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REPORT FOR ANGLIAN WATER, NRA UNIT ON THE INCLUSION OF STORM WATER OVERFLOWS INTO THE ORWELL ESTUARY MODEL - AND ITS USE TO PREDICT LIMITS FOR SWO DISCHARGES

C.J. PENNEY

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National Rivers Authority
Anglian Region

SUMMARY

The mathematical model of the Orwell Estuary has been amended to include storm water overflows.

A WASSP analysis of the Ipswich Borough Council sewer system model was run by WRc for the first 26 storms in the Times Series Rainfall. The data on storm water overflows was summarised to calculate their effect on predicted estuary water quality.

The Orwell Estuary model predicts that the rehabilitated sewer system will cause unacceptable conditions in the top segments of the estuary when all the other discharges meet proposed long term consent limits.

Various options are proposed that the model predicts would achieve acceptable conditions by reducing the predicted 99-percentile B.O.D levels to 12 mg/l or below, the MAC value suggested for transient pollution. The suggested level of discharge and number of times a discharge can occur per year are summarised in Table 7.

CONTENTS

LIST OF TABLES

LIST OF TABLES continued

Page

LIST OF FIGURES

LIST OF FIGURES - continued

APPENDICES

1 INTRODUCTION

1.1 The mathematical model of the Orwell Estuary has been used to determine suggested long term consent limits for the main discharges into the Orwell Estuary. Ref: Report for Anglian Water NRA Unit, April 1989. To continue this work it was proposed that the Storm Water Overflows from the Ipswich sewage system which discharge into the estuary should also be included in the model to enable it to be used to determine consent limits for them.

1.2 This report summarises the information available from the Ipswich B.C sewer catchment plan and its inclusion in the model of the Orwell Estuary. With the Storm Water Overflows (SWO) added to the Orwell model the "Monte-Carlo" type procedure was used to estimate discharge limits which would not cause unacceptable conditions in the estuary.

1.3 Current RQS 's are expressed in terms of standards for continuous pollution control. The NWC classification takes no explicit account of transient pollution caused by intermittent discharges such as SWO 's. For current rehabilitation schemes interim procedures are required. WRc has two schemes for river systems which use empirically derived, acceptable, transient river quality based on the NWC classification system. (WRc report ER317E) .

A draft report by the Welsh Water Authority (pers. comm.) also propose the use of Maximum Acceptable Concentrations (MAC values) of pollutants in the watercourse receiving a SWO discharge. These are derived by using 99 percentile NWC Standards. Extending this theory to the Orwell Estuary the proposed EQS would result in MAC values of:-

Ammonia	3.0 mg/l
B.O.D	12 mg/l
D.O	20% sat. (min) - stretch 1
D.O	30% sat. (min) - stretch 2

2. IPSWICH B.C HIGH AND LOW LEVEL SEWER CATCHMENT DRAINAGE AREA PLAN

2.1 A computer model of the Ipswich high and low level sewer catchment has been produced. In January 1985 Anglian Water initiated a hydraulic Analysis of the Ipswich catchment using WASSP. (Wallingford Storm Sewage Package)

This used the Time Series Rainfall (TSR) - the 99 most significant observed rainfall events which occur in a typical year, to study pollution effects. For cost effective reasons a selective "run" was done using the 5 highest ranked storms and every fifth storm thereafter.

Ipswich B.C produced a report in March 1988 with the results of this analysis.

2.2 A total of 20 storm water overflows have been built into the sewage system discharging into the the River Gipping and Orwell Estuary.

The results from the time series rainfall gives values of the frequency and quantity that each SWO discharges in a "typical" year.

This hydraulic analysis was done at four levels :-

1) The existing system.
2) A rehabilitated system - the existing system is improved to remove all flooding.
3) Initial development - includes discharges from land already set aside for housing or industrial development.
4) Final development - utilising all other areas of land where development is possible.

For options 2,3 and 4 it was agreed with A.W that the system should not worsen the situation and ideally some improvement should be achieved, regarding SWO's.

2.3. To use the results of this study in the Orwell Estuary model it was decided that the Initial Development stage should be used. As looking to the future there will be further development in the area, but it is not as speculative as the Final Development.

2.4. POLLUTION ASSESSMENT USING WASSP AT THE INITIAL DEVELOPMENT STAGE

A total of 12 SWO 's discharge into the Orwell Estuary in this scheme, some combine before discharging and number 215 is also removed in this scheme giving a total of 6 outfalls into the Estuary . FIGURE 1 is a map of the part of the sewer system which discharges to the estuary showing the outfall locations.

1 - D/S Horseshoe Weir
2 - D/S Constantine Weir
3 - D/S Constantine Weir
4 - U/S Stoke Bridge
5 - D/S Lock Gates
6 - West Bank Ferry Terminal

The fresh water limit of the Orwell Estuary is Horseshoe Weir for most of the time there is virtually no flow over the weir as the flow bypasses by a side channel and joins the estuary upstream of Constantine weir. Therefore SWO 1 receives very little dilution also because Constantine weir is a half tide weir for part of the tidal cycle the water is impounded in the top segment of the estuary. FIGURE 2 is a photograph of Horseshoe weir which also shows the location of SWO 1. FIGURE 3 is a photograph of Constantine weir taken in December 1988 which shows how little flow there is at this point. FIGURE 4 is a photograph of SWO 2 & 3 which discharge D/S of Constantine weir and FIGURE 5 shows SWO 4 U/S of Stoke bridge.

2.5 The Ipswich B.C report included the following results relating to SWO's which discharge into the Orwell Estuary.

1) The number of times each SWO discharged in a "typical" year
2) The Maximum spill volume.
3) The annual spill volume.

This information was based on a selective run of the TSR which used the first 5 then every fifth storm. This indicated that the SWO only discharged during the first 25/26 storms. To be able to more accurately assess the effect of the SWO on Estuary Water Quality the Ipswich B.C WASSP model was run by WRc for the first 26 storms in the TSR.

2.6 The Ipswich B.C model does not include Cliff Quay Sewage Treatment Works or any SWO which may occur there. The works receive sewage from the Eastern Area and South Eastern Area as well as Ipswich high and low level system. There is an untreated overflow from the Eastern area of flows >6 DWF directly into the estuary by the works. The rest of the flow >3 DWF from all the areas is diverted to storm tanks which usually contain it. Any alteration to flows from the SWO could result in higher flows at the treatment works . A schematic diagram of Cliff Quay STW and description are in Appendix 1.

3 ANALYSIS OF IPSWICH B.C WASSP DATA and THE INCLUSION OF SWO INTO THE ORWELL ESTUARY MODEL

3.1 The data supplied by WRc of a run of the first 26 storms in the time series rainfall was summarised to provide the following information :-

a) The total volume discharged at each point for each storm.

b) The mean and standard deviation of the volume discharged at each point

c) The maximum volume discharged at each SWO outfall.

d) The maximum length of time each SWO discharged.

e) The average length of time each SWO discharged.

f) The total number of times a discharge occurred at each point and the locally adjusted number.

3.2 The initial inclusion of the SWO into the Orwell estuary model was described in the April report for Anglian Water NRA Unit. Following this preliminary work the model was further modified so that during each monte-carlo run the SWO 's operate for a proportion of the time according to the number of times the WASSP model predicts they will discharge in a year. The results table was also extended to include predicted water quality in each segment expressed as a 99-percentile.

3.3 From this analysis of the WASSP results the data in TABLE 1 were used in the Orwell Estuary model to assess the effect of the Storm water overflows (SWO) on water quality. The model was run with the same water quality for the boundary values and Belstead Brook and flows of inputs into the estuary as in the previous report. The proposed consent limits for the main discharges were also used and the quality of the SWO discharge was as suggested by WRc. All these values are summarised in Appendix 2 - Tables 1 to 5

3.4 Using the data from table 1 resulted in the estuary model underestimating the volumes discharged by the SWO. There were several possible reasons for this and assumptions which were necessary to proceed without numerous changes to the computer programme or excessive use of computer time.

3.5 ASSUMPTIONS

3.5.1 There is no correlation in the Orwell model between the length of time a SWO discharges for and the volume discharged. A correlation could be included if there was found to be one, Appendix 3 - summarises the rainfall data from the TSR. After discussions with Headquarters staff it was decided that it was not necessary to include a correlation factor at present.

3.5.2 The volumes discharged at the other outfalls are a rate whereas the SWO data has been analysed in terms of of a total volume discharged per event. The model data file is to be amended to show the change of input data.

3.5.3 The Mean and Standard Deviation of the volumes discharged from the SWO as calculated from the WASSP data were manipulated to achieve similar mean volume discharged from each SWO as the WASSP model predicts, so the loading in the estuary was correctly assessed for predicting estuary water quality. The factor used to achieve this was to increase the WASSP data by 75%. TABLE 2 summarises the data used. For the model to produce similar maximum values the number of "shots" calculated would have to be increased using excessive computer time, and was considered unnecessary at present.

4 CALCULATIONS - MADE TO ASSESS EFFECT OF STORM WATER OVERFLOWS AND DISCHARGE VALUES REQUIRED TO ACHIEVE ACCEPTABLE ESTUARY WATER QUALITY

4.1 EFFECT OF INDIVIDUAL STORM WATER OVERFLOWS

4.1.1 Each SWO was turned off in turn with the quantity and frequency of the other SWO remaining unchanged.

4.1.2 The volume and frequency of discharge from SWO 1 was reduced by 30%, 40%, 45% and 50% with the other SWO remaining the same.

4.2 EFFECT OF COMBINED CHANGES TO SWO DISCHARGES

4.2.1 For SWO 1, 2 & 3 the volumes discharged and the number of times a discharge is predicted to occur each year were reduced by 10%, 20%, 30%, 40% and 50%. The volumes and frequency from SWO 4, 5 & 6 remained unaltered.

4.2.2 For SWO 1 the volume and frequency of the discharge was reduced by various amounts and the flow it was reduced by was added to SWO 2 :-

1) All the flow from SWO 1 was transferred to SWO 2.

2) 40% of the flow of SWO 1 was added to SWO 2.

3) 50% of the flow of SWO 1 was added to SWO 2.

5 RESULTS

To study the effect of the SWO discharges the predicted 99-percentile B.O.D results have been used. This is because the Ammonia results predicted in the estuary when all the SWO are discharging are fairly low as a result of the low concentration in the WRc estimate for SWO water quality. The Dissolved oxygen results do not show the SWO 's to be having much of an effect which is not the case as is known from local knowledge. This may be an inherent weakness in the model or the input data for the SWO needs further refining.

5.1 EFFECT OF COMPLETELY REMOVING INDIVIDUAL SWO DISCHARGE POINTS

The predicted 99-percentile results for B.O.D in the first 6 segments of the estuary are listed in TABLE 3. Below segment 5 there is no predicted effect from the SWO discharges. FIGURE 6 is a graph of these results this shows that :-

1) SWO 1,2,3 & 4 effect water quality in the top 3 segments of the estuary.
2) SWO 5 & 6 have a minimal effect in segments 5 and 6.
3) SWO 1 & 3 have the greatest effect.
4) Removing SWO 1 completely brings the predicted water quality below the MAC value.

5.2 EFFECT OF REDUCING THE VOLUME AND FREQUENCY FROM SWO 1

The predicted 99-percentile B.O.D results in the top 6 segments of the estuary when SWO 1 is reduced by various percentages are listed in TABLE 4. These results are shown graphically in FIGURE 7.

Reducing the volume discharged and frequency by 45% results in a predicted B.O.D in segment 1 of 12 mg/l - the MAC value. A reduction of 50% achieves the MAC value with spare capacity.

5.3 EFFECT OF REDUCING THE VOLUME AND FREQUENCY OF DISCHARGE FROM SWO 1, 2 & 3 BY VARIOUS PERCENTAGES

Since the discharges into the top 2 segments of the estuary are having the greatest effect on water quality the combined result of altering these was investigated. TABLE 5 lists the predicted water quality in the top 6 segments when these SWO discharges were reduced by various percentages. FIGURE 8 is a graph of these results and this shows that a reduction of 30% reduces the predicted B.O.D to below the MAC value.

5.4 THE EFFECT OF TRANSFERRING A PERCENTAGE OF THE FLOW FROM SWO 1 TO SWO 2

The results so far indicate that altering SWO 1 has the greatest impact on predicted water quality. If the flow from SWO 1 is reduced it must go somewhere else otherwise flooding could occur. In these calculations the effect of passing the flow through the sewer system to the next discharge point was investigated.

TABLE 6 lists the results in the first 6 segments of the estuary and they are shown graphically in FIGURE 9.

1) If all the flow from SWO 1 is transferred to SWO 2 the predicted B.O.D in segment 1 is 13.6 mg/l which exceeds the MAC value.

2) If 40% of the flow from SWO 1 is transferred to SWO 2 the MAC values is exceeded in segments 1 and 2.

3) If 50% of the flow from SWO 1 is transferred to SWO 2 the model predicts a B.O.D of 12 mg/l in segment 1 - the MAC value.

5.5 TABLE 7 summarises the the results of the volumes and frequency of discharge from the storm water overflows which the model predict would achieve acceptable conditions in the estuary.

6 CONCLUSIONS

6.1 The mathematical model of the Orwell estuary has been amended to include storm water overflows. This could still be refined further but the increased work load and computer time may not be justified. It is difficult to validate the results except by local knowledge and historical data of water quality after storms have occurred, but there is no sampling of storm water discharges or record of discharge frequency.

6.2 The model predicts that when the river Gipping achieves its RQS and the other discharges into the estuary meet the proposed long term consent limits, the storm water overflows as predicted at the initial development stage in the rehabilitated sewer system by the WASSP model, will cause unacceptable conditions in the top segments of the estuary.

6.3 With the model at this stage of development it was considered adequate to asses the impact of the SWO's on the estuary water quality, related to predicted 99 percentile B.O.D results.

This showed that the discharges at points 1, 2 and 3 were having the greatest impact on predicted water quality. Due to the geography of the estuary the discharge at point 1 has the most effect. The discharge from point 2 appeared to have little impact because the volume discharged was small compared to SWO points 1 and 3

The model was run with different combinations of flows and this resulted in various options which would achieve acceptable estuary water quality, reducing the predicted B.O.D level to the MAC value of 12 mg/l or below.

6.3 Acceptable water quality in the estuary is shown by the model to be achieved by the following options:-

1) Remove the discharge at point 1 completely

2) Reduce the volume and frequency of discharge from points 1, 2 & 3 by 30%.

3) Reduce the volume and frequency from SWO 1 discharge point by 45%.

4) Reduce the volume and frequency from SWO 1 by 50% and transfer this flow to SWO 2.

6.4 Option 4 is the only combination calculated so far which takes account of all the flow produced during the storm. For the other options extra storage capacity may have to be made according to the predictions of the WASSP model.

6.5 Further work that would help validate these results would be to run the model with the proposed volumes and frequencies with an increased number of shots in the monte-carlo calculation. This would improve the degree of confidence that could be attributed to the results.

TABLE 1 - SUMMARY OF DATA EXTRACTED FROM WASSP RUN OF THE FIRST 26 STORMS OF THE TSR.

	SWO OUTFALL NUMBER					
	1	2	3	4	5	6
Mean Flow (tcmd)	1.03	0.24	1.02	0.68	0.80	0.11
S.D.	1.20	0.27	1.01	1.00	1.08	0.16
No. times operate/Yr.	22	22	24	9	12	16
Longest Discharge (Hrs:Mins)	5:50	6:20	18:80	3:40	3:00	3:00
Seconds	21000	22800	65400	13200	10800	10800

TABLE 2 - SWO DATA USED IN THE ORWELL MODEL TO ACHIEVE SIMILAR MEAN LOADINGS AS PREDICTED BY WASSP

SWO OUTFALL No.		Calculated from WASSP	Vol used in Orwell model WASSP + 75%	Estimated Mean Discharge Calc. by Orwell model
1	Mean	1.03	1.08	1.09
	S.D.	1.20	2.10	
2	Mean	0.24	0.42	0.26
	S.D.	0.27	0.47	
3	Mean	1.02	1.79	1.05
	S.D.	1.01	1.76	
4	Mean	0.68	1.19	0.71
	S.D.	1.00	1.75	
5	Mean	0.80	1.40	1.07
	S.D.	1.08	1.89	
6	Mean	0.11	1.19	0.12
	S.D.	0.16	0.28	

All volumes in thousand cubic meters.

TABLE 3 - PREDICTED 99 PERCENTILE B.O.D RESULTS IN THE FIRST 6 SEGMENTS OF THE ESTUARY WHEN INDIVIDUAL STORM WATER OVERFLOWS ARE REMOVED

SEGMENT	Storm Water Overflow operating							
	ALL ON	1 OFF	2 OFF	3 OFF	4 OFF	5 OFF	6 OFF	ALL OFF
0	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
1	16.6	10.3	15.9	13.3	16.3	16.6	16.6	7.4
2	13.0	9.8	12.6	10.9	12.0	12.8	13.0	8.1
3	8.5	7.8	8.4	8.1	8.4	8.4	8.4	7.4
4	7.1	7.1	7.1	7.1	7.1	7.1	7.1	6.7
5	7.1	6.9	7.0	6.9	6.9	6.9	7.0	6.8
6	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9

TABLE 4 - PREDICTED 99 PERCENTILE RESULTS FOR B.O.D IN THE FIRST 6 SEGMENTS OF THE ESTUARY WHEN THE DISCHARGE FROM SWO 1 IS REDUCED BY VARIOUS PERCENTAGES

SEGMENT	ALL ON	Percentage SWO 1 Reduced By 30%	40%	45%	50%	ALL OFF
0	4.9	4.9	4.9	4.9	4.9	4.9
1	16.6	13.3	12.6	12.1	10.4	7.4
2	13.0	11.1	11.1	11.1	10.3	8.1
3	8.5	8.4	8.4	8.3	8.0	7.4
4	7.1	7.1	7.1	7.1	7.1	6.7
5	7.1	6.9	6.9	6.9	6.9	6.8
6	5.9	5.9	5.9	5.9	5.9	5.9

TABLE 5 - PREDICTED 99 PERCENTILE RESULTS FOR B.O.D IN THE FIRST 6 SEGMENTS OF THE ESTUARY WHEN THE DISCHARGE FROM SWOs 1, 2 & 3 ARE REDUCED BY VARIOUS PERCENTAGES

SEGMENT	ALL ON	SWO 1, 2 & 3 Percentage Reduction 10%	20%	30%	40%	50%	ALL OFF
0	4.9	4.9	4.9	4.9	4.9	4.9	4.9
1	16.6	15.1	13.9	11.4	9.9	9.1	7.4
2	13.0	12.4	11.9	10.4	10.4	8.5	8.1
3	8.5	8.4	8.4	8.3	8.1	7.8	7.4
4	7.1	7.1	7.1	7.1	7.1	7.1	6.7
5	7.1	6.9	6.9	6.9	6.9	6.9	6.8
6	5.9	5.9	5.9	5.9	5.9	5.9	5.9

TABLE 6 - PREDICTED 99 PERCENTILE RESULTS FOR B.O.D IN THE FIRST 6 SEGMENTS OF THE ESTUARY WHEN VARIOUS PERCENTAGE FLOWS FROM SWO 1 ARE TRANSFERRED TO SWO 2

SEGMENT	ALL ON	ALL SWO 1 to SWO 2	40% from SWO 1 to SWO 2	50% from SWO 1 to SWO 2	ALL OFF
0	4.9	4.9	4.9	4.9	4.9
1	16.6	13.6	14.8	12.0	7.4
2	13.0	11.4	12.3	11.2	8.1
3	8.5	8.4	8.4	8.4	7.4
4	7.1	7.1	7.1	7.1	6.7
5	7.1	7.1	7.1	7.1	6.8
6	5.9	5.9	5.9	5.9	5.9

TABLE 7 - SUMMARY OF VOLUMES AND FREQUENCY OF DISCHARGES FROM STORM WATER OVERFLOWS PREDICTED BY THE MODEL TO PRODUCE ACCEPTABLE ESTUARY WATER QUALITY

SWO OUTFALL No.		OPTIONS							
		SWO 1 REMOVED	No per Yr.	SWO 1 - 45% REDUCTION	No per Yr.	SWO 1,2 & 3 REDUCED BY 30%	No per Yr.	SWO 1 - 50% REDUCTION to SWO 2	No per Yr.
1	Mean	0	0	0.57	12	0.72	16	0.52	11
	S.D	0		0.66		0.84		0.60	
2	Mean	0.24	22	0.24	22	0.17	16	0.76	22
	S.D	0.27		0.27		0.18		0.87	
3	Mean	1.02	24	1.02	24	0.58	17	1.02	24
	S.D	1.01		1.01		0.58		1.01	
4	Mean	0.68	9	All the same					
	S.D	1.00							
5	Mean	0.80	12	All the same					
	S.D	1.08							
6	Mean	0.11	16	All the same					
	S.D	0.16							

All flows in TCM

FIGURE 1 - DIAGRAM OF THE IPSWICH SEWER SYSTEM SHOWING THE POSITION OF STORM WATER OVERFLOWS INTO THE ORWELL ESTUARY

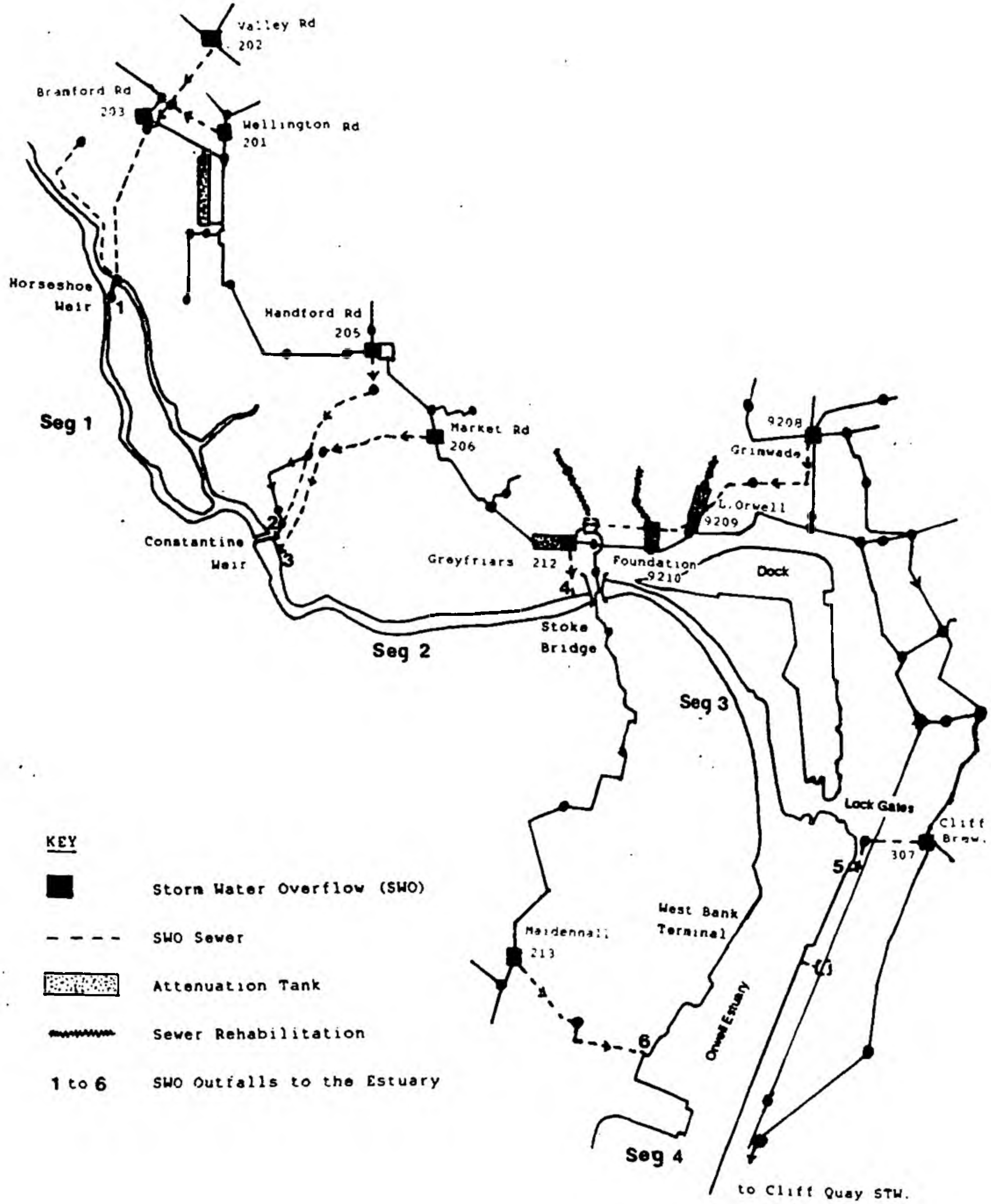


FIGURE 2 - PHOTOGRAPH OF HORSESHOE WEIR SHOWING SWO 1 ON RIGHT HAND SIDE

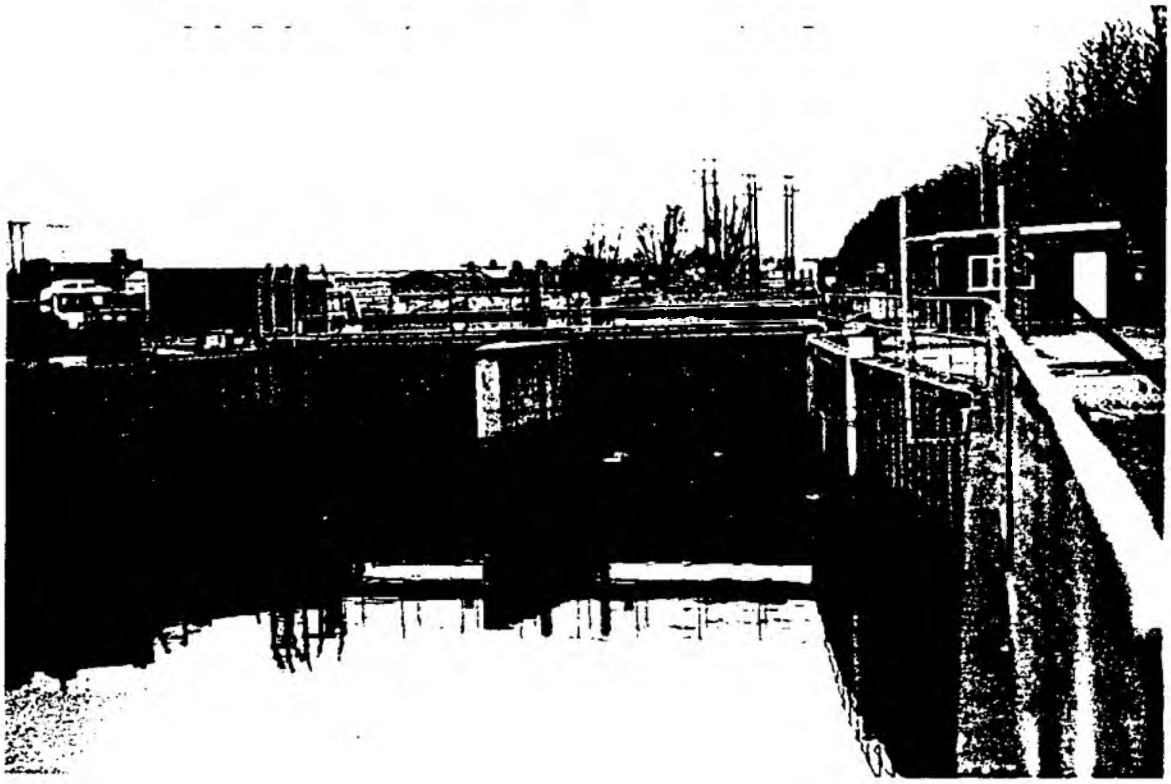


FIGURE 3 - PHOTOGRAPH OF CONSTANTINE WEIR

FIGURE 4 - PHOTOGRAPH OF SWO POINTS 2 & 3 - DOWNSTREAM OF CONSTANTINE WEIR

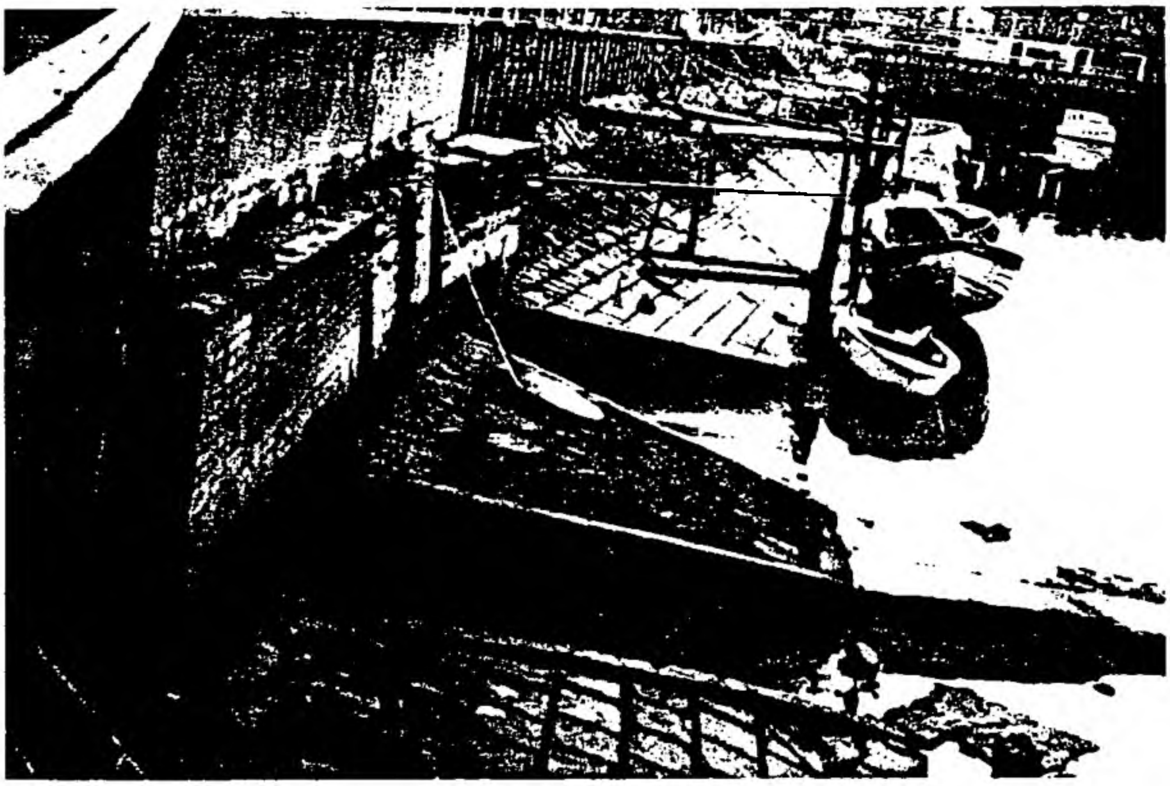


FIGURE 5 - PHOTOGRAPH OF SWO POINT 4 - UPSTREAM OF STOKE BRIDGE

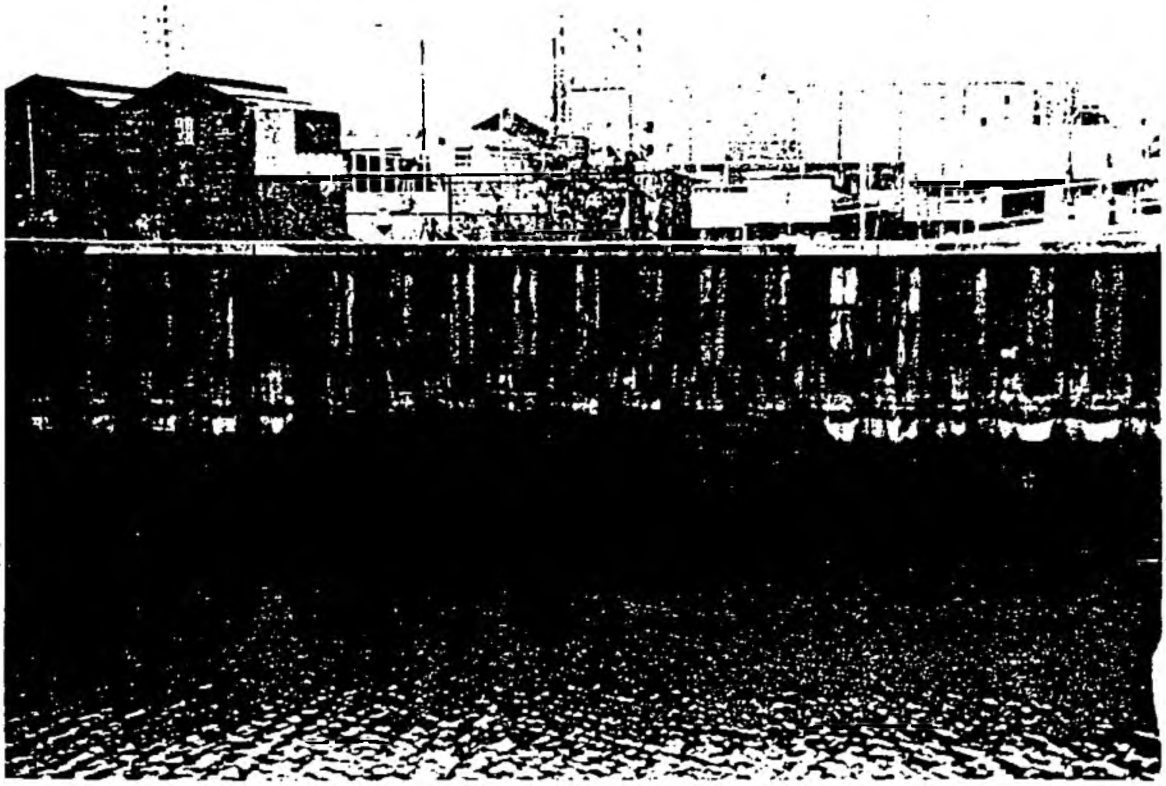


FIGURE 6

STORM WATER OVERFLOWS–DATA FROM WASSP

CALCULATED 99 percentile B.O.D IN THE ORWELL ESTUARY

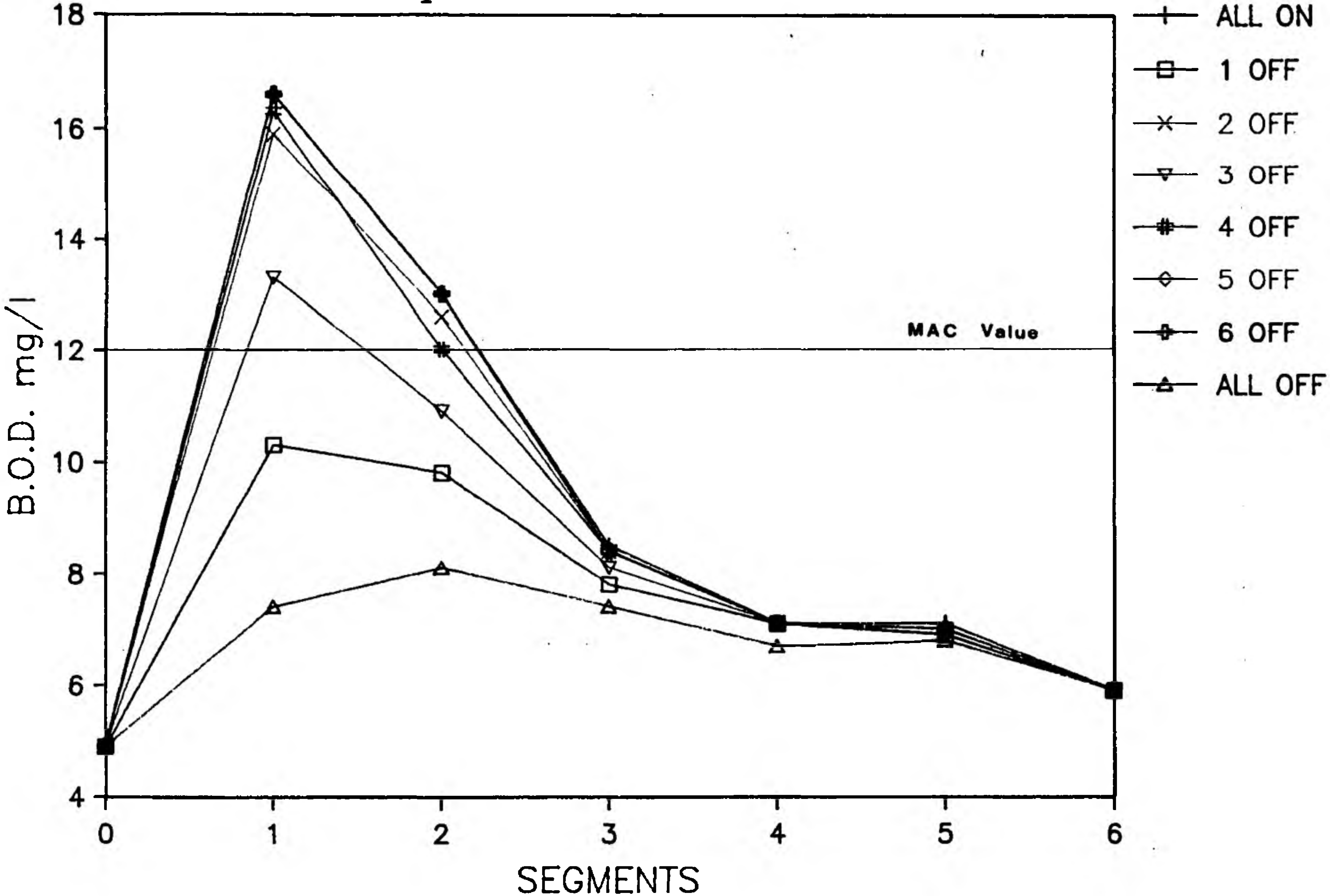
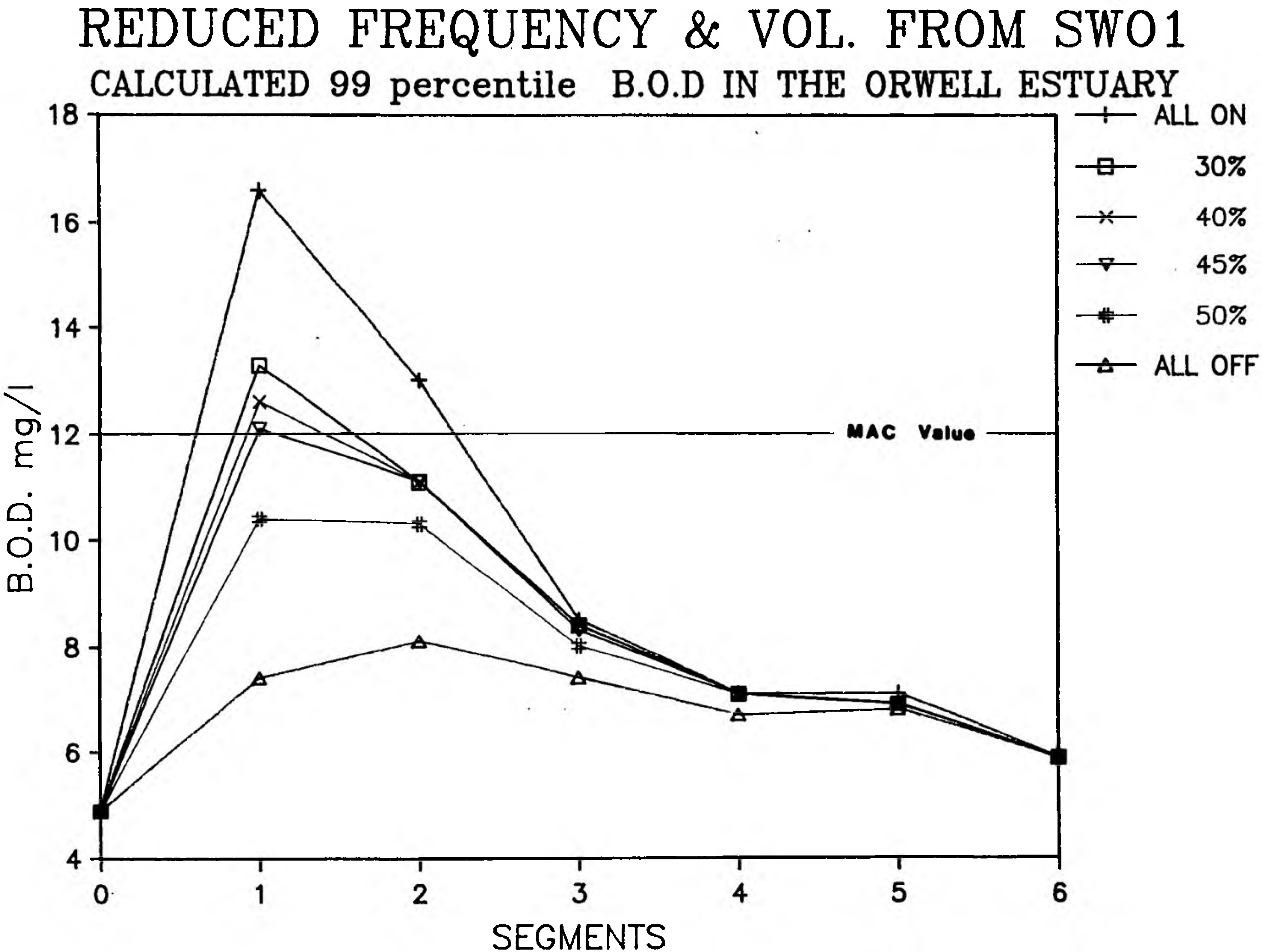


FIGURE 7



REDUCED FREQUENCY & VOL. FROM SW01
CALCULATED 99 percentile B.O.D IN THE ORWELL ESTUARY
B.O.D. mg/l
SEGMENTS
MAC Value
ALL ON
30%
40%
45%
50%
ALL OFF
18
16
14
12
10
8
6
4
0
1
2
3
4
5
6

FIGURE 8

REDUCED FREQ. & VOL.FROM SWO 1,2 & 3

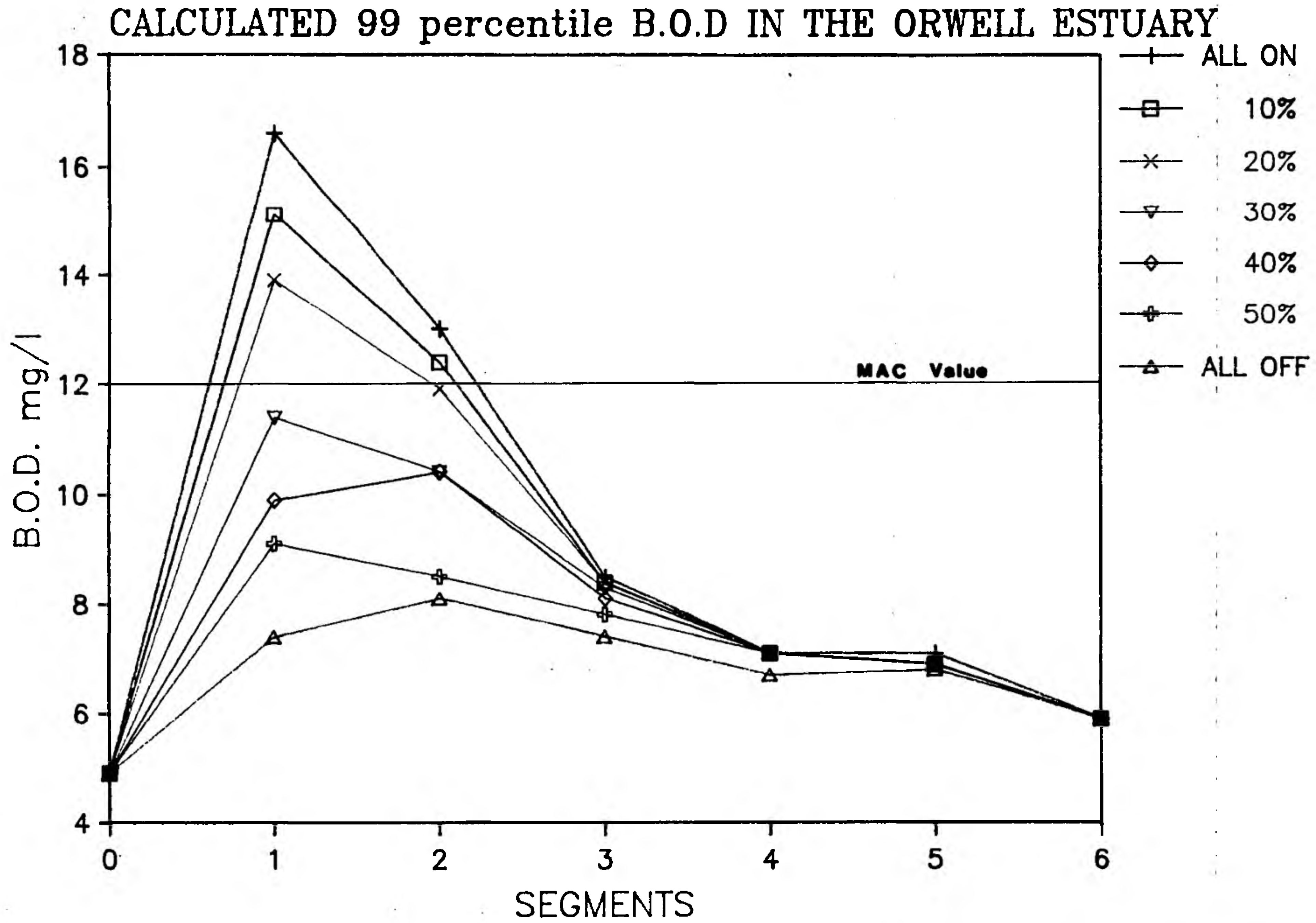
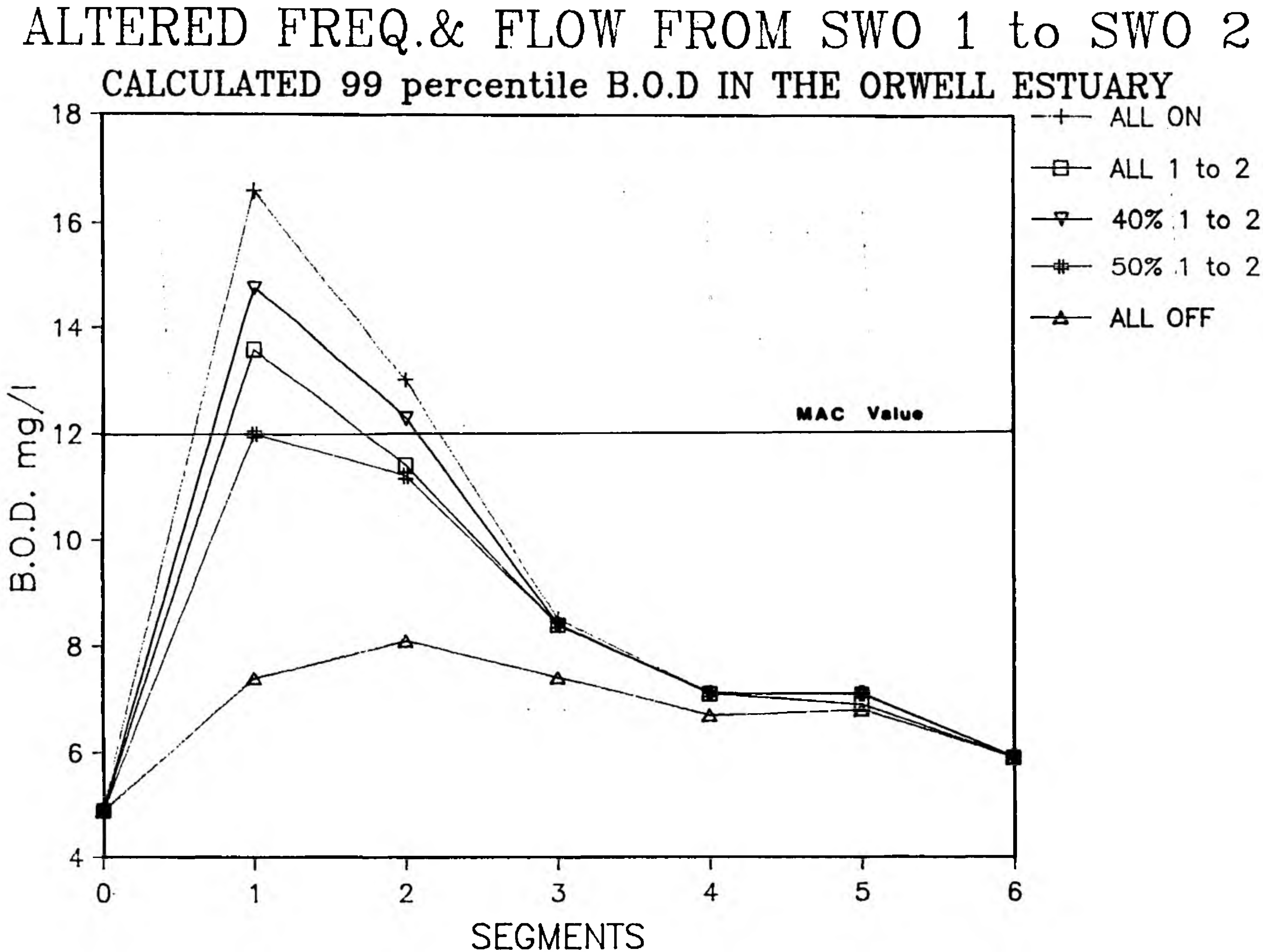


FIGURE 9



ALTERED FREQ.& FLOW FROM SWO 1 to SWO 2
CALCULATED 99 percentile B.O.D IN THE ORWELL ESTUARY
B.O.D. mg/l
18
16
14
12
10
8
6
4
MAC Value
0
1
2
3
4
5
6
SEGMENTS
ALL ON
ALL 1 to 2
40% 1 to 2
50% 1 to 2
ALL OFF

7 REFERENCES

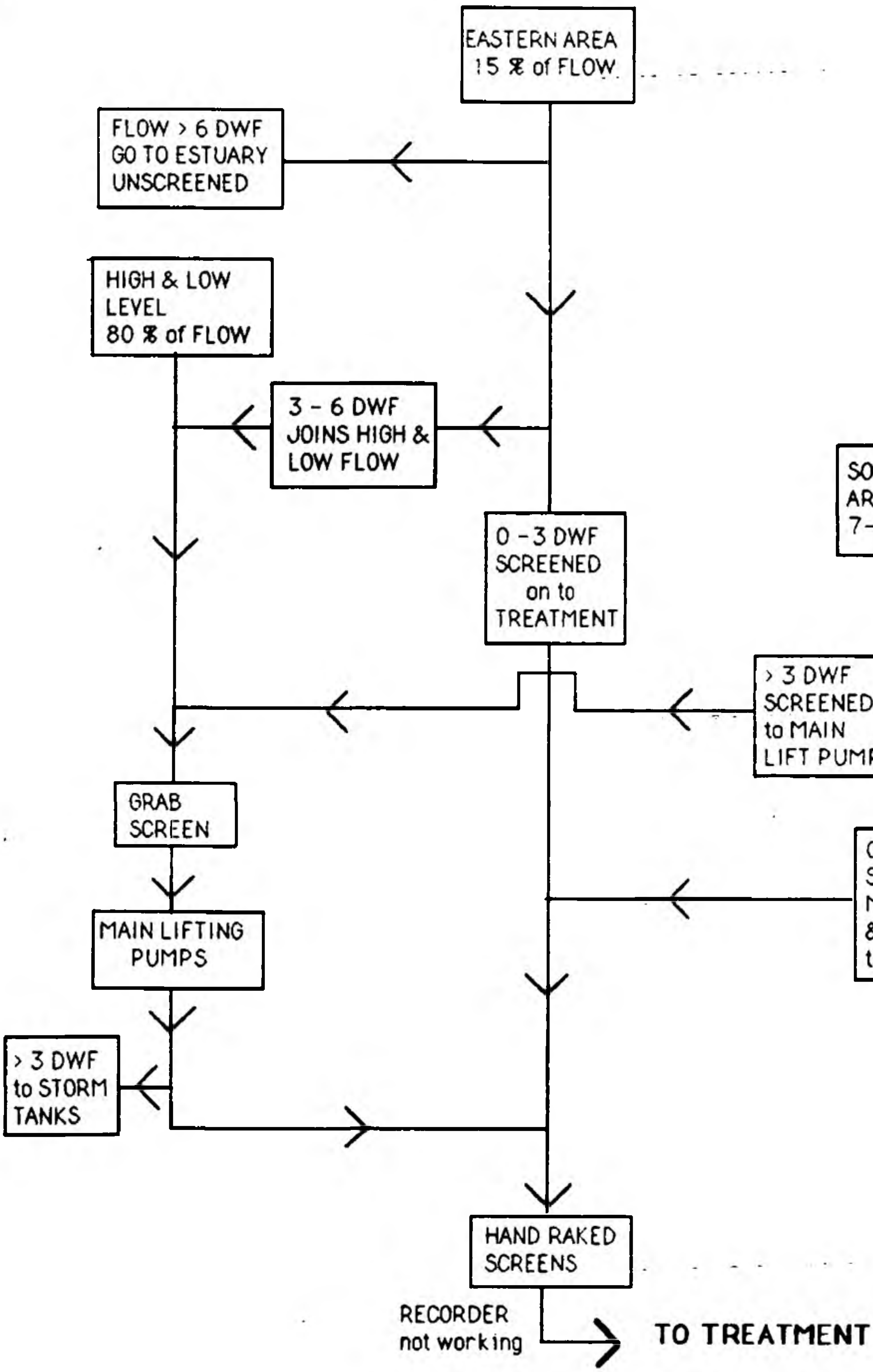
1) Crabtree R W, Crockett C P and Toft A R. - INTERIM RIVER WATER QUALITY PLANNING PROCEEDURES FOR CONTROLLING INTERMITTENT POLLUTION FROM STORM SEWAGE OVERFLOWS. No. ER317E, WRc Engineering, 1988.

2) Ipswich Borough Council - HIGH AND LOW LEVEL SEWER CATCHMENT DRAINAGE AREA PLAN, March 1988.

3) Penney C J - REPORT FOR ANGLIAN WATER, NRA UNIT ON THE USES OF THE ORWELL AND THE STOUR ESTUARIES AND THE USE OF THE MATHEMATICAL MODEL TO DERIVE LONG TERM CONSENT LIMITS FOR ALL INPUTS TO THE ORWELL ESTUARY April 1989

4) Welsh Water Authority - STORM SEWAGE OVERFLOWS. Pers comm.

SCHEMATIC DIAGRAM OF CLIFF QUAY SEWAGE TREATMENT WORKS - IPSWICH



CLIFF QUAY SEWAGE TREATMENT WORKS - EXPLANATION OF SCHEMATIC DIAGRAM

1 EASTERN AREA INLET

This comprises of approximately 15 % of the total flow to the works. Flows above 6 X Dry Weather Flow (DWF) are diverted directly to the estuary with no screening or settlement.

Flows of 3-6 DWF join the main flow into the works from the high and low drainage area of Ipswich.

The remaining 0-3 DWF is screened and continues on to treatment.

2. SOUTH EASTERN AREA INLET

This has recently increased and is now 7-8% of the flow.

Flows above 3 DWF are screened and diverted to the main works flow at the lifting pump.

Flows of 0-3 DWF are screened, the screenings are macerated and returned to the flow. This then joins with the main flow to treatment.

3. HIGH AND LOW LEVEL DRAINAGE AREA INLET

This is about 80% of the total flow to the works. This is added to by the 3-6 DWF from the Eastern Area and all flows above 3 DWF from the South Eastern Area.

All flows then pass through grab screens (no longer working very efficiently) and on to the main lifting pumps.Flows greater than 3 DWF are then diverted to the storm Tanks where primary sedimentation occurs. The retention in these tanks is approximately 8 hours after which they will discharge to the estuary. In practice discharges rarely occur and the effluent is returned to treatment.

The flow from the main lifting pumps then joins with the 0-3 DWF flows from the other two areas. The entire flow then passes through hand raked screens to remove excess rag etc due to the inefficient grab screens. The only flow recorder in the works is also situated at this point but due to the hand raked screens is not currently working. There are no recorders at the main inlets to the works.

The combined flow then passes on to primary treatment then discharges to the estuary.

APPENDIX 2 - DATA USED IN THE MODEL TO ASSESS EFFECT OF THE STORM WATER OVERFLOWS

TABLE 1 - BOUNDARY VALUES FOR EACH END OF THE ESTUARY

Mean (X) and Standard Deviation (SD) values in mg/l

LANDWARD		SEAWARD		VARIABLE
X	SD	X	SD	
2.4	0.80	2.5	0.83	BOD
0.2	0.07	0.1E-10	0.1E-10	TOTAL ORGANIC N.
0.3	0.10	0.1	0.1	AMMONIA
7.9	2.37	0.2	0.07	OXIDISED NITROGEN
85.0	10.00	100.0	15.0	DISSOLVED OXYGEN
10.8	5.92	13.0	5.0	TEMPERATURE

TABLE 2 - WATER QUALITY CONCENTRATIONS FOR THE BELSTEAD BROOK

Mean (X) and Standard Deviation (SD) values in mg/l

X	SD	VARIABLE
2.4	0.8	BOD
0.3	0.1	AMMONIA
7.9	2.6	OXIDISED NITROGEN
0.5	0.2	TOTAL ORGANIC NITROGEN
8.5	1.0	DISSOLVED OXYGEN

TABLE 3 - SUMMARY OF FLOWS OF INPUTS INTO THE ESTUARY

All flows in tcmd unless otherwise stated

INPUT	MEAN FLOW	STANDARD DEVIATION	LOW FLOW
Tidal Limit	1.3 CUMECS		0.2 CUMECS
Belstead Brook	0.21 CUMECS	0.07 CUMECS	
Burtons	0.06	0.02	
Pauls	0.47	0.04	
B.S.C	1.49	0.58	
Cliff Quay	37.5	12.5	
Felixstowe	10.0	3.3	

TABLE 4 - PROPOSED LONG TERM CONSENT LIMITS FOR MAJOR DISCHARGES INTO THE ORWELL ESTUARY

DISCHARGE tcmd	FLOW mg/l		B.O.D	NH_3
Cliff Quay	30	DWF	200	45
Burtons	0.06	Mean	250	12
Pauls	0.47	"	250	7
B.S.C	1.49	"	250	40

TABLE 5 - CALCULATION OF MEAN STORM SEWAGE CONCENTRATION

DETERMINAND	STRENGTH mg/l	FACTOR SRM TABLE F1	STORM FLOW CONC. mg/l Mean	S.D
BOD	327	0.5	163.0	54.3
AMMONIA	38.8	0.3	11.00	3.7

APPENDIX 3 - RAINFALL DATA

RAINFALL DATA

EVENT NUMBER	DATE	LENGTH OF STORM Mins.	VOLUME DISCHARGED per UNIT AREA MM
1	4 Aug.	320	21.24
2	3 April	280	19.76
3	15 Sept.	610	19.67
4	9 Jan.	320	8.42
5	13 Dec.	730	23.42
6	12 Aug.	90	6.96
7	4 July	400	7.87
8	7 Nov.	1600	29.85
9	3 July	590	12.53
10	8 Oct.	330	9.01
11	7 April	890	11.40
12	6 July	270	8.02
13	11 June	650	11.79
14	2 March	330	8.54
15	5 Aug.	110	3.66
16	13 Oct.	790	9.15
17	11 Oct	240	5.32
18	1 Nov.	270	6.02
19	5 Sept.	540	7.58
20	4 Dec.	210	5.14
21	11 Jan.	350	4.26
22	11 Sept	340	5.04
23	10 June	50	3.49
24	6 Feb.	910	13.85
25	7 July	120	4.78
26	2 June	470	5.19