories and migrate through estuaries, as adults, to enter the spawning streams from about March to August. Both species spawn within the rivers in November - January and the young fish, after one or two years spent in fresh water migrate to the sea mainly in April/May. It is also possible that numbers of young fish (smolts) migrate downstream in October - November and in lesser numbers throughout the remainder of the year. In general only the sea trout feed in the estuarine regions and in fact many of the juvenile and adult sea trout never leave the vicinity of the river mouth. Salmon and sea trout are said to be present in increasing numbers in the River Medway and the stages most susceptible to estuarine pollution are likely to be the smolts.

Critical periods for fish species inthe Medway estuary

Species	Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bass	Juvenile												
Thick-lipped mullet	Adult												
Black goby	Breeding												
Common goby	Breeding												
Sand goby	Breeding												
Sandeel	Adult/Juv.												
5 Bearded rockling	Adult												
Flounder	Migration												
Juvenile flatfish	Juveniles												
Thin-lipped mullet	Adult												
Eel	Adult												
	Immigrant												
	Emigrant												
Twaite shad	Breeding												
Allis shad	Breeding												
Smelt	Adult/Fry												
Salmon	Immigrant												
	Emigrant												
Sea trout	Immigrant												
	Emigrant												

Observations on the Fish Populations of an East Coast Estuary

J.R. Wharfe, S.R. Wilson and R.A. Dines

Southern Water Authority, Kent Division, Capstone Road, Chatham

Abstract

Monthly samples of fish were collected from the cooling-water intake screens at Kingsnorth Power Station on the Medway Estuary. A total of 26,372 fish, comprising 41 species, was recorded between April 1981 and August 1983. The seasonal distribution of both species numbers and abundance of fish was similar to earlier studies although the community structure has altered in recent years. The regular occurrence and increased population size of *Osmerus eperlanus*, the smelt, and *Clupea harengus*, the herring, were the most notable changes. The results are compared with previous studies, and the indirect effects of enhanced water quality conditions in the tidal Thames and the subsequent recolonisation by fish, which were previously absent for many years, are discussed.

Introduction

The technique of sampling fish from power station cooling-water intake screens has been employed by a number of authors (Wheeler, 1969; Grimes, 1975; Hardisty and Huggins, 1975; Mathur et al, 1977; Andrews and Rickard, 1980), and van den Broek (1979) evaluated the method during a study of the Medway Estuary fish populations. A sampling programme undertaken once a month at Kingsnorth Power Station between May 1973 and August 1975 identified 49 species and produced a wealth of data on fish migrations, feeding patterns, growth rates and seasonal distributions (van den Broek, 1977, 1979, 1980). Van den Broek

concluded that the technique offered a most useful means of obtaining regular, quantitative samples of fish.

Wheeler (1969), and more recently Andrews and Rickard (1980), sampled fish from the intake screens of power stations on the tidal Thames to assess the rehabilitation of the inner estuary following improvements in the quality of effluent discharges. In recent years greater species diversity and increases in fish population size have demonstrated the success of a campaign to rebuild and extend the major London sewage treatment works and to enhance tidal water quality conditions. Features of recolonisation of the tidal Thames include marked improvements in the diversity and abundance of macroinvertebrates, benthic algae and waterfowl in addition to the restoration of a stable fish community.

The confluence of the tidal Medway and the Thames Estuary ensures a flood-tide common to both systems. Observed changes in the structure of the Thames estuarine fish community might, therefore, be manifest in the Medway Estuary. Historic evidence suggests a decline in the aquatic life of the Medway Estuary in response to the increased volume of polluting discharges (Smith, 1928) and some fish previously caught, including salmon, are now absent. Smelt, close relations of the salmon, were once plentiful but a large reduction in the numbers caught (van den Broek, 1980) was emphasized by their infrequent occurrence in samples from Kingsnorth Power Station between May 1973 and August 1975 (van den Broek, 1979).

Results from studies on the fish populations of the Medway Estuary (Fig. 1), based on screen samples collected from Kingsnorth Power Station since April 1981, indicate recent

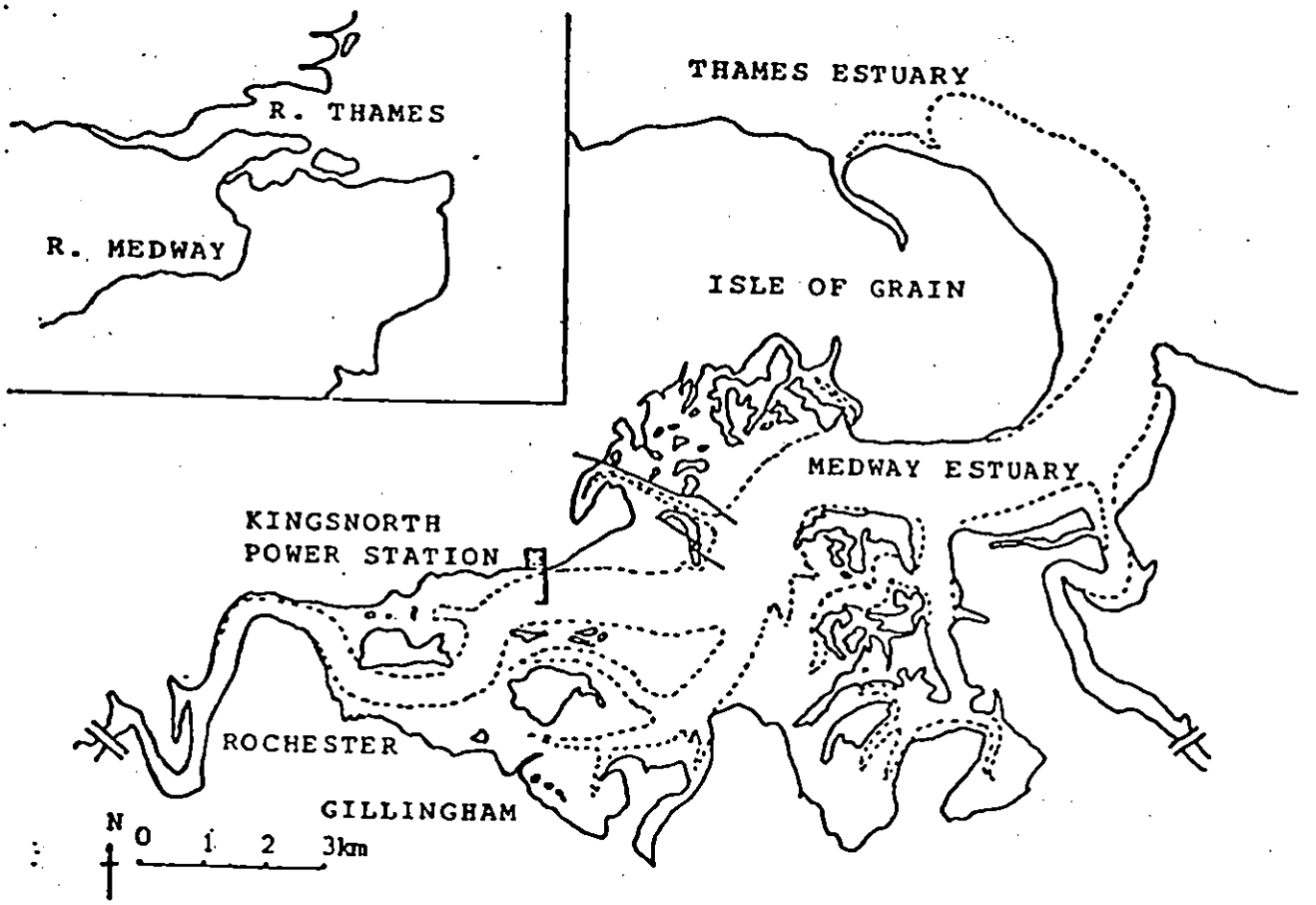


Fig. 1. The Lower Medway Estuary showing the location of Kingsnorth Power Station

changes in the community structure. The results are compared with earlier studies on the Medway Estuary fish populations and the indirect effects of recolonisation of the tidal Thames are considered.

Methods

The cooling-water intake at Kingsnorth Power Station, including the system for the removal of extraneous material, has been described by van den Broek (1979). Four revolving drum screens filter out waste material, including fish, and the debris is washed via culverts to trash buckets which facilitate sampling.

Samples of fish from the intake screens have been identified and enumerated once each month since April 1981. A sample-run constituted an eight hour day period of approximately equal duration either side of a high spring tide. Diurnal and tidal variations in the numbers of fish entering the cooling-water intake arrangement have been recognised (van den Broek 1979; Utting and Holmes, 1982) so for comparative purposes the technique employed by van den Broek (1977) was followed. A simple correction was applied to enumerate monthly catches to a constant water volume.

Results

A total of 26,372 fish, comprising 41 species, was recorded in twenty-six quantitative samples collected in consecutive months between April 1981 and August 1983. Four species, *Alosa fallax* (twaite shad), *Hyperoplus lanceolatus* (greater sandeel), *Liza ramada* (thin-lipped grey mullet) and *Gaidropsarus mediterraneus* (shore rockling) had not been recorded previously from the Medway Estuary.

Seasonal variation in the diversity and abundance of screen samples is shown in Fig. 2. The highest number of both species and individuals occurred in the late autumn/early winter, reaching a maximum in October 1981 and in December 1982. A second smaller peak followed in late spring.

Seasonal changes in the estuarine fish populations are attributed to emigration and immigration although this is not evident in all species. The twelve most abundant species (Fig. 3) accounted for 98% of the total catch with *Clupea harengus* (herring) and *Sprattus sprattus* (sprat) dominating the samples and together accounting for more than 63%. *C. harengus*, *S. sprattus*, *Osmerus eperlanus* (smelt), *Pomatoschistus minutus* (sand goby), *Platichthys flesus* (flounder), *Syngnathus rostellatus* (Nilsson's pipe-fish) and *Anguilla anguilla* (eel) were present in all or most of the monthly samples. Some species including *C. harengus*, *Merlangius merlangus* (whiting), *Trisopterus luscus* (bib), *Dicentrarchus labrax* (bass), *S. rostellatus*, *Limanda limanda* (dab) and *P. flesus* exhibited clear seasonal distributions. Maximum numbers of *C. harengus* and *S. rostellatus* occurred in the winter months and were sparse during summer. *M. merlangus*, *T. luscus*, *D. labrax* and *L. limanda* were also most abundant during the winter months and were mainly absent for the remainder of the year. In contrast, greater numbers of *P. flesus* occurred during spring. *S. sprattus*, *O. eperlanus*, *A. anguilla* and *Solea solea* (sole) showed no clear seasonal migration patterns although numbers of *S. sprattus* were high in April 1981 and in December 1982.

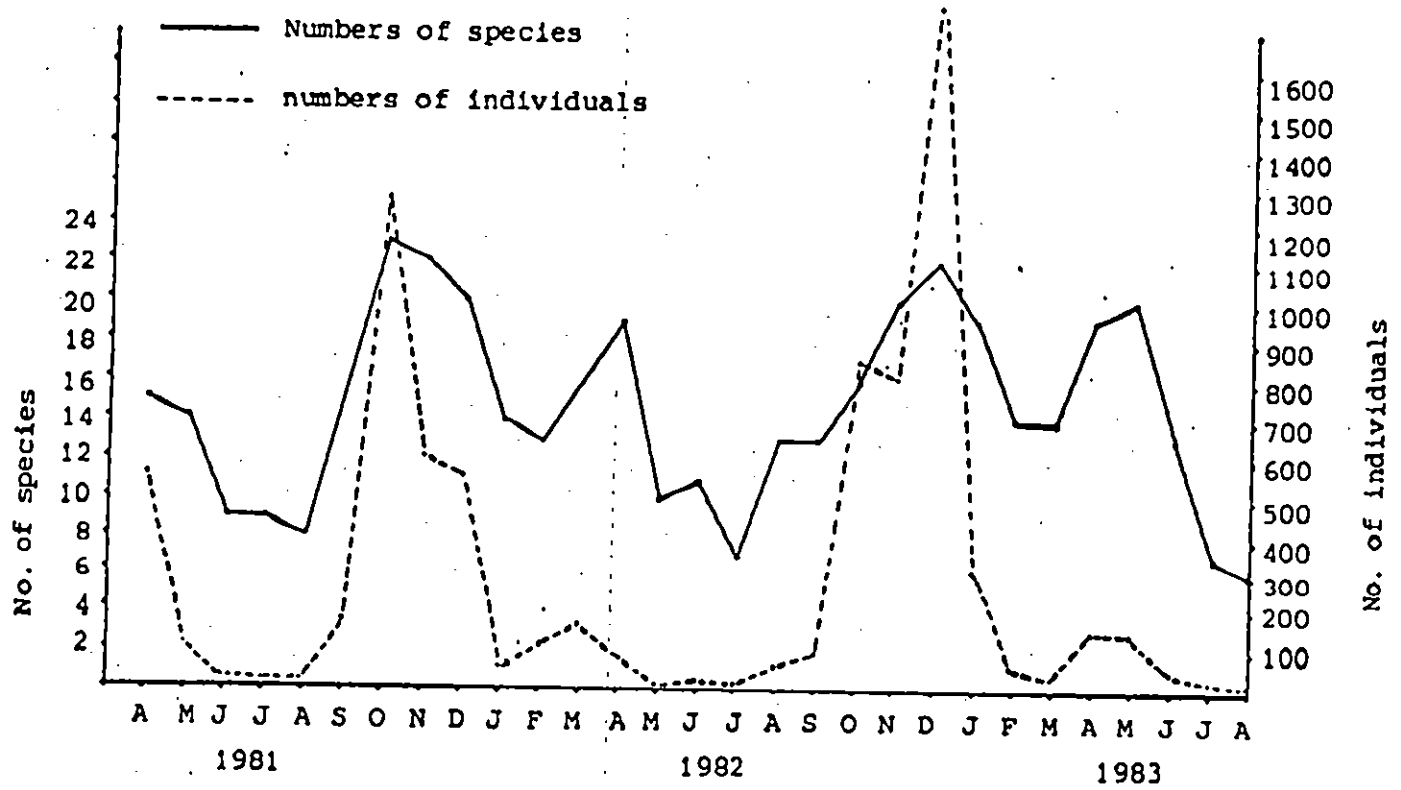


Fig. 2. Seasonal variation in the total number of species and individuals in monthly screen samples from Kingsnorth Power Station

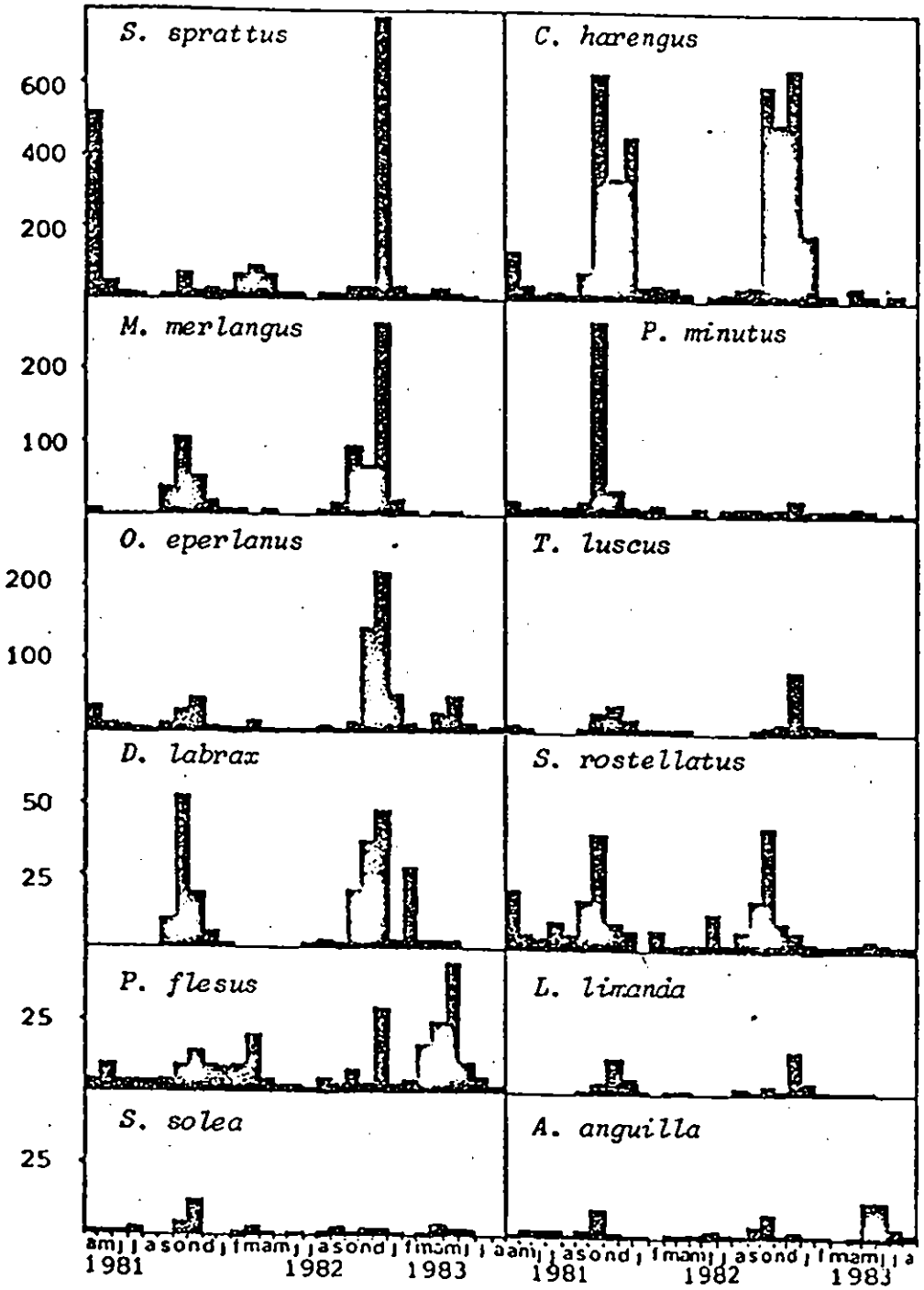


Fig. 3. Seasonal distribution of the twelve most common species in monthly screen samples from Kingsnorth Power Station

Discussion

The Medway Estuary and North Kent Marshes are of considerable ecological interest and a working party report (NCC, 1971) records the area as one of international scientific importance, with a range of habitats and a diversity of flora and fauna. The absence of some species of fish previously recorded in the estuary and the disappearance of the oyster and mussel industry, which once flourished, belie the former importance of Rochester as a fishing port. The decline of the commercial fishery during the early twentieth century, is attributed to a number of factors including over exploitation and the discharge of increasing amounts of domestic and trade waste (Smith, 1928).

The freshwater flow to the Medway Estuary is low, relative to the volume of saline water, and strong tidal currents ensure well mixed, unstratified waters which, in the lower estuary, are of good quality with dissolved oxygen concentrations in excess of 80% saturation at all times. However, major discharges of carbonaceous organic material to the estuary upstream of Rochester have a profound effect on oxygen concentrations, with values below 10% saturation often recorded in the upper reaches.

Recent studies have shown that fish are plentiful in the lower estuary and with a variety of species. The seasonal distribution of species diversity and abundance of fish, illustrated in Fig. 2, is similar to that recorded by van den Broek (1979) with an influx of young fish during the autumn months. Numbers of both species and individuals attain a maximum during September to January each year and seasonal migration patterns agree with those previously described (van den Broek, 1980) although changes in the community structure are apparent. The total number

of fish collected, employing comparable techniques, increased from 290 fish per station pump, during 1973-75, to 326 fish per station pump during 1982-83. These figures indicate an increase in the size of some populations although relatively few species, twelve, account for more than 90% of the total catch.

The most notable change to have occurred in recent years is the increased population size of *O. eperlanus* (Fig. 4). During 1973-75 *O. eperlanus* was recorded infrequently and accounted for less than 1% of the total number of fish collected at Kingsnorth power station. During the period from April 1981 to August 1983, it was present on all sampling occasions and accounted for more than 6% of the total catch. The return of *O. eperlanus* to the Medway Estuary is undoubtedly associated with its recolonisation of the tidal Thames. It is a close relative of the salmon and is similarly sensitive to water quality changes. A dramatic increase in the population of *O. eperlanus* in the Thames (Andrews and Rickard, 1980) is evidence of the improved estuarine water quality following a programme to rebuild and extend London's major sewage treatment works.

The population size of *C. harengus* has also increased in recent years (Fig. 4) with large numbers of young fish, spawned in the outer Thames Estuary during spring, entering the Medway Estuary during late autumn and winter. In 1981 and 1982 the total numbers of *C. harengus* collected at Kingsnorth during the period October to December, when they are most numerous, were 4674 and 5177 fish respectively. These figures compare with 427 and 384 fish collected during the same period in 1973 and 1974 respectively. In contrast, the numbers of *S. sprattus* have apparently decreased although wide fluctuations in the population size are known to

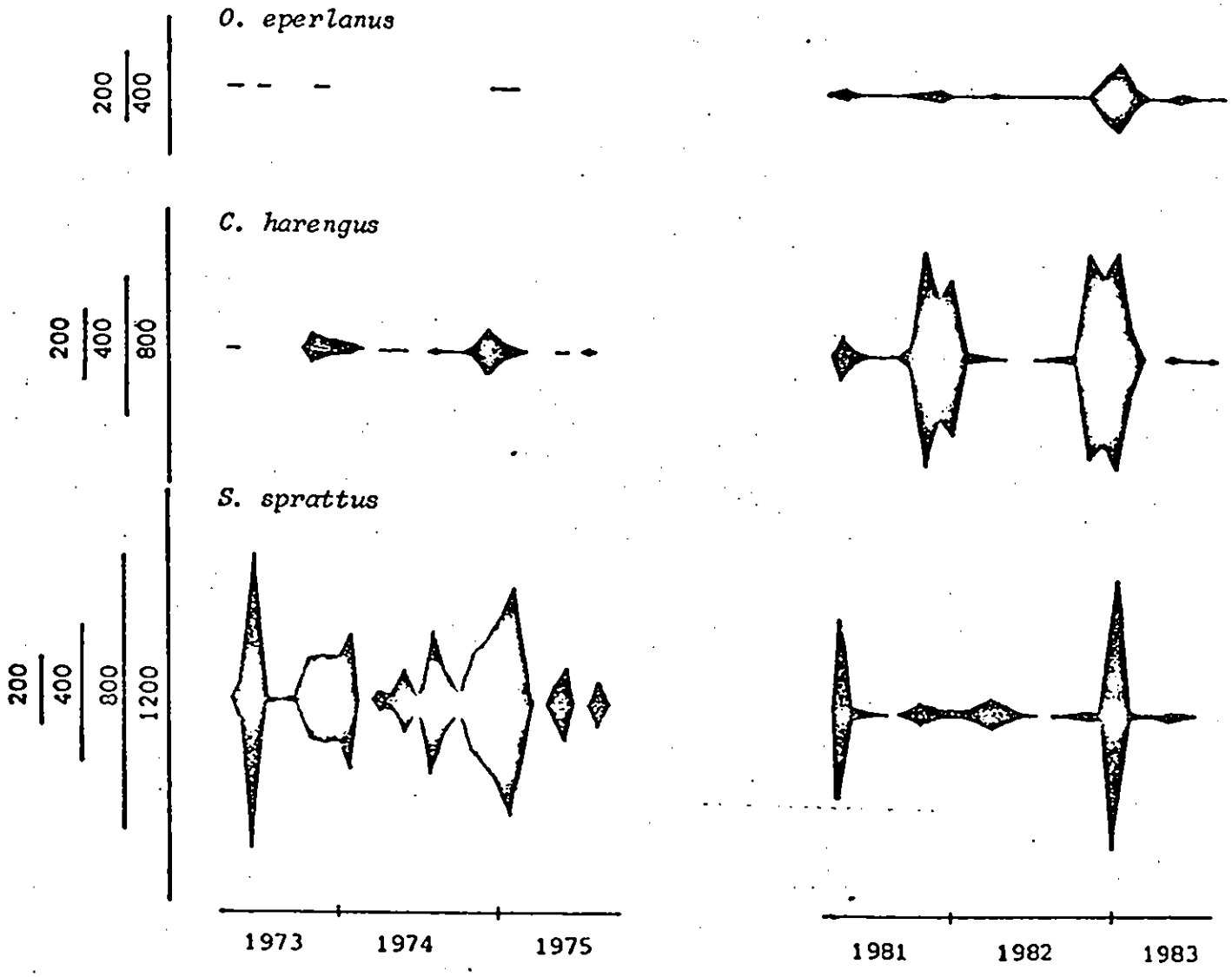


Fig. 4. Numbers of fish per unit volume of water entrapped on the screens at Kingsnorth Power Station 1973-75 and 1981-83

occur. Young fish are present at Kingsnorth throughout the year although large numbers of recently spawned fish are evident in the autumn and winter months (van den Broek, 1977). Adults appear during the winter but in late spring and early summer a seaward migration greatly reduces the population size of *S. sprattus* in the estuary. During 1973-75 *S. sprattus* was dominant and accounted for more than 60% of the fish collected at Kingsnorth. Fewer numbers of *S. sprattus* and a concurrent increase in the population size of other species during 1981-83 account for its reduction to 20% of the total catch.

The East Coast estuaries are important nursery grounds for a number of flatfish including *S. solea*, *Pleuronectes platessa* (plaice), *L. limanda* and *P. flesus*. The composition of samples collected at Kingsnorth indicates that the Medway Estuary supports a relatively stable flatfish community. During 1973-75 flatfish accounted for 4.7% of the total number of fish collected compared with 4.4% of the total catch during 1981-83.

In conclusion, good water quality conditions prevail in the Lower Medway Estuary and samples of fish collected from the intake screens at Kingsnorth power station display a diversity of species and a seasonal abundance of individuals. The current studies have shown that the community structure has altered in recent years with the more frequent occurrence, and increased population size of *O. eperlanus* and *C. harengus*. The change is largely attributed to improved water quality conditions in the tidal Thames and the subsequent recolonisation by species of fish which were previously absent for many years.

Acknowledgements

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