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NRA

Guardians of the Water Environment

Diogelwyr Amgylchedd Dŵr

NRA WELSH REGION

A SURVEY OF FERRUGINOUS MINEWATER IMPACTS IN THE WELSH COALFIELDS.

WELSH OFFICE CONTRACT (No. WEP 100/138/11)

SOUTH EAST ENVIRONMENTAL APPRAISAL UNIT

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EXECUTIVE SUMMARY

1. Ferruginous minewater discharges from abandoned coal mines in the South and North Wales coalfields have been causing problems to receiving watercourses for many years (eg. Pelenna catchment). The rapid contraction of coal mining in the South Wales coalfield resulted in the closure of many of the remaining pits during the 1980's, leaving Tower colliery, near Aberdare, and Bettws colliery, near Ammanford, the last remaining deep mines in South Wales. The spate of mine closures, in recent years, has resulted in several new ferruginous discharges to a number of rivers, particularly in the eastern area of the coalfield and the effects of these discharges on the aquatic environment are of growing public concern (eg. R. Rhymney at Hengoed).

2. Though the problem of ferruginous minewater discharges is well documented, the true extent of the problem in the Welsh region of the NRA was unknown prior to this study. The aims of this survey were to locate all ferruginous discharges within the coalfield areas and to assess their impact upon receiving watercourses. The project was carried out in two stages. The first stage of the assessment of all minewaters involved analysis of the discharges and the receiving watercourse for iron, aluminium, suspended solids, pH, dissolved oxygen, conductivity, sulphate and temperature. Visual assessments of the area of river bed affected by iron hydroxide (ochre) deposition, the level of deposition and physical characteristics of the receiving watercourse, such as flow and width, were also made at sites affected by discharges.

3. Stage 1 of the survey located 90 discharges and found that the total length of river impacted by ferruginous discharges in Wales was 59.4 km and an area of 220 x 10^3 m^2 was affected by iron hydroxide deposits.

4. A ranking method, incorporating the physical / chemical determinands, was developed to assess the comparative impact discharges were having on receiving watercourses. Area impacted was the most important criterion, though length affected and water quality criteria were also included.

5. A total of 33 of the top ranked discharges (20 to classified watercourses and 13 to unclassified watercourses) having the highest environmental impact were selected and chemical, biological and fisheries impact assessments were carried out on these discharges in stage 2 of the project.

6. Samples of benthic invertebrates were taken immediately above and below the discharges and at intermediate points downstream until a return to upstream conditions was reached. Samples were assessed to give Biological Monitoring Working Party (BMWP) scores. Expected invertebrate quality in the absence of polluting discharges was predicted for each site using the computer model RIVPAC's (River InVertebrate Prediction And Classification System).

7. Quantitative electrofishing surveys were carried out upstream and downstream of discharges. Impact was determined using the Regional Juvenile Salmonid Monitoring Programme classification (RJSMP) to assign a class to the fishery above and below the discharge, based upon the numbers of juvenile salmonids caught in a given area. The computer model HABSCORE (Salmonid habitat score) was used to assess the quality of the habitat for salmonids and the degree of utilisation of the habitat by salmonids.

8. Minewater discharges are often referred to as acid mine drainage, but many of the discharges in the Welsh coalfields were found to have pH values near neutral. There were exceptions, for example a number of acid discharges entered the Pelenna causing damage to the biota. Where the discharges were acidic they were, generally, rapidly neutralised by the receiving watercourses and pH was not a major problem downstream. This had implications for the amount of dissolved aluminium downstream of discharges. The toxicity and solubility of aluminium increases when the water becomes more acidic, but at pH 6-8 the solubility of aluminium and thus its toxicity are limited. As most of the discharges and many of the receiving watercourses were in this pH range, dissolved aluminium levels were not elevated at the majority of sites.

9. The Environmental Quality Standard (EQS) of 2 mg/l total iron was exceeded on at least one sampling occasion at eleven of the thirty three highest ranked sites. The precipitation of iron hydroxide, which caused a

blanketing and binding of the substrate and subsequent loss of benthic habitat, was the single most important factor affecting the biota downstream of minewater discharges.

10. Minewaters can be low in dissolved oxygen following the oxidation of pyrites below ground. Further oxidation of iron hydroxides in the receiving watercourse also requires oxygen and a small reduction in oxygen concentration downstream of a discharge occurred at the majority of sites. The oxygen capacity of the receiving watercourses were, however, sufficient to meet the oxygen demands of the minewater and the dissolved oxygen level at most sites, remained above 70 % oxygen saturation (considered important for salmonids) downstream of the discharges.

11. Suspended solid concentrations downstream of discharges were generally at a level (<25 mg/l) which would not affect the biota. Since, during high flow events, there will be high suspended solid concentrations due to general erosion of land and river bed, the resuspension and transport of ochre deposited on the river bed would probably not be a significant addition.

12. Biological impact was assessed on the basis of absolute loss and/or reduction in density of pollution sensitive taxa over significant areas of river bed. Of the 33 sites assessed in stage 2, a high biological impact was shown at 10 sites. Three of these discharges to classified waters and two to unclassified waters were also ranked highly on physical / chemical impact (based upon stage 1 data) indicating a relationship between the physicochemical characteristics assessed in stage 1 and biological impact assessed in stage 2. Medium biological impact was demonstrated at 13 sites and 9 sites showed no biological impact.

13. At a number of sites fisheries impact was not easily demonstrated because of poor baseline water quality in the receiving watercourse. This was particularly evident in a number of the S.E area rivers which suffer from intermittent storm sewage discharges which affect salmonids. Other streams had poor upstream fisheries because of low pH, as already described above. Where the water quality of receiving watercourses was poor it is considered that the full impact of the discharges on fisheries was masked. However, fisheries impacts were demonstrated in a number of cases. For example on a

tributary of the R. Llynfi, where a good nursery stream with an excellent upstream salmonid population was reduced by two classes to a moderate fishery according to the Regional Juvenile Salmonid Monitoring Programme classification.

14. In summary, a total of 90 ferruginous discharges impacted on 59.4 km of river. Impact assessment of 33 of the worst discharges showed high biological impact below 10 discharges, medium impact below 13 discharges and no impact at 9 sites. Fisheries surveys of 19 discharges indicated high impact at 3 sites, medium impact at 5 sites and no demonstrable impact at 11 sites.

15. It is important to emphasise that this survey represents a snapshot of the position in 1993, and there was some evidence that the situation was changing even during the survey period. The scale of British Coal's deep mining operations in Wales has now almost stabilised with one remaining colliery in S. Wales. However a large number of small private mines extract coal and may be the source of future mine discharges. In addition, further polluted minewater discharges from recently abandoned mines may emerge in an unpredictable way as the groundwater recharges. These discharges will continue to pollute, unless preventative or remedial action can be carried out.

16. The NRA is currently using the information gathered during this survey to produce a list of the worst case minewater discharges that will be included in a study to scope possible remedial solutions.

Minewater Discharges in the Welsh Coalfields

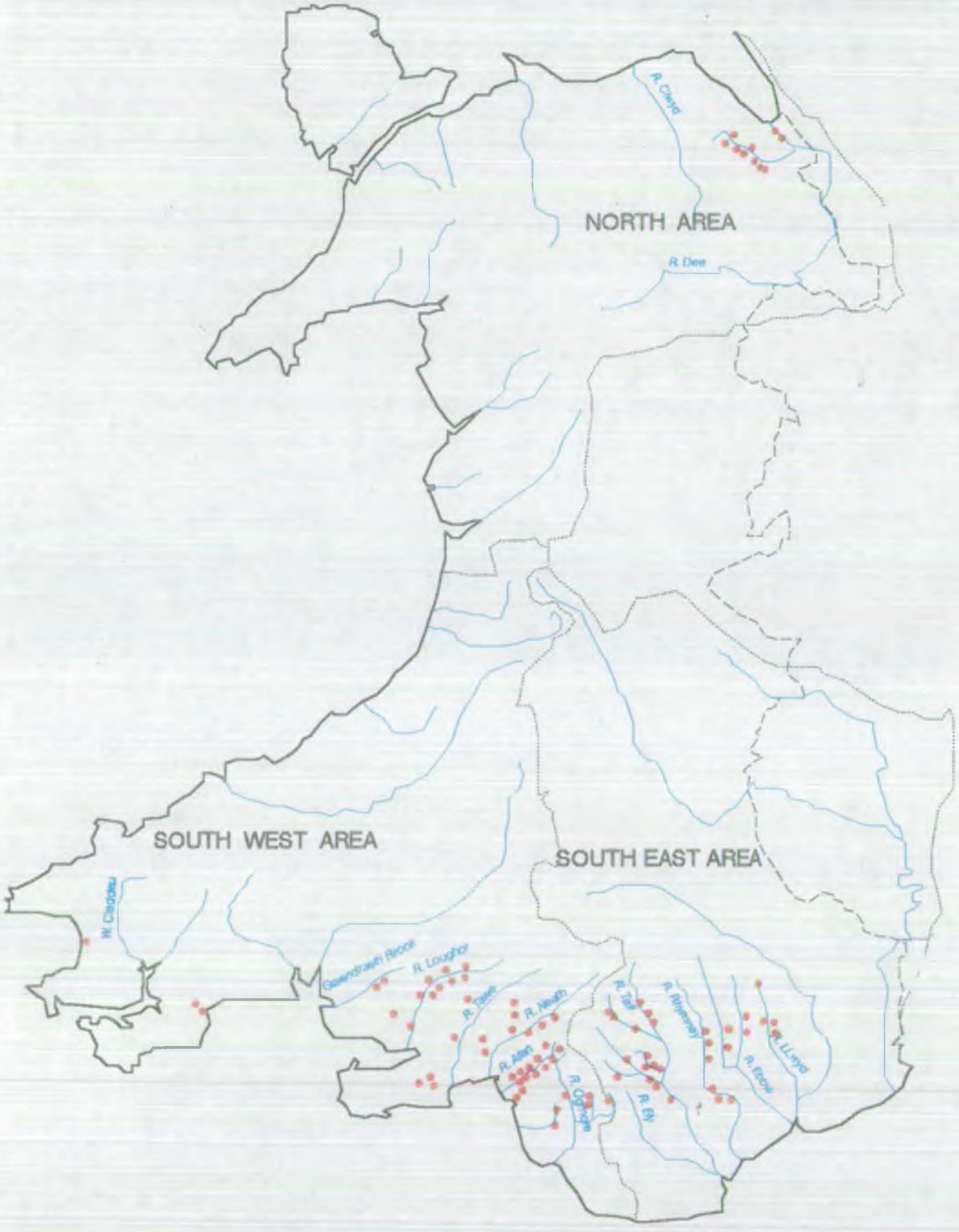

PLATE 1.

Ferruginous minewater discharge to the R. Sirhowy (6) at Pontllanfraith.

Ferruginous minewater entering a tributary of the River Llynfi (15).

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1. INTRODUCTION

This is the final report for the joint Welsh Office and NRA funded study of ferruginous minewater impacts in Wales (Ref. WEP/100/138/11). The study took place between October 1992 and October 1993.

1.1 BACKGROUND

Ferruginous discharges from both active and abandoned coal mines have caused pollution problems in Wales for many years (eg. the Pelenna catchment), often resulting in significant deterioration in water quality and subsequent detrimental effects on aquatic life. Recent closures of many deep coal mines, particularly in the South Wales coalfield have resulted in additional discharges to a number of rivers (eg. Rhymney, Ebbw, Sirhowy, Neath) and a rise in public concern over this issue.

The NRA sets water quality objectives for classified river stretches. At present 25 % of classified river stretches in South Wales do not meet their long term water quality objectives. A proportion of these stretches are affected by ferruginous minewater discharges together with other sources of pollution such as storm sewage. Ferruginous discharges are therefore an important factor in the NRA's urbanised river recovery programme and, as other sources of pollution are removed, will become the limiting factor.
In addition to classified reaches, the true extent of the impact of ferruginous minewaters on the smaller, unclassified streams and rivers was unknown, prior to this study. Such watercourses are essential nursery areas for fish breeding and provide genetic pools of organisms which are necessary for the maintenance of a healthy, diverse aquatic ecosystem and associated terrestrial fauna.

At the Welsh Affairs Committee (11 March 1992) hearing into water pollution from abandoned coal mines, a recommendation made in the Flowers Report of 1981 that 'there was an urgent need to establish the extent of the pollution and range of costs of the necessary remedial treatment' was raised. Since this recommendation had not been properly addressed in the intervening period this project to determine the extent of the ferruginous minewater problem in Wales was carried out.

1.1.1 Chemical processes leading to ferruginous minewaters

During mining operations the mineral pyrite, or iron sulphide, which is often found in the coal seam, is exposed. When exposed to air and water pyrite is oxidised to ferrous sulphate and sulphuric acid, a process which may be catalysed by the presence of chemosynthetic bacteria. These are bacteria which form organic material by means of energy derived from chemical changes. Pumping operations ensure that active mines are kept free of groundwater and the pyrite exposed during mining operations which is in contact with the air on exposed surfaces may be subject to such processes. When mines are closed pumping operations typically cease, water builds up within the mines, dissolves the available oxidised ferrous salts and acid, and may overspill into surrounding watercourses. This drainage may be acidic or may have been neutralised during passage through surrounding base rock (eg. limestone). When minewater enters a watercourse further oxidation occurs and ferrous sulphate is converted to ferric hydroxide. The ferric hydroxide precipitates out as an orange flocculant deposit (Ochre) on the river bed. Such minewaters are described as being ferruginous.

At high concentrations ferrous and ferric iron may be toxic to the aquatic biota, while the precipitated iron hydroxide may smother habitats and organisms. Blanketing of the riverbed by ferruginous deposits is particularly detrimental to salmonid reproduction for which clean, well aerated gravels are essential.

1.2 OBJECTIVES OF THE STUDY

To identify all ferruginous discharges emanating from or connected with abandoned coal mines in the Welsh region of the National Rivers Authority and to determine their impacts on the water quality, biological quality and fisheries status of the receiving waters.

The project was carried out in two stages. In the first stage discharges were located and their impact upon the receiving watercourses was assessed by visual observation and from water quality analysis. The second stage of the project involved full impact assessment of 33 of the worst case discharges using biological and fisheries surveys and further water quality analysis.

2. STAGE 1 - METHODOLOGY

2.1 Desk study

The Welsh coalfield areas to be covered by the study were determined from geological maps and marked on OS 1:10,000 maps. Rivers, tributaries, mines, collieries, shafts and levels were identified within these areas in advance of survey work.

2.2 Survey procedures

An initial survey to identify the sources and determine the extent of ferruginous discharge impacts was carried out by visiting sites on all the main rivers and tributaries in the coalfield areas to visually assess the presence or absence of ferruginous deposits.

The rivers were visited at a minimum frequency of one site every km along their lengths within the coalfield area. All tributaries were visited at a minimum of one site, usually within one km of the confluence with the main river, plus additional sites on larger tributaries.

Sections with known or suspected minewater discharges, or where vehicular access was unsuitable were walked. All sites visited and lengths walked were marked on both 1:10,000 and 1:50,000 OS maps, and ferruginous sites were identified.

2.3 Ferruginous sites

For the purpose of this survey, sites were regarded as lengths of rivers affected by minewater discharges, even if there were multiple discharges (within a short distance of each other) into that reach. The downstream impact was measured as a sum of the discharges and multiple discharges within a reach were counted as one site.

Ferruginous sites were sampled as follows:

The following data were determined, either in the field or in the laboratory, for upstream and downstream of the discharge, and for the discharge itself.

Field Data	Laboratory data
Width of river.	pH.
Dilution of ferruginous input where it enters the watercourse, visual assessment (eg. 10:1, 100:1, 1000:1)	Suspended solids (mg/l).
Length of river affected.	Total alkalinity (mg/l).
% Bed affected.	Dissolved sulphate (mg/l).
Surface area affected (calculated from length x average width x % bed affected).	Total aluminium (mg/l).
Colour intensity and degree of flocculant deposit.	Dissolved aluminium (mg/l).
pH.	Total iron (mg/l).
Dissolved oxygen (mg/l).	Dissolved iron (mg/l).
Conductivity (uS).	Dissolved oxygen (% saturation).
Water temperature (^{0}C)	

3. STAGE 1 RESULTS

Between October 1992 and April 1993 stage 1 of the ferruginous minewaters project was completed. A total of one thousand and sixty five sites were visited and 90 ferruginous sites were identified as follows.

Table 1 Number and occurrence by catchment of Ferruginous Sites in Wales

Catchments Surveyed	No. of Ferruginous Sites Found	Sampled	Length of River Affected (Km)	Surface Area Affected (1000 m^2)
South East Area				
Llwyd	4	4	3.2	13.8
Sirhowy	2	2	2.2	17.4
Ebbw	2	2	2.4	10.8
Rhymney	6	5	4.2	38.3
Taff	15	15	6.8	21.9
Ely	-	-	-	-
			18.8	102.2
South West Area				
Ogmore	5	4	4.4	10.6
A.Cynffig	2	2	4.5	13.5
Afan/Pelenna	13	13	16.1	52.4
Neath	9	6	3.3	14.8
Tawe	2	2	1.5	3.2
Loughor	11	11	8.9	18.3
Gwendraeth Fawr	2	2	0.3	0.3
Gower	3	3	0.6	4.0
			39.6	117.1
Pembrokeshire	3	3	0.6	0.6
North				
Dee/Alyn	11	8	0.4	0.4
GRAND TOTAL	90	82	59.4	220.3

A total length of 59.4 km of river within the South, Pembrokeshire, and North Wales coal measures were found to be affected by ferruginous minewaters (Table 1).

Rivers in the South West area accounted for 39.6 km of the total length; the Afan/Pelenna catchment being the worst in the area. The rivers of the South East area were affected over a distance of 18.8 km; the Taff/Rhondda catchments being the worst affected in this area. Rivers in the smaller Pembrokeshire and North Wales coal measures were affected over 0.6 km and 0.4 km length respectively. The size and extent of the problem in these areas compared to the South East and South West areas is considered to be small..

A total area of 220.3 x $10^3 m^2$ of river bed was visually affected by ferruginous minewaters in Wales (Table 1). The Rhymney and Taff/Rhondda catchments in the South East, and the Afan/Pelenna and Loughor catchments in the South West account for most of the total area of affected river in the Welsh coalfields. The area of river bed affected in the Pembrokeshire and the North Wales coalfields was much smaller in comparison (Table 1).

4. THE RANKING OF MINEWATERS LOCATED IN STAGE 1 OF THE STUDY

The data collected in stage 1 of the minewaters survey were reviewed and assessed and a ranking method for the impact of minewater discharges on rivers was developed. The ranking was used to identify which sites should be fully assessed in stage 2.

4.1 METHOD

The following criteria (listed in order of importance as indicators of environmental impact) were used to describe the impact of ferruginous minewater discharges on receiving waters. Each impact criterion was graded high, medium or low based either on absolute ranges or on distributionally derived ranges which are described further below.

Table 2. Grading of Physicochemical Data From Stage 1 Surveys

IMPACT CRITERIA (In Decreasing Order of Importance)	HIGH (A)	MEDIUM (B)	LOW (C)	NO IMPACT (D)
1. AREA AFFECTED (m^2)	> 2,500	10-2,500	< 10	-
2. LENGTH AFFECTED (Km)	> 0.5	0.01-0.5	< 0.01	-
3. SUBSTRATE QUALITY FOR SALMONID REPRODUCTION	ROCKS/ STONES/ GRAVEL	BEDROCK/ BOULDERS/ ROCKS	ARTIFICIAL CHANNEL SAND/SILT	-
4. IRON DEPOSITION (VISUAL)	HIGH	MEDIUM	LOW	-
5. TOTAL IRON (mg/l)	> 3.0	2 - 3	< 2.0	-
6. pH, DO (%), TOTAL Al (mg/l)	3 FAILURES	2 FAILURES	1 FAILURE	NO FAILURES

The ranking was perfomed in a specific order, so that rivers and streams which received an A rating for area of river bed affected appeared at the top of the list, followed by all those receiving a B rating etc. to give three main groups. These were then ranked according to the second criterion, length of river affected, to give three sub-groups per main group. Each sub-group was then ranked according to quality of substrate and so on for the remaining parameters. For example, a site with an A rating for area affected but a B rating for all other parameters appears above a site with a B rating for area affected and an A rating for all other parameters.

This dichotomous method of ranking was derived, following a series of trials with various scoring techniques, as the best assessment of the data.

The discharges were ranked separately for classified and unclassified stretches so that the most severe cases could be identified for each of the two types according to the number of A, B, and C ratings. A number of discharges to both classified and smaller, unclassified rivers were selected from these lists for the second stage assessment as it was considered important to assess ferruginous minewater impacts on headwater streams as well as on main rivers.

4.2 DESCRIPTION OF IMPACT CRITERIA

4.2.1 Area and length affected

Both the area and length of river bed affected by iron hydroxide deposition were used to indicate potential loss of aquatic habitat and were therefore considered to be the two most important measures of impact. However the area affected was considered to be the best overall measure of potential loss of habitat to the aquatic fauna. Area can be large even when the length affected is relatively short, if the channel is wide and the percentage cover is high. Area was therefore considered the most important criterion and was calculated from the actual length of river affected by visible evidence of ferruginous deposits x the average width of river channel x the percentage cover of the bed. Length of river affected is more a measure of the scale of visual impact and, although it may not always reflect ecological impact as well as area, it is important to the public perception of impact.

4.2.2 Substrate Quality

Substrate was classified according to its potential to support diverse fauna and salmonid reproduction. Absolute classes were used, based upon the critical criteria from the HABSCORE and RIVPACS computer models. Classification of the quality of substrate is similar in the two models and requires visual assessment of the substrate based upon the percentage composition of bedrock, boulders, cobbles, gravel, silt and sand.

4.2.3 Iron Deposition

A visual assessment of the depth and amount of ferruginous material (ochre) was performed in the field. This gave a comparative measure of the physical blanketing and binding of the substrate by iron hydroxide precipitation and was subjectively assessed as high, medium or low. This is a relative measurement which was applied across the region with photographic evidence to support it.

4.2.4 Iron concentration in receiving water

The ranges for the bands describing iron concentration downstream of the discharge were based on a proposed Environmental Quality Standard of 2 mg/l total iron (annual average) for surface waters supporting salmonids (Mance G. and Campbell J.A. 1988)

4.2.5 Other chemical criteria

pH, dissolved oxygen and aluminium concentration were grouped together so that a combined score was given based on how many parameters were adversely affected by discharges at each site. Failures for each parameter were established, if the following values occurred in the receiving water downstream of a discharge:

pH values less than 7
DO values less than 70% saturation
Total aluminium concentration downstream of discharge greater than the EQS of 1 mg/l (ie. The EQS for surface waters of pH 6-8).

5. RESULTS OF RANKING EXERCISE - STAGE 1

Tables 3.1 and 3.2 are ranked lists of all the identified ferruginous minewaters discharging to classified and unclassified rivers with the discharges having the greatest impact appearing at the top of the tables. It can be seen from tables 3.1 and 3.2 that there is a good spread of sites showing high (A), medium (B) and low (C) impact for the determinands used in the ranking.

The selection of sites for full impact assessment, in stage 2, was based upon impact demonstrated in stage 1 of the study as shown in tables 3.1 and 3.2. The top 19 discharges to classified waters had high or medium impacts on the area and length of river to which they discharged. Impact upon substrate, and water quality was also typically high and these sites were selected for study in stage 2. 10 discharges to unclassified waters which also had a high impact upon the area and length of river affected and a significant effect upon the other determinands used in the ranking were selected for study in stage 2. A further 4 discharges to the Afan/Pelenna catchment were included for study because of the remedial work planned for that catchment.

Summarising, a total of 33 discharges were selected for full impact assessment in stage 2 of the study and included the top 19 discharges to classified waters, the top 10 discharges to unclassified waters and 4 additional sites on the Afan/Pelenna (See Tables 3.1 and 3.2). This gave a realistic number of sites to survey in stage 2 selected from a range of classified and unclassified streams, ensuring that discharges throughout the coalfield measures were studied.

The discharge to the Neath canal near Ynysarwed (62) which arose in spring 1993 was assessed after stage 2 had commenced. Details of this most recent discharge are included in Appendix 3.

Table 3.1 Table Showing the Scale of Impact of Ferruginous Minewaters to Welsh Classified Rivers

RANK	SITE NO.	CATCHMENT	RECEIVING WATER	LAB REFERENCE	SCORE FOR AREA AFFECTED	SCORE FOR LENGTH AFFECTED	SCORE FOR QUALITY OF SUBSTRATE	SCORE FOR DEPOSITION	SCORE FOR TOTAL IRON DOWNSTREAM OF DISCHARGE	CUMULATIVE SCORE FOR pH DO ALUMINIUM	WIDTH OF RIVER CHANNEL
1	24/25	AFAN	NANT BLAEN PELENNA	E 248125	A	A	A	A	A	C	MEDIUM
2	30	LOUGHOR	MORLAIS	E 253202	A	A	A	A	A	D	MEDIUM
3	26	AFAN	TRIB OF GWENFFRWD	E 248122	A	A	A	A	A	D	SMALL
4	5	SIRHOWY	SIRHOWY	E 250287	A	A	A	A	C	C	LARGE
5	16	KENFIG	NANT CRAIG Y ABER	E 251699	A	A	A	A	C	D	SMALL
6	1	LLWYD	A.LLYWD	E 245758	A	A	A	A	C	D	MEDIUM
7	23	AFAN	FFRWD WYLLT	E 248826	A	A	A	A	C	D	MEDIUM
8	7	RHYMNEY	RHYMNEY	E 250770	A	A	B	A	B	D	V.LARGE
9	19	AFAN	NANT GWYNFI	E 251087	A	A	B	A	B	D	SMALL
10	4	EBBW	EBBW	E 246784	A	A	B	A	C	D	MEDIUM
11	21	AFAN	A.CORRWG	E 248118	A	A	B	A	C	D	MEDIUM
12	2	LLWYD	LLWYD	E 250291	A	A	B	A	C	D	LARGE
13	3	LLWYD	LLWYD	E 245761	A	A	B	B	C	D	LARGE
14	6	SIRHOWY	SIRHOWY	E 246320	A	B	A	A	C	D	V.LARGE
15	13	TAFF	RHONDDA	E 250776	A	B	B	B	B	D	LARGE
16	34	DEE	BROUGHTON BROOK	E 165767	B	B	A	A	A	C	V.SMALL
17	9	TAFF	UNNAMED TRIB	E 249926	B	B	A	A	C	D	SMALL
18	10	LLWYD	UNNAMED TRIB	E 233777	B	B	A	A	C	D	SMALL
19	22	AFAN	FFRWD WYLLT	E 251696	B	B	A	B	C	D	SMALL
20	67	LOUGHOR	LOUGHOR	E 254179	B	B	A	B	C	D	LARGE
21	54	NEATH	CLYDACH	E 254182	B	B	A	C	B	D	LARGE
22	83	DEE	CEGIDOG	E 165674	B	B	A	C	C	D	SMALL
23	47	TAFF	TRIB OF CYNON	E 249923	B	B	A	C	C	D	SMALL
24	20	AFAN	AFAN	E 251090	B	B	A	C	C	D	MEDIUM
25	53	AFAN	AFAN	E 251687	B	B	B	B	C	D	MEDIUM
26	85	DEE	ALYN	E 165680	B	B	B	C	A	D	LARGE
27	63	TAWE	A.TWRCH	E 254349	B	B	B	C	C	D	LARGE
28	84	DEE	DEE	E 165764	B	C	A	A	B	D	V.LARGE
29	37	RHYMNEY	RHYMNEY	E 246787	C	C	A	B	C	D	LARGE
30	79	DEE	R.TERRIG	E 165671	C	C	A	B	C	D	SMALL
31	55	NEATH	CLYDACH	-	C	C	A	B	C	D	LARGE
32	81	DEE	ALYN	E 165668	C	C	A	C	A	C	SMALL
33	72	GWENDRAETH	GWENDRAETH FAWR	E 252759	C	C	A	C	C	D	MEDIUM
34	36	RHYMNEY	RHYMNEY	-	C	C	A	C	C	D	LARGE
35	51	OGMORE	N. GARW	-	C	C	A	C	C	D	MEDIUM
36	78	ALYN	ALYN	-	C	C	A	C	C	D	SMALL
37	86	DEE	ALYN	-	C	C	A	C	C	D	MEDIUM
38	87	DEE	ALYN	E 165677	C	C	A	C	C	D	MEDIUM
39	48	TAFF	RHONDDA FACH	E 249930	C	C	B	C	C	D	LARGE
40	57	NEATH	DULAIS	-	C	C	B	C	C	D	LARGE
41	58	NEATH	NEATH	-	C	C	B	C	C	D	LARGE

Table 3.2 Table Showing the Scale of Impact ofFerruginous Minewaters

RANK	SITE NO.	CATCHMENT	RECEIVING WATER	LAB REFERENCE	SCORE FOR AREA AFFEC
1	31	GOWER STREAMS	CLYNE TRIB.	E 253388	A
2	33	TAWE	UNNAMED TRIB	E 254517	A
3	29	LOUGHOR	CATHAN	E 253391	A
4	12	TAFF	Y-FFRWD	E 247257	A
5	15	OGMORE	LLYNFI TRIB.	E 245148	A
6	14	OGMORE	OGWR FACH	T 251084	A
7	69	LOUGHOR	UNNAMED TRIB	E 253008	A
8	18	AFAN	A.CORRWG FECHAN	E 248112	A
9	11	TAFF	CWM CLYDACH	E 247254	A
10	17	AFAN	A.CORRWG	E 248115	A
11	62	NEATH	NEATH CANAL	E 281139	A
12	64	LOUGHOR	UNNAMED TRIB	E 253554	B
13	68	LOUGHOR	UNNAMED TRIB	E 253545	B
14	56	NEATH	CRYNANT	E 256703	B
15	28	AFAN	NANT-Y-FEDW	E 251684	B
16	43	TAFF	UNNAMED TRIB	T 251082	B
17	65	LOUGHOR	UNNAMED TRIB	E 252762	B
18	39	RHYMNEY	RUDRY BROOK	E 246326	B
19	46	TAFF	UNNAMED TRIB	T 249927	B
20	32	LOUGHOR	NANT MELYN	E 254346	B
21	70	LOUGHOR	UNNAMED TRIB	E 253548	B
22	71	GWENDRAETH	UNNAMED TRIB	E 253006	B
23	44	TAFF	UNNAMED TRIB	E 247251	B
24	41	TAFF	NANT CAEACH	E 256853	B
25	45	TAFF	LLYS NANT	E 247260	B
26	50	OGMORE	GARW FECHAN	E 245145	B
27	66	LOUGHOR	NANT-Y-CI	E 253551	B
28	27	AFAN	TRIB OF NANT CREGAN	E 251690	B
29	76	PEMBROKESHIRE	CRESSWELL	E 253952	B
30	35	EBBW	NANT CYFFIH	T 250288	B
31	77	PEMBROKESHIRE	UNNAMED STREAM	E 253955	B
32	49	TAFF	UNNAMED TRIB	T 251083	B
33	73	GOWER STREAM	UNNAMED TRIB	T 253204	B
34	60	NEATH	GARWED BROOK	E 256697	B
35	59	NEATH	CLYDACH BROOK	E 256694	B
36	40	RHYMNEY	UNNAMED TRIB	T 256850	B
37	75	PEMBROKESHIRE	UNNAMED TRIB	E 253949	C
38	42	TAFF	UNNAMED TRIB	E 246323	C
39	52	OGMORE	NANT CYNFFIG	T 251700	C
40	61	NEATH	R.GWRACH	E 256700	C
41	74	GOWER STREAM	UNNAMED TRIB	E 253384	C
42	80	DEE	UNNAMED TRIB	E 165595	C
43	38	RHYMNEY	UNNAMED TRIB	T 250284	C
44	82	DEE	UNNAMED TRIB	-	C

to Welsh Unclassified Rivers

TED	SCORE FOR LENGTH AFFECTED	SCORE FOR QUALITY OF SUBSTRATE	SCORE FOR DEPOSITION	SCORE FOR TOTAL IRON DOWNSTREAM OF DISCHARGE	CUMULATIVE SCORE FOR pH DO ALUMINIUM	WIDTH OF RIVER CHANNEL
	A	A	A	A	B	SMALL
	A	A	A	B	C	SMALL
	A	A	A	C	C	SMALL
	A	A	A	C	D	SMALL
	A	A	A	C	D	SMALL
	A	A	B	C	D	MEDIUM
	A	A	B	C	D	V.SMALL
	A	B	A	B	D	MEDIUM
	A	B	A	C	D	MEDIUM
	A	B	A	C	D	MEDIUM
	A	C	A	A	D	MEDIUM
	A	A	A	B	C	SMALL
	A	A	A	B	D	SMALL
	A	A	A	C	C	MEDIUM
	A	A	A	C	D	SMALL
	A	A	A	C	D	SMALL
	A	A	A	C	D	SMALL
	A	A	B	B	D	SMALL
	A	A	B	C	D	SMALL
	A	A	B	C	D	SMALL
	A	A	C	C	D	SMALL
	B	A	A	B	C	V.SMALL
	B	A	A	B	D	SMALL
	B	A	A	C	D	SMALL
	B	A	A	C	D	SMALL
	B	A	A	C	D	SMALL
	B	A	A	C	D	V.SMALL
	B	A	B	B	D	SMALL
	B	A	B	B	D	V.SMALL
	B	A	B	C	D	V.SMALL
	B	A	C	C	B	V.SMALL
	B	A	C	C	D	SMALL
	B	A	C	C	D	V.SMALL
	B	B	A	A	B	MEDIUM
	B	B	A	C	D	MEDIUM
	B	C	A	C	D	V.SMALL
	B	A	C	C	D	V.SMALL
	C	A	A	C	D	SMALL
	C	A	B	C	D	SMALL
	C	A	C	C	D	SMALL
	C	A	C	C	D	MEDIUM
	C	C	B	B	D	V.SMALL
	C	C	C	C	D	V.SMALL
	C	C	C	C	D	V.SMALL

6. STAGE 2 METHODOLOGY

6.1 Survey procedures

A total of 33 sites (see catchment maps Appendix 1) identified and assessed in stage 1 of the minewaters study were selected for full impact assessment in stage 2 of the study, 20 of these sites were located in SW area, 12 were in SE area and 1 in the Northern area.

6.1.1 Biological impact assessment

Biological assessments were carried out at each site by taking upstream, immediate downstream and subsequent downstream samples, at short intervals, to a point where the visible effects of iron deposition had ended. The final sampling point was considered to represent a point of recovery. Biological sampling produced a total of 112 samples from the 33 sites. These samples were obtained using the standard Institute of Freshwater Ecology (IFE) 3 x 1 minute kick sampling methodology and were processed in the laboratory to give a Biological Monitoring Working Party (BMWP) score for each sample. This involved identifying invertebrates to family level and then allocating each family a score between 0 and 10 according to its sensitivity to pollution. Those with the greatest sensitivity scored 10. The BMWP score is designed particularly for organic pollution but it is also sensitive to other types. The scores for each taxon were totalled to give the BMWP score which provides a numerical estimate of biological quality. Abundance of invertebrate taxa was also estimated on a logarithmic scale of 1-10, 11-100, 101-1000 and used in determining biological impact (See below).

The River InVertebrate Prediction And Classification System (RIVPACS) is a computer model developed by IFE to predict the invertebrate fauna one would expect to find in a variety of natural river types under pristine water quality conditions. The model requires that data on channel width, mean depth, substrate composition and hardness, are collected for each site. Also, the slope and altitude of the site are calculated from 1:50,000 maps as is the distance from source. A grid reference allows the model to locate the site geographically and, in conjunction with the above data, the package can be used to predict the expected fauna and BMWP score of a site assuming it was in pristine condition. The model uses biological survey data from sites all over the country to achieve these predictions. The ratio of the observed (O) to the expected (E), BMWP scores can be used as an Environmental Quality Index (EQI). See section 10 for further information on the EQI.

The impact of a minewater discharge was considered to be significant when a reduction in BMWP score of $\geq$ 40% occurred between the upstream and immediate downstream sites. Additionally, a reduction in $\log_{10}$ abundance of 4 or more high scoring families (i.e. $\geq$6) was used to reflect more subtle changes in species abundance (See Appendix 10C worked example). A combination of these two criteria was used to grade the biological impact as follows :-

HIGH IMPACT (A) A reduction in BMWP score $\geq$40 % between the upstream and immediate downstream site AND a reduction in $\log_{10}$ abundance between the upstream and downstream sites of 4 or more families scoring $\geq$6 on the BMWP system.

MEDIUM IMPACT (B) Either: A reduction in BMWP score $\geq$40 % between upstream and downstream site;

Or A reduction in $\log_{10}$ abundance between the upstream and downstream site of 4 or more families scoring $\geq$6 on the BMWP system.

NO IMPACT (C) Neither of the criteria in A or B.

Biological data was also used to indicate the area of river bed impacted by a minewater discharge by measuring the surface area of bed affected between the discharge and the first point downstream at which the biological quality (C) was the same or better than upstream of the discharge. The area affected was graded into high (A), medium (B) or low (C) impact categories and the band sizes for each category were the same as applied in the stage 1 ranking for area of river bed affected. viz:-

IMPACT		AREA AFFECTED (m^2)
High	(A)	> 2,500
Medium	(B)	10 - 2,500
Low	(C)	< 10

6.1.2 Fisheries Impact Assessment

Quantitative electrofishing surveys were carried out upstream and immediately downstream of the minewater discharges at 15 sites in SW area and 4 sites in SE area. A number of sites were not electrofished, for a variety of practical reasons. For example, the Tawe tributary (33) and Broughton brook (34) had very low flow upstream of the discharges and were considered to be unsuitable for salmonids. The site at Newbridge on the R. Ebbw (4) was not surveyed because of continuing reclamation of the adjacent colliery site and the recent re-channelisation of the river (see stage 2 results).

HABSCORE is a computer model which predicts the numbers of fry (0+) and parr (>0+) (which are both stages of growth <1 year old) at a site, based upon the physical characteristics of unpolluted sites in Wales (Milner & Wyatt 1991). The model requires field data to be collected which includes; for each 10 m section electrofished, measurements of the channel width, depth and substrate composition (similar to RIVPACS). The stretch is described as riffle, run etc and the bankside vegetation, important to salmonids for cover, is also classified along with land use. The slope, gradient, catchment area, altitude and distance from source are calculated from 1:50,000 maps. The conductivity of the site is recorded in the field using portable meters. HABSCORE was used to quantify the potential of the fishery habitat, called the Habitat Quality Score (HQS) and the Habitat Utilisation Index (HUI) (see Appendix 12).

Fisheries data were assessed according to the method used by the NRA for the Regional Juvenile Salmonid Monitoring Programme (RJSMP) as shown below.

Fish densities for fry (0+) and parr (>0+) (< 1 year old) age groups are divided into five categories as follows:-

ABUNDANCE CATEGORIES (Number per 100 m^2) FOR JUVENILE SALMONIDS FOR QUANTITATIVE RUNS

	Fry (0+)	Parr (>0+)
Excellent	>100	>25
Good	50.01-100	15.01-25
Moderate	25.01-50	5.01-15
Poor	0.01-25	0.01-5
Absent	0	0

These abundance categories are then combined to give a classification matrix as follows:-

CLASSIFICATION MATRIX FOR JUVENILE SALMONIDS

		(Fry (0+)				
		Excellent	Good	Moderate	Poor	Absent
	Excellent	A	A	A	B	C
	Good	A	A	B	B	C
Parr	Moderate	A	B	B	C	D
(>0+)	Poor	B	B	C	D	D
	Absent	C	C	D	D	E

Reductions in regional juvenile salmonid monitoring programme (RJSMP) class between the upstream and downstream sites were used as a measure of the impact of minewaters on fisheries as follows.

A reduction of 2 classes between u/s and d/s = A (High impact)

A reduction of 1 class between u/s and d/s = B (Medium impact)

No change in class between u/s and d/s = C (No impact)

The HABSCORE indices (HQS and HUI) were also used in the interpretation of significant changes (Appendix 12) and to determine where habitat quality was more limiting than water quality.

6.1.3 Water sampling

All 33 sites were sampled chemically a second time when the biological surveys were carried out, and a third time during the fishery surveys using the same methods and for the same parameters as in stage 1 of the survey (See section 2.3).

6.1.4 Flow gauging

The flow of the minewater discharges were gauged by SE area and SW area hydrology departments using standard flow gauging methods. Results are cited in Appendix 9.

7. STAGE 2 RESULTS

7.1 WATER QUALITY AND FLOW

All the 33 minewater sites selected for full impact assessment were sampled on three occasions in the periods: November 92 - April 93, June 93 and July - October 93 except for Broughton Brook (34) in the North which was sampled on two occasions. Results are tabulated in appendices 5-7. Chemical analysis data is summarised in Appendix 8 and flow measurements for the discharges are summarised in Appendix 9

7.1.1 Temperature

The results for mean temperature indicate that in all cases there was little difference between the discharge and the receiving watercourse. However, the discharge temperatures tended to be fairly constant throughout the year so that during the winter period they were approximately $2^{0}C$ higher than the temperature of the receiving water. Small increases in temperature were observed at many downstream sites, though these increases are not considered to be high enough to significantly affect the biota.

7.1.2 Dissolved oxygen

Before they discharge, minewaters can be low in dissolved oxygen due to absorption of oxygen during the oxidation of pyrites below ground. Further rapid oxidation to iron hydroxide which precipitates in the receiving watercourse, also requires oxygen. The results show that at the majority of sites only a small reduction in oxygen concentration occurred downstream of the discharge. The oxygen capacity of the receiving waters was sufficient to meet the oxygen demand of the minewater discharges without the dissolved oxygen falling to levels which could be deleterious to the aquatic biota. A value of 70 % oxygen saturation was considered to be the value below which salmonid fisheries and sensitive invertebrate taxa might start to be affected (Proposed statutory water quality objective).

Sites at which the dissolved oxygen of the receiving water was affected included Broughton Brook (34), in North Wales, where the stream is composed almost entirely of minewater. There was a large reduction in dissolved oxygen downstream of this discharge, to a mean of 36% saturation (Appendix 8). At this level the stream could not support salmonids and the low oxygen saturation would also affect many invertebrate taxa. Moderate reductions in downstream

dissolved oxygen were also noted on the A. Corrwg fechan (18), R. Morlais (30), R. Clyne (31) and the N. Melyn (32).

In a small stream near Saundersfoot (site 75) the minewater caused a substantial reduction in dissolved oxygen from 98.6 % saturation upstream to 39.2 % saturation downstream of the discharge in the spring (Appendix 3). The levels of oxygen at this site were clearly unsatisfactory and would effect the survival of salmonids. However, dissolved oxygen levels at most sites were not significantly reduced and low oxygen below the minewater discharges was generally not a problem.

7.1.3 pH

A low pH is often associated with mine drainage due to the chemical processes occurring underground. Such discharges are also frequently referred to as acid mine drainage. However, the results of sampling ferruginous minewaters in the South and North Wales coalfields demonstrate that most of these discharges were not particularly acidic. Only four of the 33 discharges had a mean pH less than 6. These were the discharges to the Nant Blaenpelenna (25), the Gwenffrwd (26), the R. Cathan (29) and the Tawe tributary (33) (Appendix 8). The discharge to the Gwenffrwd (26) compounds the pH problems of the receiving watercourse which was acidic upstream of the discharge on all sampling occasions (Appendix 6). The absence of salmonids from sites (18) and (26) is a reflection of this impact (Appendix 11). The effects of acid pH were also evidenced by the impoverished macroinvertebrate fauna of sites (18), (25) and (26) both upstream and downstream of the discharges (Appendix 10, 10a).

It is assumed that the majority of minewaters had been neutralised by the limestone which is associated with the South Wales coal measures, especially in the eastern area, before they emerged to the surface. As a result precipitation of iron hydroxide occurred quickly at or near the point of entry to the watercourse. Where pH of the minewater discharge and the receiving watercourse were more acidic the rate of precipitation was slower. This was the case for the N. Blaenpelenna (25) and explains why the visual intensity of deposition increased several hundred metres below the discharge. Part of the reason why such a long stretch of the river is affected is that the iron is taking longer to come out of solution. In the SE area the rivers are near neutral and the discharges are generally less acidic than in SW area. As a result of this the rate of precipitation of iron was generally faster and the area affected was relatively less but the degree of deposition of iron hydroxide was generally greater near to the discharge.

7.1.4 Iron

The iron content of the minewaters was the most important chemical criterion affecting the downstream water quality of the rivers. The Environmental Quality Standard (EQS) of 2 mg/l total iron was exceeded on at least one sampling occasion at eleven of the highest ranked sites including the R. Sirhowy at Pontllanfraith (6), R. Rhymney at Hengoed (7) N. Craig yr Aber (16), N. Blaenpelena (25) and the R. Morlais (30) where the volumes of minewater are relatively large (Appendix 9). Iron concentrations above 2 mg/l can be harmful to fish and may impact on the fishery (See fishery results and discussion section). The N. Gwynfi (19) and the N. Melyn (32) also failed the EQS for iron on at least one sampling occasion.

High concentrations of total iron were observed downstream of the discharge in the N. Craig yr aber (16) 3.17 mg/l, N. Blaenpelenna (25) 5.81 mg/l, the Gwenffrwd (26) 4.21 mg/l, R. Morlais (30) 16.46 mg/l, R. Clyne (31) 5.37 mg/l, Tawe tributary (33) 3.06 mg/l and Broughton Brook (34) 6.26 mg/l. Alabaster & Lloyd (1980) suggest that for iron hydroxide 'there is no evidence that average concentrations less than 25 mg/l have done any harm to fish or fisheries.' These findings refer to the direct toxicity of iron on fish and not the indirect effects of loss of food organisms or spawning gravels which result from the precipitation of iron hydroxide and which may have an impact upon the status of the fishery. However, Alabaster and Lloyd (1980) note a case whereby iron hydroxide precipitating, from acid solutions containing 3 mg/l iron onto the gills of trout was acutely toxic when pH values rose above 5.5. This suggests that the actual process of iron precipitation is damaging to fish.

7.1.5 Aluminium

The amount of dissolved aluminium, the toxic component, in freshwater is dependant upon the pH of the water. Between pH 5-8 aluminium is least soluble and has a low toxicity to the biota. At many of the sites in this survey the pH values were within this range. When the pH becomes more acidic the amount of dissolved aluminium increases causing a subsequent increase in the toxicity. It was found that aluminium did not exceed the EQS of 1 mg/l at pH 6 - 8 at any of the sites receiving full impact assessment. The discharge to the Gwenffrwd (26) contained 0.969 mg/l dissolved aluminium on one sampling occasion but downstream the concentration was 0.031 mg/l at pH 6.4 which is within the EQS for aluminium.

Garwed Brook, (60) which is a tributary of the R. Neath, received a minewater discharge which contained 22.38 mg/l of dissolved aluminium and had a pH of 3.07. The high aluminium concentration of this discharge is compounded by the receiving watercourse also being acidic (pH 5.73) and downstream of the discharge the dissolved aluminium concentration considerably exceeded the EQS (6.9 mg/l at a pH of 3.59). However, the site was not ranked highly on the other criteria (physical/visual) in stage 1 and so was not surveyed in stage 2.

7.1.6 Suspended solids

Suspended solids at concentrations of less than 25 mg/l are considered to have no direct impact upon freshwater fisheries (Alabaster & Lloyd, 1980). The concentrations of suspended solids (SS) downstream of most minewater discharges generally remained well below 25 mg/l. In the range of 25-80 mg/l SS Alabaster and Lloyd (1980) suggest sites should support moderate or good fisheries. For all of the sites included in the impact assessments, the maximum concentrations of suspended solids did not exceed the above concentrations downstream of the discharge eg. R. Corrwg (21) 28 mg/l, Nant y fedw (28) 35 mg/l, R. Morlais (30) 74 mg/l, R. Clyne (31) 50 mg/l and the Tawe tributary (33) 34 mg/l. It is important to note that increases in the level of suspended solids, over a short distance below a discharge, were not unusual due to the precipitation of iron hydroxide. During high flow events scouring of the ochreous deposits from the river bed may result in much higher suspended solid concentrations occurring in the areas of ferruginous deposition, but these have not been measured. High suspended solid concentrations during rainfall events are in any case a 'natural' phenomenon and fish and invertebrates are generally well adapted to cope with them.

7.1.7 Sulphate and Alkalinity

Sulphate and Alkalinity were measured to enable a better understanding of the hydrogeology of the coalfield and the quality of the minewater discharges. They are however not particularly relevant to the biology or fisheries components of this study.

Mine drainage may contain high concentrations of sulphates due to the oxidation of pyrites. In 32 of the 33 sites sampled, on more than one occasion it was found that downstream sulphate concentrations were increased, often by as much as several hundred percent.

7.1.8 Flows

Minewater discharges were flow gauged to provide information on the volume of minewater entering a watercourse. A minewater discharge large in volume may, for example, enter a small stream and cause significant ecological impact. However, the discharge may be important to the baseline flow of that stream. Flow gauging of the discharges provided information useful for explanation of ecological impact but was also important to the understanding of the hydrogeology of the system.

7.2 BIOLOGICAL IMPACTS

In this section, the biological impact assessments are reviewed and compared with the results of chemical analysis carried out in stage 2. Details on criteria for assigning the level of impact are given in sections 6.1.1 and 8.0. Biological assessments are listed in Appendix 10.

7.2.1 Discharges having a high biological impact

A high (A) biological impact was shown at 10 sites, which included the 3 most significant discharges to classified waters and the top 2 discharges to unclassified waters, as ranked at the end of stage 1 (Tables 3.1 and 3.2). This indicates a correlation between physical/chemical impact (stage 1) and actual biological impact as demonstated in stage 2. Of the top 10 sites showing a high biological impact, 7 are located in S.W area and 3 are located in S.E area.

The site at which the greatest environmental impact occurred was below the discharge from Morlais colliery, Llangennech, Llanelli. This discharge drains minewater from the old Brynlliw colliery and discharges to the R. Morlais near to the confluence with the R. Loughor. The site is near to the tidal limit of the Loughor estuary. A riffle site was sampled downstream of the discharge but further downstream sampling was not possible because of the physical changes in substrate at the tidal limit. However, the 82 % reduction in BMWP score between the upstream and immediate downstream site was highly significant and the minewater was having a dramatic impact upon the invertebrate fauna. The number of taxa scoring ≥ 6 (ie. those taxa scoring 6 or more in the BMWP score, see Appendix 10B) fell from 9 at the upstream site to 1 at the downstream site. The degree of deposition of iron hydroxide at the site was very high and the

downstream iron concentration (max. 26.42 mg/l) was the highest of the 33 sites studied and well in excess of the environmental quality standard (EQS) for total iron. Such a high iron loading had a highly deleterious impact upon the invertebrate fauna causing a complete loss of 14 families and a reduction of 3 families at the site immediately downstream of the discharge. These losses included the high scoring Heptageniidae, Chloroperlidae, Leuctridae, Sericostomatidae, Goeridae and Rhyacophilidae. Other families, notably Gammaridae, Hydroptilidae, Hydropsychidae, Tipulidae, Simuliidae, Planariidae, Hydrobiidae and Baetidae also suffered loss. The ferruginous deposits impacted upon a wide range of families some of which are recognised as tolerant of other forms of pollution (eg. sewage).

Although the Nant Craig yr Aber (16) and Y Ffrwd (12) receive discharges in afforested stretches of their catchments, the O:E RIVPACS ratio (the EQI) for the control site on the Y ffrwd was 0.99 and for the N. Craig yr Aber 0.8 which indicated that the upstream biological quality was close to the optimum for these sites. The upstream site on the N. Gwynfi (19), however had an RIVPACS EQI of 0.59 which is significantly poorer and suggests that the upstream water quality of this site is not pristine. The cause of this poor upstream quality is not evident but it may be due to the smaller diffuse sources of iron which occur upstream in the catchment. However, there were no visible affects of iron at the upstream site during site visits. Although in an afforested section of the catchment acidification of this watercourse was not evident from the water quality data, pH values being near neutral. The values for iron and aluminium at the upstream site were also below the EQS's.

At sites (16 and 19) the area of river bed biologically impacted was high and downstream water quality was poor with the mean iron concentration exceeding the EQS of 2 mg/l at site 16 (3.17 mg/l). On one occasion the EQS for iron was also exceeded at site 19 (Appendix 6). In the N. Craig yr Aber (16) 10 families were lost below the discharge and there was a reduction in abundance of 3 families. A reduction in the abundance of Chironomidae at this site was particularly unusual as this family is considered to be less sensitive to many types of pollution than most other invertebrate families. At site 19 a reduction in Oligochaeta and Chironomidae was also noted. Reductions in the abundance of the stonefly Leuctridae were observed and Sericostomatidae were lost from both sites below the discharges.

In the Y Ffrwd (12), a tributary of the R. Clydach, 8 taxa were lost downstream of the discharge and a reduction in BMWP score of 62 % was observed. The EQS for total iron was not exceeded downstream of the discharge on any sampling occasion.

The major discharges to the Gwenffrwd (26) and the Nant Blaenpelenna (25) caused a high biological impact over a large area of river bed. These two discharges were ranked numbers 3 and 1 respectively in stage 1 of the study. Both are in upland areas with substantial afforestation. On the Nant Blaenpelenna (25) 10 families were found at the upstream site giving a BMWP score of 58. Only Leuctridae and Chloroperlidae represented those families scoring 10 and taxa scoring a range of BMWP scores made up the rest of the fauna. A reduction in diversity at the downstream site to just 4 families resulted in a significant reduction (69%) in BMWP score. The RIVPACS EQI values for the upstream samples at both sites were indicative of poor water quality (being 0.62 for the N. Blaenpelenna (25) and 0.53 for the Gwenffrwd (26)). The mean pH of both discharges was < 6 but as the pH of the receiving watercourses was already acidic (<7 in the Gwenffrwd on all 3 sampling occasions and < 7 on one occasion in the N. Blaenpelenna at the upstream site) the impoverished fauna at the upstream sites was probably attributable to episodes of low pH.

The discharges to the Gwenffrwd (26) had a similar effect on the biota. A total of 10 families at the upstream site were reduced to 5 families downstream of the discharges. At both site 25 and 26 the low pH of the receiving watercourse meant that the rate of precipitation of iron from solution was delayed and, in conjunction with the high loading of iron in the discharge, explains why such extensive lengths of river were visually impacted.

The discharges to the Tawe tributary (33) and the R. Clyne tributary (31) are to headwater streams with narrow channels and small flows. The impact of minewater discharges on these streams was high due to the heavy deposition of ferruginous precipitates. Further downstream the impact remained high and the area impacted was substantial even though channel width was relatively small. The Tawe tributary (33) saw a loss of 9 taxa below the discharge and a 75 % reduction in BMWP score. No $\geq$ 6 scorers were found at the first downstream site. The R. Clyne tributary (31) supported 17 families upstream of the discharge but this was reduced to only 4 families at the site immediately downstream of the discharge. However, recovery occurred at the subsequent downstream site, 1.2 km below the discharge, where 18 families were present.

The discharge to the R. Llwyd at Pontnewydd (2) also had a high biological impact. Here the RIVPACS EQI of 0.88 suggests that the invertebrate fauna had not been degraded significantly at the upstream site. The high biological impact occurred over a medium area and was demonstrated by a 45 % reduction in

BMWP score between the upstream and immediate downstream sites together with a loss of 5 families scoring 6 or more. The families lost included the high scoring Perlodidae, Leuctridae and Caenidae; additionally reductions in abundance of Gammaridae and Chironomidae were observed at the downstream site.

The discharge to the R. Llwyd (10) at Blaenavon had a high impact with a 98 % reduction in BMWP score downstream of the discharge. A total of 23 taxa were lost below the discharge and the diversity of the upstream site was not realised at subsequent downstream sites.

7.2.2 Discharges having a medium biological impact

A total of 13 discharges were found to cause a medium biological impact and of these, 8 discharges caused a medium impact over a large area (Table 5). At some sites upstream biological quality was relatively poor, as indicated by the RIVPACS EQI, and difficulty was experienced in assessing the true impact of the ferruginous discharges.

The discharges to the A. Corrwg (17) and A. Corrwg fechan (18) had volumes of 0.0249 cumecs and 0.0051 cumecs respectively (Appendix 9). They are similar in that they discharge to their respective watercourses on different sides of the same hill, and at a similar altitude. This suggests that these discharges, which arise from old mines, may be hydrogeologically linked.

The RIVPACS EQI values for the upstream sites on the A. Corrwg (17) of 0.44 and the A. Corrwg Fechan (18) of 0.38 were significantly less than 0.7 and suggest that an impoverished fauna exists at the upstream sites. This may be a result of poor upstream water quality, though the limited water quality data do not indicate there are problems. However, despite the poor upstream quality the impact of the minewater discharges at both sites was still significant and 52 % and 69 % reductions in BMWP scores were recorded at sites 17 and 18 respectively. These impacts resulted in the downstream sections of these watercourses having very limited macroinvertebrate faunas. For example on the A. Corrwg (17) 10 taxa were observed at the upstream site whilst at the first downstream site only 5 taxa remained. Downstream of the discharge to the A. Corrwg fechan (18) 2 taxa remained (Baetidae and Polycentropidae). Polycentropidae was also found downstream of the discharge to the A. Corrwg (17) which suggests this family of caddis is relatively tolerant of ferruginous pollution.

The discharge to the R. Cathan (29), a tributary of the R. Loughor, had a dramatic aesthetic impact on the river down as far as the confluence with the R. Loughor, below which impact was minimal. The pH of the discharge was found to be < 6 on each sampling occasion but at the downstream site the receiving watercourse remained near neutral. Aluminium was not a problem in the discharge, whilst iron was found on one sampling occasion to be just below the EQS at 1.9 mg/l (mean of 1.63 mg/l). The discharge had a medium biological impact based upon the reduction in abundance of high scorers; the reduction in BMWP score was not significant at 12 %.

The discharges to the R. Ebbw (4), R. Sirhowy (5), R. Sirhowy (6) and the R. Rhymney (7) are considered as a group because they are believed to be hydrogeologically linked to the same mining system. The discharge to the R. Rhymney (7) at Hengoed has been the subject of recent litigation against British Coal. The most recent discharge to the R. Sirhowy (5) at Blackwood was first observed in November 1992 and its close proximity to the R. Sirhowy (6) discharge at Pontllanfraith, which is 2 kilometres downstream, suggests it may also be hydrogeologically linked to the aforementioned minewaters.

All 4 discharges were shown to have a medium biological impact upon the receiving water but the area biologically impacted was high. These minewater discharges are large (see appendix 9) particularly those to the R. Rhymney (7), and the resulting deposition of iron over large areas of riverbed cause substantial aesthetic impacts.

The discharge to the R. Ebbw at Newbridge (4) arises from the old North Celynon mine at the site where three shafts were sunk. During 1993 reclamation of the colliery site has caused major changes to the river channel which have affected the biota. Firstly the river was rechannelised from a culverted to an open section and secondly capping of the shafts changed the point of entry of minewater to the river. All minewater now discharges from two adjacent culverts on the left bank. General water quality in this area is poor and sewage litter was recorded at the site on each sampling occasion. The RIVPACS EQI (0.49) for the upstream site indicates the paucity of the upstream fauna due to the poor water quality. Nevertheless despite the problems with upstream water quality due to storm sewage discharges the minewater caused a medium biological impact at this site due to the reductions in the abundance of sensitive invertebrate taxa. pH, aluminium and iron concentrations were all within the recommended EQS limits indicating again that the impact was due to the deposition of ferruginous precipitates.

A total of 4 taxa were lost downstream of the discharge to the R. Sirhowy at Blackwood (5) and at Pontllanfraith (6) 3 taxa were lost, resulting in reductions in BMWP score of 24 and 27 % respectively. At site 6 the upstream RIVPACS EQI of 0.61 suggests that an impoverished invertebrate population existed upstream of the minewater due to poor water quality. Again, evidence of pollution, in the form of sewage litter, was prevalent at this site. Still, despite other pollution problems the area impacted biologically was high at both sites indicating that the minewater discharges cause an additional effect over a large area. The EQS for iron was exceeded on one sampling occasion at site 6 when it reached 3.5 mg/l at the downstream site.

The R. Rhymney (7) at Hengoed also suffers from water quality problems associated with storm sewage and the RIVPACS EQI of 0.64 indicates the degree of impact on the upstream fauna. However, the ochre, deposited over up to 3 kilometres of the R. Rhymney, impacted on the biota over a very large area. Iron failed the EQS at the downstream site when it reached 2 mg/l on one occasion. The mayfly family Heptageniidae were lost at the first downstream site and were reduced in abundance at subsequent downstream sites. Other normally less sensitive families such as Hydroptilidae, Gammaridae, Dytiscidae, Elminthidae and Erpobdellidae were also lost at the first downstream site.

The discharge to the R. Llwyd at Pontypool (3) had a medium biological impact causing a reduction in the abundance of high scoring taxa. The RIVPACS EQI of 0.82 suggests that the Llwyd upstream was not significantly polluted. However, the minewater discharge is also close to a storm sewer overflow which discharges frequently just upstream and may be exacerbating the impact of the minewater on the invertebrate fauna.

At five sites discharges were having a medium biological impact over a medium sized area (B and B respectively). These included minewater from old levels entering the R. Llynfi tributary (15) which impacted on a stream of excellent biological quality where the upstream BMWP score was higher than the predicted (EQI >1.0). The discharge caused a 35 % reduction in score between upstream and immediate downstream sites, which, although not considered significant was an appreciable reduction in biological quality.

The R. Clydach tributary (11) is a similar stream to the R. Llynfi tributary discussed above. The minewater discharge to this stream had a medium impact on the invertebrate fauna causing a significant reduction in the abundance of high scoring taxa. The reduction in BMWP score of 38 %, although again not quite

significant, was substantial and indicated that the discharge was affecting the stream invertebrates. The loss of Heptageniidae, Perlodidae, Sericostomatidae, Philopotamidae and Tipulidae together with reductions in the abundance of Leuctridae, Rhyacophilidae, Baetidae and Oligochaeta illustrate the range of taxa affected.

The discharge to the N. Blaenpelenna (24) from middle mine has a medium biological impact upon the Blaenpelenna with a 46 % reduction in BMWP score downstream of the discharge and a loss of 4 taxa.

The one site surveyed in the North Wales coalfield concerned a discharge to Broughton Brook where the minewater was up to 10 times greater in volume than the flow of the receiving stream. The effects of this were a very high deposition of iron hydroxide downstream of the discharge and a 67 % reduction in BMWP score between the upstream and immediate downstream sites. A wide range of taxa were affected including the loss of Sericostomatidae, Tipulidae, Simuliidae, Asellidae, Hydrobiidae and Lymnaeidae plus reductions in Oligochaeta and Chironomidae below the discharge.

7.2.3 Discharges having no biological impact

Discharges to a total of 9 sites were shown to have no biological impact. The degree of aesthetic impact to the R. Afan (20), the N. Cregan tributary (27), Nant y Fedw (28) and the N. Melyn (32) suggested that the biological impact would not be significant and this was confirmed by the biological data.

The discharges to the R. Rhondda (13) and to the A. Corrwg WDA site (21) which are relatively large watercourses, did not have as significant an aesthetic impact as for example, the discharge to the R. Rhymney (7). Significant biological impacts were not demonstrable at either site as shown by only a 3 % reduction in BMWP scores between the upstream and immediate downstream site on the A. Corrwg (21). The discharge to the R. Rhondda was at a point where sewage litter was evident and the RIVPACS EQI of 0.48 suggests that the upstream fauna was affected by poor water quality, probably as a result of storm sewer overflow discharges. However, the reduction in BMWP score of 30 % between the upstream and downstream site suggests that the minewater was affecting the invertebrate fauna.

Minewater discharging to a small tributary of the R. Dare (9) had no demonstrable biological impact on the receiving watercourse, the 21 % reduction in BMWP score below the discharge and the loss of 3 taxa not being significant.

The minewater discharges to the Ffrwd Wyllt (23) at Goytre and at Bryn (22) had no biological impact as shown by the minimal reduction in BMWP scores between the upstream and downstream sites of 7 % and 2 % respectively.

7.2.4 BIOLOGICAL SENSITIVITY TO MINEWATERS

A more detailed examination of the susceptibility of invertebrates to iron deposition follows:

Across the region a total of 12 taxa were apparently eliminated from the immediate downstream sites by iron hydroxide deposition. They included the mayfly Leptophlebiidae which was lost from only one site, downstream of the discharge to the R. Clyne (31). Its occurrence at only one site is an indication of its rarity in rivers within the coalfield area. Cased caddis larvae of the taxa Goeridae, Odontoceridae and Lepidostomatidae, which are all high scorers in the BMWP index, were absent below a number of discharges. The blanketing effect of iron hydroxide on the substrate may have a threefold effect on cased caddis larvae. Firstly by physically reducing available habitat, secondly by reducing the availability of materials for case building and thirdly by affecting the availability of suitable food. Helodidae and Dryopidae, which score 5 in the BMWP system, were also absent at 100 % of the immediate downstream sites. The lower scoring taxa which were impacted 100 % by minewaters included members of the Gastropoda. viz. Lymnaeidae and Planorbiidae which are likely to be affected by the loss of epilithon (algal layer on substrate) on which these gastropods graze. Sphaeriidae (bivalve) which was lost at 100 % of sites, is a filter feeder and precipitation of iron hydroxide may interfere with this process. In the BMWP scoring system these taxa receive a low score because they show a degree of tolerance to organic pollution. Minewater discharges do not organically enrich the receiving watercourse and the blanketing of substrate by iron hydroxide explains why these taxa were absent below discharges.

Where taxa were present at a reasonable number of upstream sites (ie. >5) they were considered to be ubiquitous in the rivers surveyed and complete loss and/or reductions in abundance of these taxa suggests they are particularly sensitive to ferruginous minewaters. On this basis the following taxa are deemed to be sensitive to minewater discharges; Perlodidae, Chloroperlidae, Sericostomatidae, Cordulegasteridae, Philopotamidae, Limnephilidae, Hydroptilidae, Dytiscidae, Hydrobiidae and Erpobdellidae (Appendix 10A). These

taxa score at all levels in the BMWP index (Appendix 10B) suggesting that the blanketing and binding of substrate by iron hydroxide is highly deleterious to a wide range of invertebrate taxa.

The above taxa could be used as indicators of the impact of ferruginous minewaters either in addition to the BMWP scoring system or as an alternative.

7.3 FISHERIES IMPACT

Quantitative electrofishing surveys were carried out at 19 sites. The aim of the surveys was to identify impacts, if any, on the fishery status of sites receiving minewater discharges.

The upstream fishery quality of the majority of sites was moderate (C) to poor (D). However, at the following sites populations were excellent (A) or good (B):- The Llynfi tributary (15) (A), R. Cathan (29) (B), N. Melyn (32) (B) and the R. Llwyd at Abersychan (1) (B) (Appendix 11). The Llynfi tributary is a small stream with good gravels and the large numbers of fry caught result in the excellent classification. The sites classified as good by the RJSMP classification support moderate to good populations of fry and parr. For the three above sites the good classification was due to the numbers of parr as none of these sites supported large numbers of fry.

The generally moderate to poor fishery quality of many of the receiving waters suggests either that the habitats are unsuitable for salmonid populations or that upstream water quality may be limiting the success of salmonids. These points are considered later.

The R. Clydach tributary (11), N. Craig yr aber (16), A. Corrwg (17), A. Corrwg (21), Ffrwd Wyllt (23), A. Morlais (30) and the R. Clyne (31) all had moderate upstream quality fisheries. These sites, with the exception of site 11 in S.E area, are all located in S.W area. They are located throughout the coalfield and represent all river types from small tributaries to main river channels and from headwaters to site 30 which is near an estuarine confluence.

No fish were caught on the Gwenffrwd (26), in the Pelenna catchment, either upstream or downstream of the discharge. The low pH observed upstream and downstream of the minewater discharge is believed to be detrimental to salmonids, contributing to their absence at this site. No fish were caught at

site (18) on the R. Corrwg Fechan which is also in an upland afforested area. There is also a long steep culverted section downstream which may inhibit fish movement up to this site, but this does not readily explain the absence of the non migratory salmonids.

At 11 sites there was no reduction in RJSMP class due to the minewater discharges. Of these 11, 8 sites showed no change in class and 3 sites had better fish populations downstream of the discharges than upstream. These included two sites where no fish were caught either upstream or downstream (no change), sites where more fish were caught downstream than up and sites where the upstream water quality was poor. In this last type poor upstream quality may mask the true effects of the minewaters on the fish populations of the receiving watercourses (Appendix 11).

Reductions of 2 RJSMP classes were observed below discharges at three sites. The discharges to the R. Llynfi (15) affected this nursery stream by impacting on the excellent upstream fry population. The reduction of 2 RJSMP classes indicated high (A) fisheries impact. A reduction of the status of the juvenile salmonid population was noted downstream of the discharge to the N. Melyn (32) where no fry (0+) were caught. Downstream of the discharge to the R. Morlais (30) no fish were caught indicating the severity of the impact of this discharge on juvenile salmonids.

Reductions of 1 RJSMP class, from good (B) to moderate (C) were noted below the discharges to the R. Llwyd at Abersychan (1) and the R. Cathan (29). These moderate changes in class indicate the degree of impact below these discharges where the suitability of habitat is reduced by the blanketing of the substrate by iron hydroxide.

The RJSMP class of the N. Craig yr Aber (16), A. Corrwg (17) and the A. Corrwg at the WDA site (21) was reduced by 1 from moderate (C) to poor (D) between the upstream and downstream sites again indicating the deleterious nature of ferruginous minewater.

The numbers of fish at any one site are dependent upon a range of complex factors which include water quality, the availability of food and the suitability of the habitat. Habscore, a computer model for predicting the suitability of a site for salmonids, was applied to 17 of the 19 sites electrofished to assess their suitability and to predict the salmonid populations which the habitat should support.

The Habscore model requires the measurement of physical, natural features in the field. Habscore can be used to produce a Habitat Utilisation Index (HUI) for fry (0+) and parr (>0+) trout. HUI compares observed and expected densities and is a measure of the extent to which the habitat is utilised by salmonids: a value of 0 occurs when the observed density is equal to the expected density and negative values indicate underutilisation. HUI's were calculated for all upstream and downstream sites (appendix 12) and all were negative, at both upstream and downstream sites, which indicated an under utilisation of habitat by salmonids at all sites surveyed.

The HUI's correlated well with the RJSMP classifications and indicated that at many upstream sites, a perturbed fishery exists, ie. poor to moderate (appendix 12). They also showed that, at sites where an excellent or good fishery existed, the quality of the fish populations could be even better. Furthermore, in many cases the reduction in the downstream RJSMP class of the fishery, due to a minewater discharge, is indicative of additional detrimental impact on the fishery which, according to the HUI, may already be under utilised by salmonids.

Habscore can also be used to produce a Habitat Quality Score (HQS%) which, on a percentage scale, is the approximate proportion of Welsh sites which have a worse habitat than that observed at this site. A value of 50 therefore represents a median habitat quality for Welsh streams, and a value of 5, for example, represents a poor quality below which only 5 % of sites in Wales are worse (Milner & Wyatt 1991).

The HQS values (Appendix 12) show that some sites had low to median quality habitats, upstream and downstream of the discharge, including the R. Sirhowy (6), R. Rhymney (7). The R. Llwyd (1) had low to medium quality downstream for parr. This indicates that, despite under utilisation of the above sites, the relatively poor quality of the habitat explains in part the low numbers of fish caught.

The HQS values for site 30 on the R. Morlais show a severe reduction in habitat quality downstream of the discharge. The site is close to the Morlais / Loughor confluence and is near the tidal limit. The highly silty downstream site was poor compared with the upstream site, which comprised shallow riffles, and no fish were caught there. The high impact (A) assigned to the discharge, due to a reduction in 2 classes of RJSMP, suggests the minewater is having a high impact on the fishery. However, the location of the downstream site near

the tidal limit and its unsuitability for salmonids is likely to be a strong contributing factor. Also the impact of this large discharge may deter migratory salmonids entering the watercourse from the estuary.

Sites on the R. Clydach tributary (11), A. Corrwg Fechan (18), N. Gwynfi (19), Ffrwd wyllt (23), Gwenffrwd (26), N. Cregan tributary (27), and the Nant y Fedw (28), (which are in the Taff-Clydach the Afan and Pelenna catchments), all had very high quality habitats, both upstream and downstream of the discharge (HQS values >90 %). However the HUI's, for all these sites indicate reduced trout densities upstream and, as a result, there was no discernible impact of the minewaters on already poor fish populations, and they scored a C for fisheries impact.

The remaining sites, on the R. Llynfi tributary (15), N. Craig yr aber (16), R. Corrwg (17), R. Corrwg (21), R. Cathan (29) and N. Melyn (32), (which are in the Ogmore, Cynffig, Afan and Loughor catchments), also had high quality habitats, but the discharges to these sites caused high to medium fisheries impacts. Increased HUI values between sites upstream and downstream of these discharges supports the evidence of reduced fish populations by suggesting greater under utilisation of habitat. At sites 15, 16, 17, 29 and 32 the minewaters were the sole known source of pollution, as the streams were not affected by other sources such as storm sewage overflows. However site 21 on the R. Corrwg is affected by storm sewage overflows and the fisheries impact may not be solely attributable to the minewater.

This study has demonstrated the scale and impact of ferruginous minewater discharges in Wales. A significant length and area of river bed are affected by ferruginous discharges. The impacts vary from largely visual to detrimental to fisheries and / or the aquatic fauna. The degree of impact on the ecology is largely related to the degree of depostion of iron hydroxide, which in turn is dependant on the quality of the minewater discharge and the receiving watercourse.

A list of the most environmentally damaging discharges has been drawn up and their impacts ranked according to the water quality, biological and fisheries data collected. A number of these discharges will be selected for the next phase of the study which will scope the remedial options for reducing or removing the impacts of these discharges.

8. RANKING METHOD FOR STAGE 2 DATA

A ranking method to provide an overall assessment of the impact of the 33 minewaters on the biological and fisheries quality of the receiving waters has been developed.

Briefly, the method is based on three components: (1) a measurable biological impact between the upstream and immediate downstream site; this is the most important component; 2) the area of river bed biologically affected; and 3) the third component is based on fisheries impact (See Section 6.1.1 and 6.1.2). Sites have been ranked against each of the three components in turn as high (A), medium (B) or low / no impact (C) according to the rules in 6.1.1 and 6.1.2.

9. RESULTS OF STAGE 2 RANKING

The results of the stage 2 ranking (prior to override) are given in Table 4. Sites were evenly distributed between the selected bands of impact, the most dramatically impacted sites were ranked at the top of Table 4. However, it was felt that a number of sites which were ranked as having a significant physical / water quality impact in stage 1 of the study but did not have measurable biological or fisheries impacts in stage 2 because of poor upstream biological quality, were erroneously placed (eg. site 1 R. Llwyd at Abersycham, see Table 4). This led to the development of an adjustment / override to take into account those minewater discharges which had an obvious impact in stage 1 but not in stage 2 of the survey.

9.1 Some points about the ranked minewaters: Tables 4 and 5

1. Those sites where fisheries surveys were not carried out are denoted by a dashed line.

2. The table also includes the ranking position of the minewaters as they appeared at the end of stage 1 and the final column denotes whether they discharge to Classified (C) or Unclassified (U) stretches of river.

TABLE 4. STAGE 2 RANKING RESULTS

RANK	SITE		STAGE 2 IMPACT CRITERIA			STAGE 1	
			BIOLOGY	AREA BIOL. IMPACTED	FISHERIES	ORIG. RANK	CLASS
1	30	A. Morlais	A	A	A	2	C
2	16	N. Craig yr Aber	A	A	B	6	C
3	19	N. Gwynfi	A	A	C	10	C
4	25	N. Blaenpelenna	A	A	C	1	C
5	26	Gwenffrwd	A	A	C	3	C
6	10	R. Llwyd Blaenavon	A	A	--	19	C
7	33	Tawe Trib.	A	A	--	2	U
8	31	R. Clyne	A	B	C	1	U
9	2	R. Llwyd Pontnewydd	A	B	--	13	C
10	12	Y Ffrwd Clydach trib	A	B	--	4	U
11	17	A. Corrwg	B	A	B	10	U
12	29	R. Cathan	B	A	B	3	U
13	18	A. Corrwg Fechan	B	A	C	8	U
14	6	R. Sirhowy Pontlanf	B	A	C	15	C
15	7	R. Rhymney Hengoed	B	A	C	9	C
16	4	R. Ebbw Newbridge	B	A	--	11	C
17	5	R. Sirhowy B'Wood	B	A	--	4	C
18	3	R. Llwyd Pontypool	B	A	--	14	C
19	15	Llynfi Trib	B	B	A	5	U
20	11	R. Clydach Trib.	B	B	C	9	U
21	24	N. Blaenpelenna	B	B	--	--	--
22	34	Broughton Brook	B	B	--	17	C
23	32	Nant Melyn	C	C	A	19	U
24	1	R. Llwyd Abersychan	C	C	B	7	C
25	21	A. Corrwg W.D.A Site	C	C	B	12	C
26	23	Ffrwd Wyllt Goytre	C	C	C	8	C
27	27	Trib. of Nant Cregan	C	C	C	27	U
28	28	Nant y Fedw	C	C	C	14	U
29	9	R. Dare trib.	C	C	--	18	C
30	13	R. Rhondda	C	C	--	16	C
31	20	R. Afan	C	C	--	25	C
32	22	Ffrwd Wyllt Bryn	C	C	--	20	C
33	14	Ogwr Fach	No upstream flow so not ranked.				

10. OVERRIDE FOR STAGE 2 RANKING

The override system mentioned above was developed as follows. The RIVPACS system can be used to predict optimum BMWP scores for the upstream 'control' sites as if they were unaffected by other sources of pollution. Using the predicted BMWP score an Environmental Quality Index (EQI) can be calculated from the observed : expected, (O:E), BMWP score ratio, which gives a measure of the actual biological quality of the receiving water relative to its potential quality. Although there is no absolute value of the EQI which is recognised as indicating a poorer observed biological quality than that predicted by RIVPACS, an EQI of < 0.7 is generally considered to be significant. Values of EQI substantially < 0.7 would certainly suggest the observed fauna was being affected by poor water quality.

The EQI values calculated for each of the 32 discharges have been used to override the stage 2 ranking using the following rule. Sites which were ranked in the top 15 in the stage 1 ranking and which had no measurable biological impact (ie. scored C) in stage 2, but which had an upstream EQI value of < 0.7, have been reranked on the assumption that there would have been a moderate biological impact had the upstream quality been better. Such sites have been given a subjective (B,B) for biological impact and biological area affected. This rule has been applied and has resulted in one site (1), the R. Llwyd at Abersychan, being reranked upwards in the table to number 20. (See Table 5)

TABLE 5 STAGE 2 RANKING RESULTS USING OVERRIDE

TABLE OF RANKED MINEWATERS			STAGE 2 IMPACT CRITERIA			STAGE 1		U/S
RANK	SITE		BIOLOGY	AREA BIOL. IMPACTED	FISHERIES	ORIG. RANK	CLASS	RIVPAC EQI
1	30	A. Morlais	A	A	A	2	C	0.78
2	16	N. Craig yr Aber	A	A	B	6	C	0.8
3	19	N. Gwynfi	A	A	C	10	C	0.59
4	25	N. Blaenpelenna	A	A	C	1	C	0.62
5	26	Gwenffrwd	A	A	C	3	C	0.53
6	10	R. Llwyd Blaenavon	A	A	--	19	C	1.33
7	33	Tawe Trib.	A	A	--	2	U	0.98
8	31	R. Clyne	A	B	C	1	U	0.88
9	2	R. Llwyd Pontnewydd	A	B	--	13	C	0.86
10	12	Y Ffrwd Clydach trib	A	B	--	4	U	0.99
11	17	A. Corrwg	B	A	B	10	U	0.44
12	29	R. Cathan	B	A	B	3	U	0.91
13	18	A. Corrwg Fechan	B	A	C	8	U	0.38
14	6	R. Sirhowy Pontlanf	B	A	C	15	C	0.61
15	7	R. Rhymney Hengoed	B	A	C	9	C	0.64
16	4	R. Ebbw Newbridge	B	A	--	11	C	0.49
17	5	R. Sirhowy B'Wood	B	A	--	4	C	0.77
18	3	R. Llwyd Pontypool	B	A	--	14	C	0.82
19	15	Llynfi Trib	B	B	A	5	U	1.06
20	1	R. Llwyd Abersychan	[B]	[B]	B	7	C	0.69
21	11	R. Clydach Trib.	B	B	C	9	U	0.84
22	24	N. Blaenpelenna	B	B	--	--	--	0.54
23	34	Broughton Brook	B	B	--	17	C	0.31
24	32	Nant Melyn	C	C	A	19	U	0.79
25	21	A. Corrwg W.D.A Site	C	C	B	12	C	0.81
26	23	Ffrwd Wyllt Goytre	C	C	C	8	C	1.15
27	27	Trib. of Nant Cregan	C	C	C	27	U	1.33
28	28	Nant y Fedw	C	C	C	14	U	1.22
29	9	R. Dare trib.	C	C	--	18	C	1.10
30	13	R. Rhondda	C	C	--	16	C	0.48
31	20	R. Afan	C	C	--	25	C	0.86
32	22	Ffrwd Wyllt Bryn	C	C	--	20	C	1.31
33	14	Ogwr Fach	No upstream flow so not ranked.					

[ ] ranked according to override rules based on RIVPACS - EQI.

11. DISCUSSION

Ninety ferruginous discharges located in the coal measure areas of Wales affect a total length of 59.4 km of river and 220.3 10^3 m^2 of riverbed. At present 25 % of classified river stretches in South Wales fail to meet their long term water quality objectives. A proportion of these stretches are affected by ferruginous minewater discharges together with other sources of pollution such as storm sewage. Ferruginous discharges are therefore an important factor in the NRA's urbanised river recovery programme and as other sources of pollution are removed, will become the limiting factor.

The majority of minewater discharges were not highly acidic and did not significantly affect the pH of the receiving watercourse. However, problems of low pH were noted at some upstream sites and acidic discharges to these streams did exacerbate the pH problems downstream. The potential toxic effects of dissolved aluminium in the discharges were generally not realised as the pH of most receiving watercourses was in the range of 6-8, at which aluminium is not toxic. Suspended solids concentrations downstream of the discharges were not at levels harmful to the biota.

The single most important chemical component of the discharges impacting on the fauna was iron, as deposition of ferric hydroxide onto the substrate has a highly deleterious impact. The Environmental Quality Standard (EQS) of 2 mg/l total iron was exceeded on at least one sampling occasion for 11 of the 33 sites selected for impact assessment in stage 2. Downstream of the discharge to the R. Morlais (30) the maximum concentration of iron was 26.42 mg/l, far in excess of the EQS. Failure of the EQS for iron has implications for the NRA's ability to meet long term statutory water quality objectives and hinders the long term improvement of water quality of a number of rivers in South Wales.

The deposition of iron hydroxide on the substratum smothers epilithic algae (ie. algae which grows on the substrate), reduces plant growth, infiltrates the substrate interstices and results in a general reduction in the quality and availability of the benthic habitat. The combination of these factors can result in a reduction in abundance and diversity of invertebrates and inhibit salmonid reproduction downstream of a minewater discharge.

As expected invertebrate taxa were most significantly reduced or absent in the areas of highest deposition of iron (near to the point of discharge) and further downstream the diversity and abundance increased again as the visual impact of the iron deposits decreased. This holds true for the majority of sites and the picture was generally not complicated by other associated

problems of low pH, aluminium or suspended solids in the Welsh coalfield discharges. Biological impacts were therefore mainly the result of precipitation of iron hydroxides onto the substrate causing loss of habitat and epilithic algae, an important food source for many invertebrates.

Biological impacts were demonstrated in receiving watercourses ranging in size from small unclassified streams to main classified rivers throughout the coalfield. The demonstration of a significant impact on some upland streams, in which there was already evidence of reduced macroinvertebrate faunas, due to poor upstream water quality (low pH), illustrated clearly the deleterious effects of the deposition of iron salts downstream of ferruginous minewater discharges.

Similar impacts were demonstrated on rivers, particularly in the south east areas of the coal field where intermittent discharges from combined storm sewer overflows resulted in an already reduced and pollution tolernt fauna comprising families less sensitive to the effects of organic pollution. Significant impact on the relatively pollution tolerant families was demonstrated at a number of these sites and over large areas of river bed. The water quality data suggested that the iron content of the discharges resulting in the subsequent deposition of iron hydroxide onto the riverbed was the single most important criterion impacting the fauna.

The BMWP score system was originally designed primarily to demonstrate the effects of organic pollution. Similarities between the effects of minewaters and organic pollution do exist; for example, deposition of organic matter onto the substrate can cause a loss of habitat as does iron hydroxide precipitation. However, in many other respects the effects are quite different; for example iron salts are inert whilst organic deposits can exert an additional oxygen demand and deoxygenate the sediments. Although some of the highest BMWP scoring taxa were sensitive to iron deposition the ferruginous deposits also had an impact on a wider range of invertebrates than organic pollution and families at all levels of the BMWP index were affected (see Appendix 10A and 10B). This suggests that the blanketing effect of iron (ochre) deposition was indiscriminate and highly deleterious to the quality of substrate and it affected invertebrates from a wide range of taxa.

The blanketing effect of iron hydroxide precipitation is also believed to be detrimental to the success of salmonids by affecting the spawning, the survival of fry, and consequently the size of juvenile populations.

Ideally an upstream 'control' site should support a good population of salmonids so that any impact of a minewater would be readily detected at the downstream site. In S.E area the R. Sirhowy (6) and the R. Rhymney (7) had poor upstream populations of salmonids and the question of poor water quality has already been discussed. Intermittent discharges of storm sewage overflows cause pollution of a number of these rivers resulting in a reduction in water quality and damage to salmonid fisheries. This general deterioration in water quality has in part, masked the impact of some minewaters on fisheries.

The impact of minewaters upon salmonid fisheries was not demonstrable where water quality problems existed above the discharge and where there was a generally under utilised habitat as indicated by Habscore. The EQS of 2 mg/l iron was exceeded on at least one sampling occasion at 11 sites downstream of the discharge (Appendix 5-7). Impact on the fisheries at three of these sites (6, 7 and 19) was not demonstrable but on the N. Melyn (32) a reduction of two RJSMP classes was observed downstream of the discharge. At two sites (16 and 30) where the EQS for iron was exceeded fisheries impacts were demonstrated but no fish were caught either upstream or downstream of the discharge to the Gwenffrwd (26) due to acidification of the upper catchment. Iron deposition downstream of this minewater also probably contributed to the fishery impact.

In conclusion therefore the impact of minewater discharges on fish populations, was only fully demonstrated at sites where upstream water quality, habitat and therefore backgound fish populations were good (eg. R. Llynfi (15)) but at sites where the upstream water quality and, in some cases, the fish habitat was moderate or poor, the deleterious effects of minewaters on the fishery were not demonstrable.

Improvements in the class of fishery, were observed below a small number of discharges. The mobility of fish and the variation in habitat suitability at some sites may account for such findings. These data highlight the fact that fish are highly mobile and will actively seek good habitat, water quality and an abundant food supply.

12. CONCLUSIONS

1. The deposition of iron hydroxide from ninety ferruginous minewater discharges affects a total length of 59.4 km of river and an area of 220.3 x 10^3 m^2 of riverbed in the coalmeasure areas of Wales. Of the thirty three most deleterious discharges selected for full assessment, the impacts demonstrated ranged from mainly aesthetic effects to significant effects on water quality, biology and fisheries status downstream of minewater discharges.

2. The minewater discharges were found to be generally mildly acidic to near neutral. Neutralisation of minewaters, by limestone associated with the coal measures, prior to discharge to surface waters, may explain this phenomenon. The minewaters in the south west area were generally more acidic than those in south east area and some of the more acidic ones discharged to acidified watercourses which were already supporting stressed or reduced biota and fish populations.

3. The concentrations of dissolved aluminium in the discharges were not generally high enough to cause failure of the EQS of 1 mg/l aluminium at pH 6-8 in the receiving watercourses.

4. Suspended solids, due to precipitation of iron hydroxide downstream of discharges, were not at concentrations which would significantly affect fish or the biota.

5. The deposition of iron hydroxides onto the substrate caused blanketing and binding of substrate, loss of habitat and reduction in the epilithon, all of which are essential for a diverse and abundant invertebrate fauna. In 10 cases considerable losses and reductions in abundance of taxa were demonstrated below discharges to both pristine quality waters and watercourses where the water quality was relatively poor and the invertebrate fauna already perturbed. The fact that significant impacts were demonstrated downstream of discharges to watercourses of relatively poor water quality emphasises the seriousness of the effects of iron hydroxide precipitation.

6. On the other hand, the impact of minewater discharges on fisheries was not readily demonstrated where the receiving watercourse was already of poor quality, for example in some of the south east area rivers. In such cases the impact of the discharges was partly masked by the poor receiving water quality, caused, for example, by intermittent discharges from combined sewer overflows. In some of the upland streams acidification was responsible for poor status of the fish populations. Only where upstream water quality and habitat were good, was the true impact of minewater discharges on fisheries demonstrable (eg. the R. Llynfi tributary (15)).

7. It is important to emphasise that this survey represents a snapshot of the position in 1993, and there was some evidence that the situation was changing even during the survey period. The scale of British Coal's deep mining operations in Wales has now almost stabilised with only one British Coal colliery remaining in South Wales. However a large number of small private mines extract coal and may be the source of future minewater discharges. In addition, further minewater discharges from recently abandoned mines may emerge in an unpredictable way. These discharges will continue to pollute, unless preventative or remedial action can be carried out.

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14. List of Appendices

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2. Table showing physicochemical data for ferruginous inputs to Welsh rivers in the South East area.
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12. Habscore results for sites electrofished in stage 2 of the survey showing HUI and HQS % for each site.

Appendix 1

Catchment Maps:

Llwyd

Ebbw/Sirhowy/Rhymney

Taff

Ogmore/Cynffig

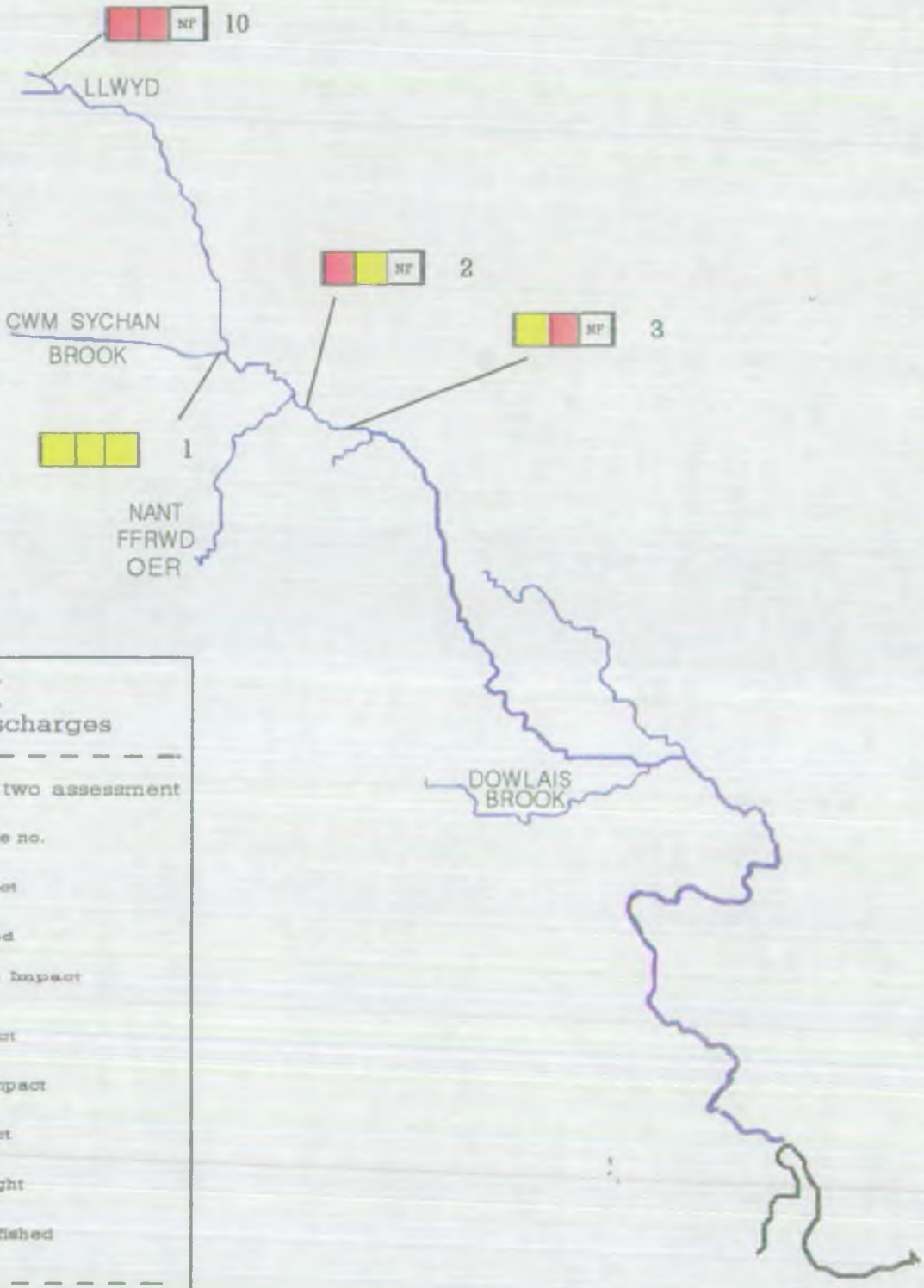
Afan/Neath

Tawe

Loughor/Gwendraeth

Dee

Minewater Discharges
Llwyd Catchment



KEY

Minewater Discharges

Discharges with Stage two assessment

site no.

Biological Impact

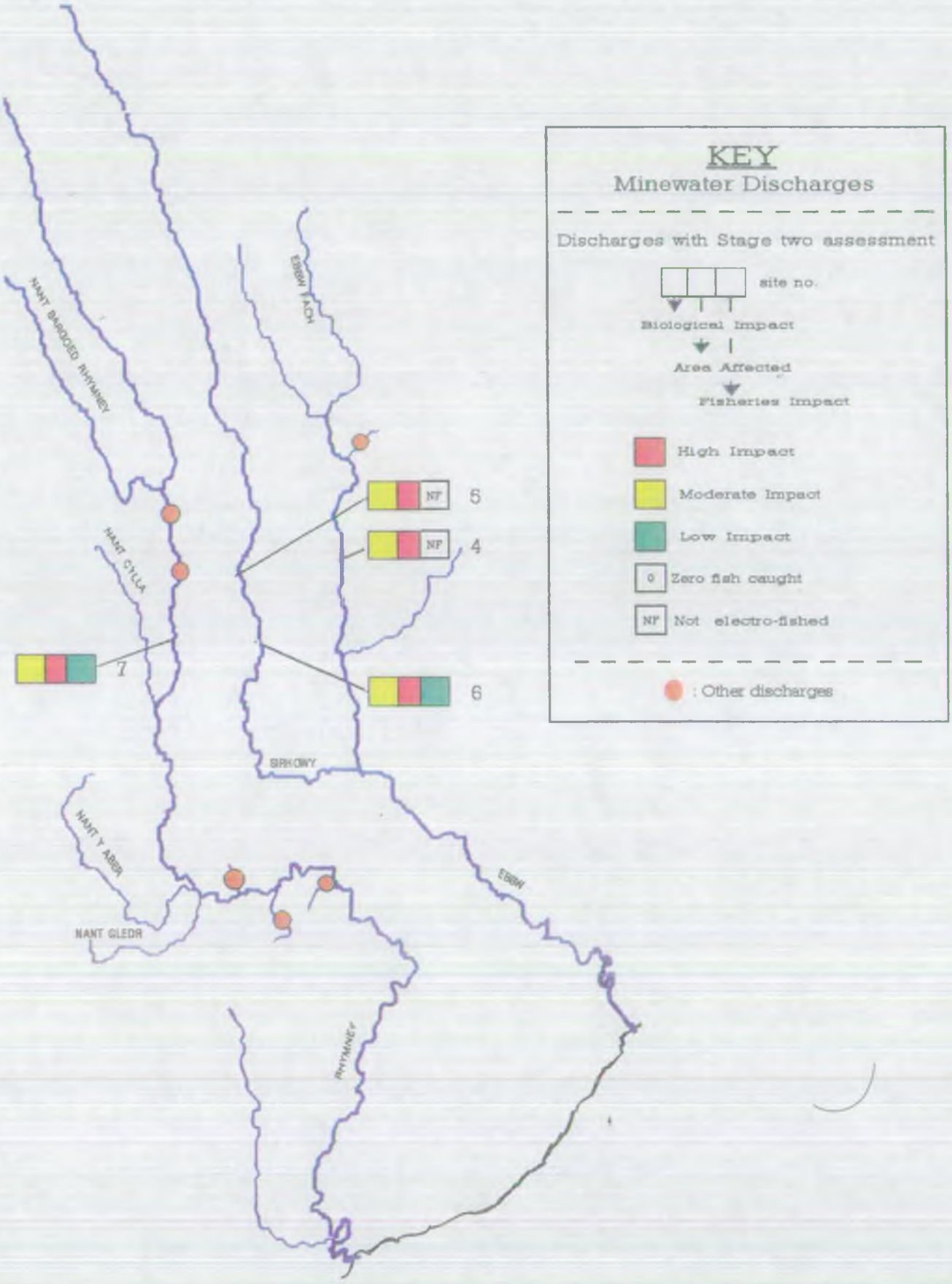
Area Affected

Fisheries Impact

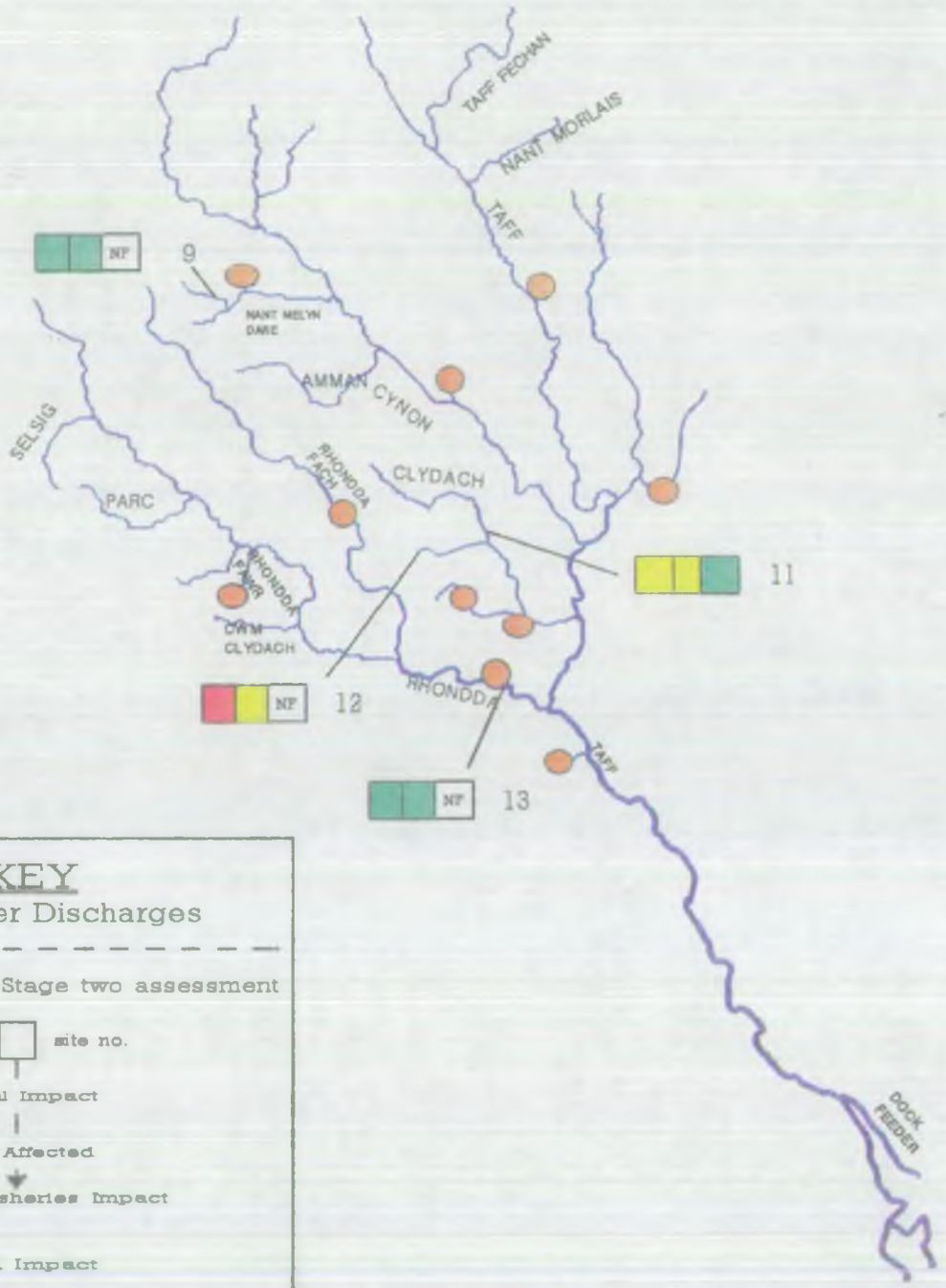
- High Impact
- Moderate Impact
- Low Impact
- 0 Zero fish caught
- NF Not electro-fished

: Other discharges

Minewater Discharges
Rhymney and Ebbw/Sirhowy Catchments



Minewater Discharges
Taff Catchment



KEY
Minewater Discharges

Discharges with Stage two assessment

site no.

Biological Impact

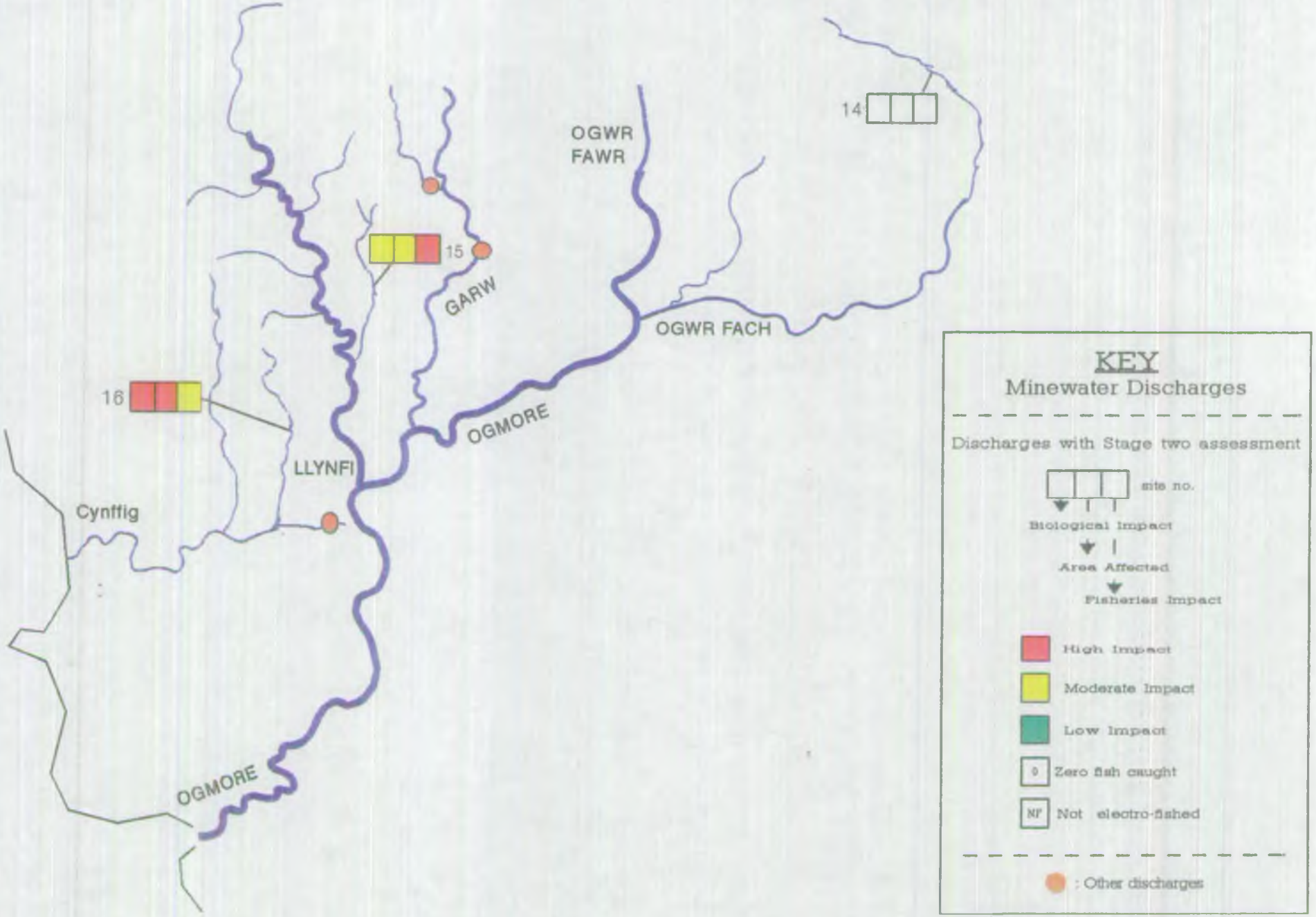
Area Affected

Fisheries Impact

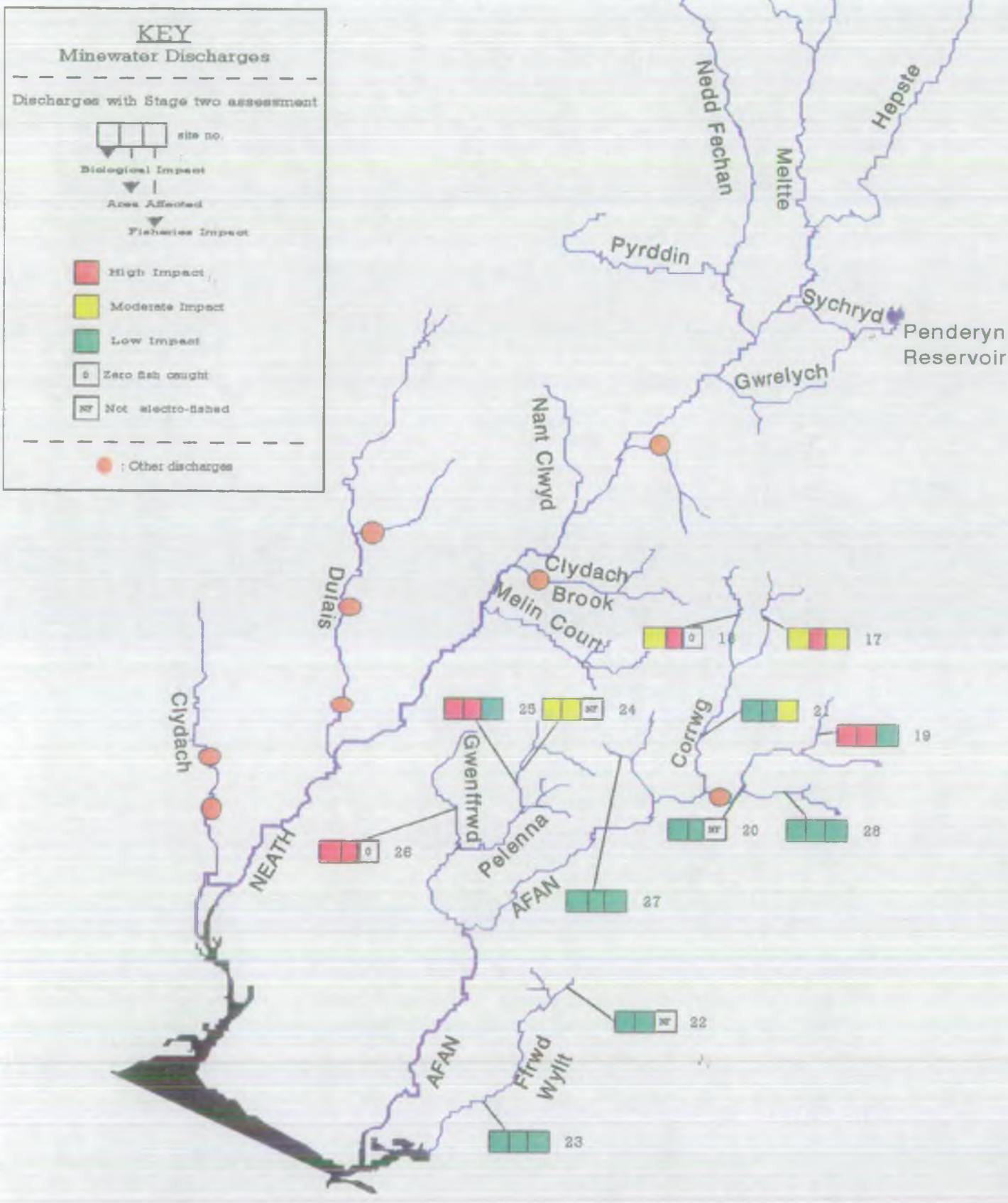
- High Impact
- Moderate Impact
- Low Impact
- 0 Zero fish caught
- NF Not electro-fished

: Other discharges

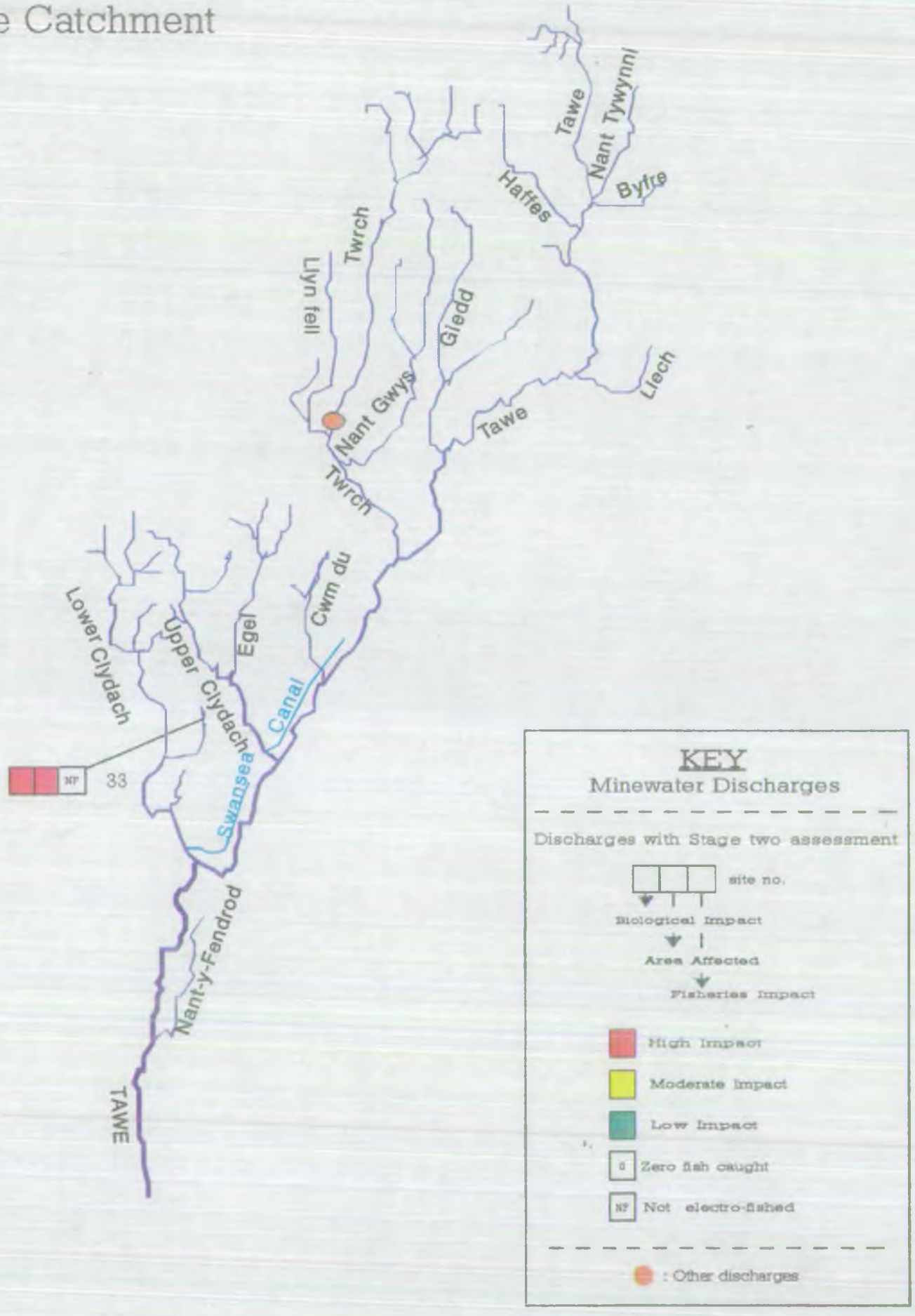
Minewater Discharges Ogmore and Cynffig Catchments



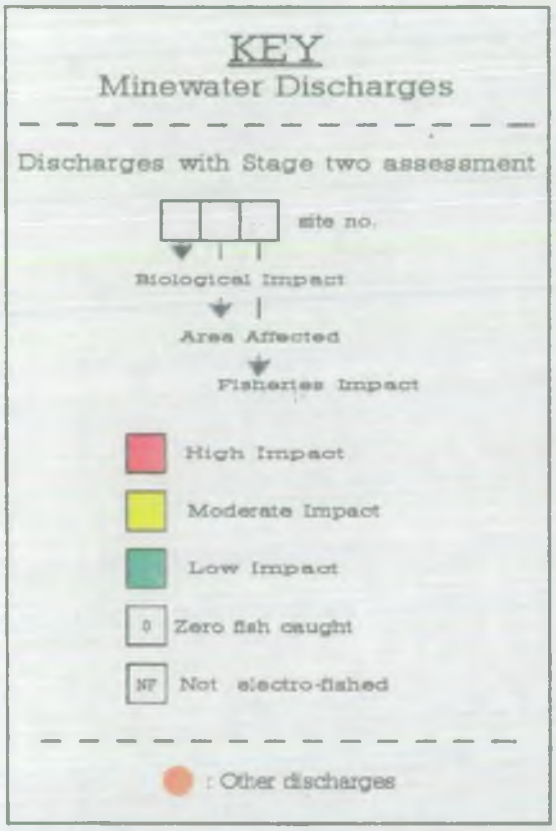
Minewater Discharges
Neath and Afan Catchments



Minewater Discharges
Tawe Catchment



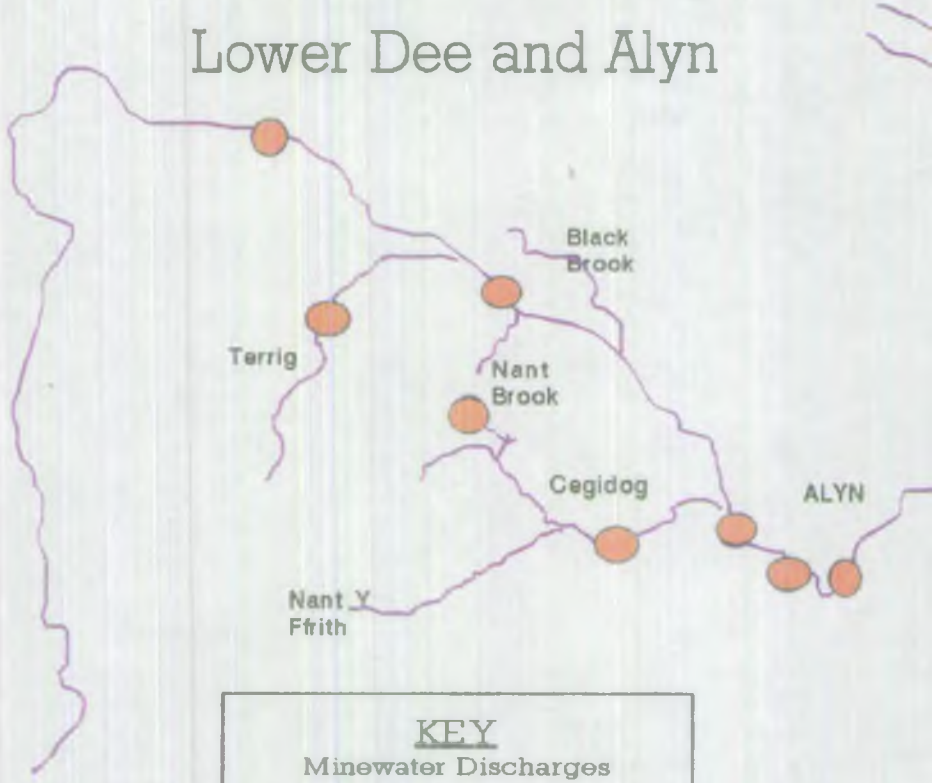
Minewater Discharges



Gwendraeth Catchment

Loughor Catchment

Minewater Discharges
Lower Dee and Alyn



KEY

Minewater Discharges

Discharges with Stage two assessment

site no.

Biological Impact

Area Affected

Fisheries Impact

High Impact

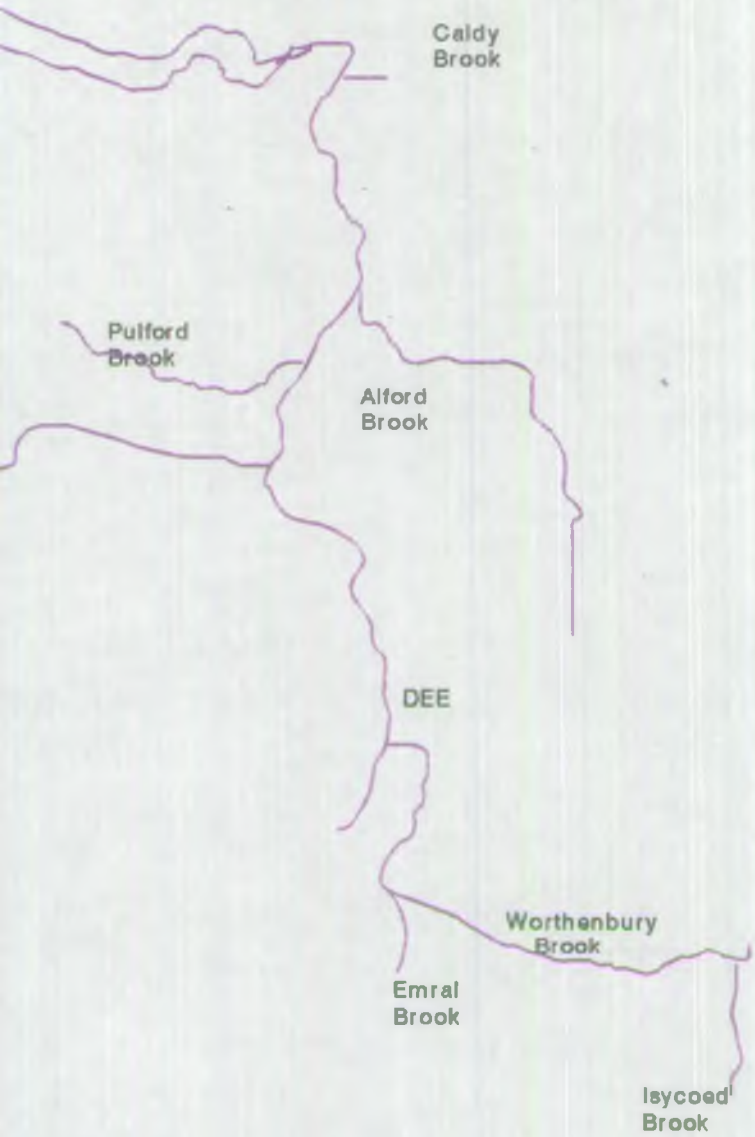
Moderate Impact

Low Impact

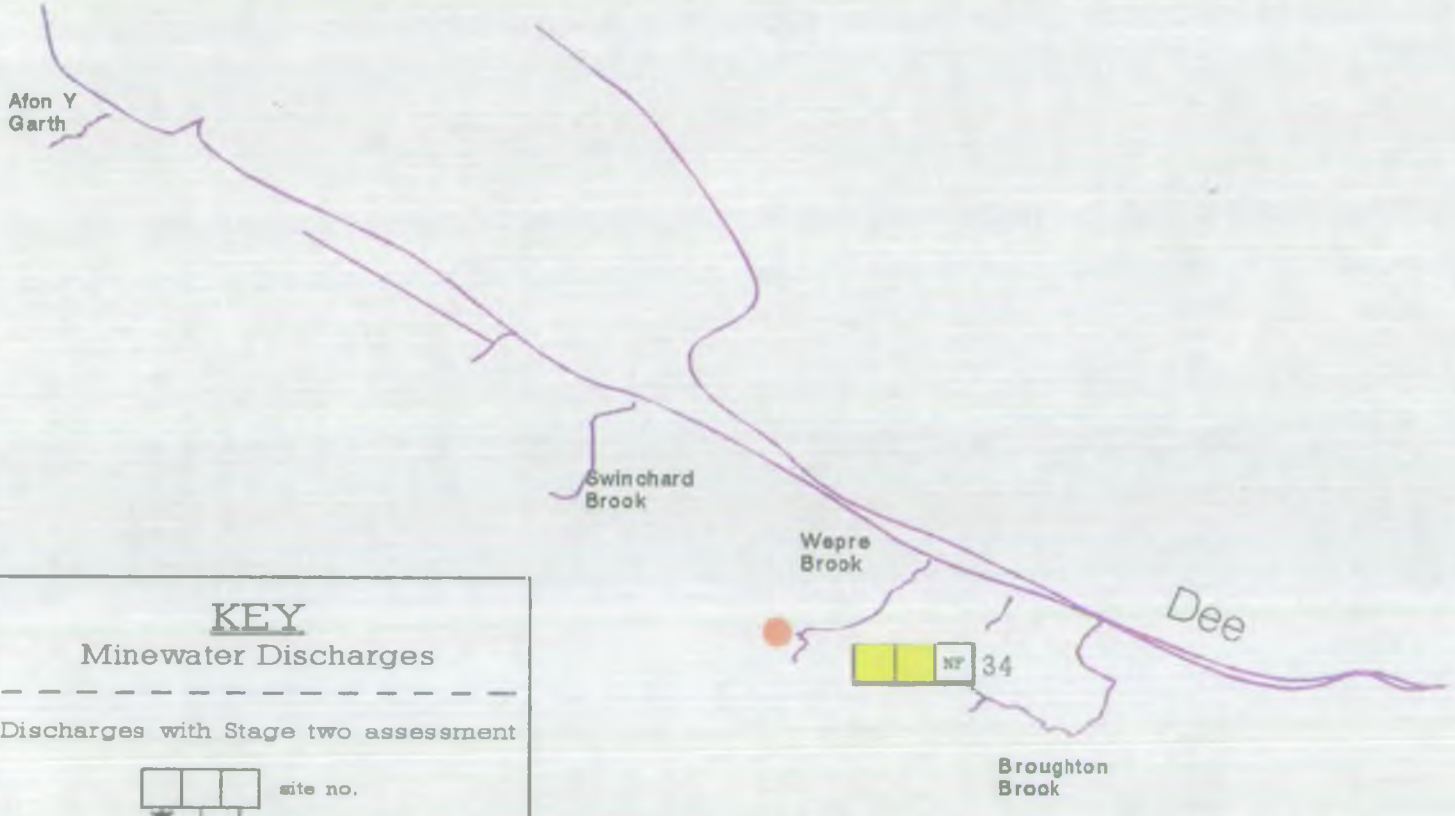
0 Zero fish caught

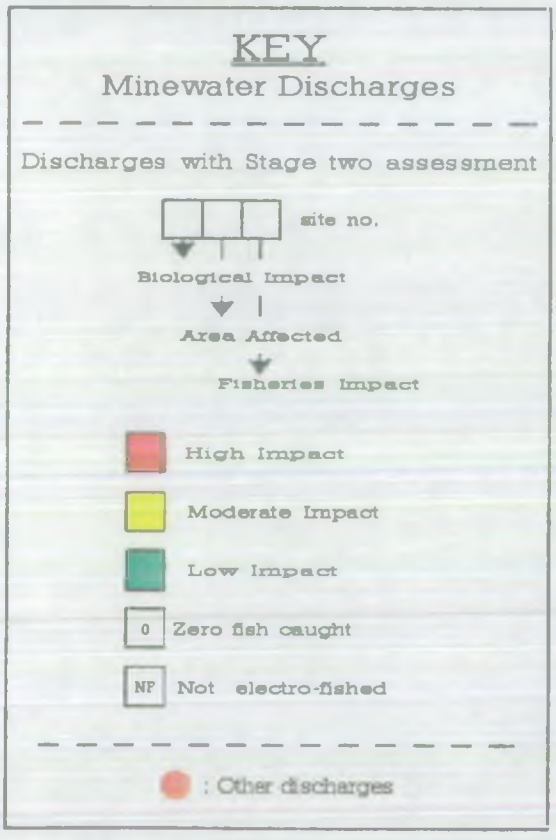
Nf Not electro-fished

: Other discharges


Caldy
Brook
Pulford
Brook
Alford
Brook
DEE
Worthenbury
Brook
Emral
Brook
Isycoed
Brook

Minewater Discharges
Dee Estuary





Appendix 2. Table showing Physicochemical data for Ferruginous Inputs to Welsh Rivers in the South East Area

NAME OF RECEIVING WATER	LAB. REF.	LOCATION	NATIONAL GRID REFERENCE	DATE	TIME	WEATHER	FLOW
LLWYD	E 234126	U/S	SO 2341 0962	16-Nov-92			
	T 233775	DISC	SO 2443 0897	11-Nov-92	11:40	DRY	HIGH
UNNAMED TRIB	E 233777	D/S	SO 2484 0869	11-Nov-92			
LLWYD	E 245759	U/S	SO 28590 00620	02-Feb-93	11:30	DRY	MED
	T 245760	DISC	SO 28600 00580				
	E 245761	D/S	SO 28660 00570				
LLWYD	E 245756	U/S	SO 27070 03200	02-Feb-93	15:00	DRY	HIGH
	T 245757	DISC	SO 27050 03150				
ABER SYCHAN	E 245758	D/S	SO 27025 03100				
LLWYD	E 250289	U/S	SO 27630 01820	01-Mar-93	15:00	DRY	LOW
	T 250290	DISC	SO 27630 01810				
	E 250291	D/S	SO 27660 01730				
SIRHOWY	E 246318	U/S	SO 18010 95650	08-Feb-93	13:00	DRY	LOW
	T 234133	DISC	SO 18010 95570	16-Nov-92			
	E 246320	D/S	SO 18010 95550	08-Feb-93			
SIRHOWY	E 250285	U/S	ST 17600 97370	01-Mar-93	12:00	DRY	LOW
	T 250286	DISC	ST 17590 97360				
ADIT	E 250287	D/S	ST 17580 97420				
EBBW	E 246783	U/S	ST 21205 97620	10-Feb-93	12:00	DRY	LOW
	T 234130	DISC	ST 21210 97550	16-Nov-92			
	E 246784	D/S	ST 21235 97420	10-Feb-93			
EBBW	T 250288	DISC	SO 22260 01340	02-Mar-93	14:00	WET	MED
NANT CYFFIH							
RHYMNEY	E 246785	U/S	ST 15610 98090	10-Feb-93	12:00	WET	MED
	T 246786	DISC	ST 15600 98030				
	E 246787	D/S	ST 15610 97950				
RHYMNEY	E 246324	U/S	ST 19390 87255	08-Feb-93	12:00	DRY	MED
	T 246325	DISC	ST 19380 87225				
RUDRY BROOK	E 246326	D/S	ST 19340 87300				
RHYMNEY							
UNNAMED TRIB	T 250284	DISC	ST 18025 89400	02-Mar-93	11:00	DRY	LOW
AT BEDWAS COLLIERY							
RHYMNEY	E 250767	U/S	ST 15510 96350	04-Mar-93	10:30	DRY	LOW
AT FLEUR-DE-LIS	T 250768	DISC 1	ST 15490 96320				
	T 250769	DISC 2					
	E 250770	D/S	ST 15470 96290				
RHYMNEY							
UNNAMED TRIB AT	T 256850	DISC	ST 21390 88735	15-Apr-93	10:00	DRY	MED
MACHEN							
TAFF	E 246321	U/S	SO 06640 02330	08-Feb-93			
	T 246322	DISC	SO 06680 02325		14:00	DRY	MED
UNNAMED TRIB	E 246323	D/S	SO 06685 02290				

DISCHARGE RATIO	WIDTH m	COLOUR	DEPOSIT	RIVER AFFECTED Km	AREA AFFECTED m2	BED AFFECTED %
-	2	HIGH	HIGH	0.25	500	100
10:1	5	MED	MED	0.7	3500	100
100:1	RIVER - 4 STREAM - 2.5	HIGH	HIGH	1.5	6000	100
100:1	5	HIGH	HIGH	0.75	3750	100
1000:1	RIVER - 12	HIGH	HIGH/MED	0.4	4800	100
100:1	ADIT - 1 RIVER - 7	HIGH	HIGH	1.6	RIVER - 12600	100
100:1	4-5	HIGH	HIGH/ MED	2.1	10500	100
-	0.5-2	MED/LOW	MED/LOW	0.25	250	100
1000:1	8	HIGH	MED	5m	5	5
10:1	2-3	HIGH	MED	0.7	1750	100
-	TRIB - 0.05	LOW	LOW	-	-	-
10:1/100:1	12	HIGH	HIGH	3	36000	100
1000:1	1	HIGH	HIGH	0.5	500	100
1000:1	RIVER - 10 TRIB - 2.5	HIGH	HIGH	RIVER - 2-5m TRIB - .1 Km	RIVER - 5 TRIB - 250	TRIB - 100 %

Appendix 2. Table showing Physicochemical data for Ferruginous Inputs to Welsh Rivers in the South East Area

NAME OF RECEIVING WATER	DOMINANT SUBSTRATE	TEMP. deg. C	pH	FIELD pH	DO mg/l	DO %
LLWYD		8.0	7.10	6.40	10.50	84.5
	STONES/PEBBLES	8.1	7.30	7.14	11.30	95.8
UNNAMED TRIB		8.9	7.20	7.93	12.20	100.0
LLWYD	BEDROCK/LARGE COBBLES/	8.2	8.10	8.33	11.30	96.0
	OOD BOULDERS	9.0	7.90	7.86	11.40	98.8
		8.3	8.00	8.21	11.10	94.6
LLWYD	ROCKS/STONES/	8.8	8.00	8.49	12.00	98.0
	BEDROCK	10.3	8.10	8.10	11.20	100.0
ABER SYCHAN		7.7	8.10	8.34	11.40	95.7
LLWYD	ROCKS/BOULDERS/	8.5	8.30	8.45	11.80	96.1
	BEDROCK	11.7	8.00	8.07	11.80	109.0
		8.8	8.10	8.41	11.60	95.2
SIRHOWY	COBBLES/ROCKS	8.8	7.70	8.11	11.60	100.0
		10.4	7.00	6.78	3.80	34.0
		8.4	7.50	7.55	11.00	93.9
SIRHOWY	ROCKS/GRAVEL/	3.7	8.00	7.51	13.10	99.3
	BEDROCK	10.5	6.80	6.29	8.40	75.4
ADIT		5.3	7.50	6.86	12.60	99.6
EBBW	ROCKS/BOULDERS/	6.3	7.90	8.48	13.40	114.0
	GRAVEL	11.6	6.90	6.59	1.80	16.7
		8.2	7.80	8.19	14.30	122.0
EBBW	FLAT ROCKS/PEBBLES	8.8	7.40	8.95	8.90	59.2
NANT CYFFIH						
RHYMNEY		7.0	7.80	8.18	13.10	108.0
		8.4	7.50	7.96	12.00	102.0
		7.6	7.60	7.87	13.20	111.0
RHYMNEY	STONES/COBBLES/	8.9	8.20	7.99	12.60	109.0
	GRAVEL	9.8	8.10	8.20	1.40	12.3
RUDRY BROOK		9.0	7.80	7.81	10.60	91.9
RHYMNEY						
UNNAMED TRIB	ARTIFICIAL CHANNEL	3.1	8.10	8.40	8.90	66.4
AT BEDWAS COLLIERY						
RHYMNEY	ROCKS/BOULDERS/	4.2	7.90	8.51	13.80	106.0
AT FLEUR-DE-LIS	BEDROCK	10.8	7.00	6.75	0.40	3.6
		10.8	7.20	8.93	0.20	1.8
		8.0	7.40	7.56	14.00	113.0
RHYMNEY						
UNNAMED TRIB AT	SAND/GRAVEL	9.2	7.00	6.85	0.20	1.7
MACHEN						
TAFF	STONES/COBBLES	9.0	8.00	8.18	12.80	109.0
		10.2	7.70	7.84	11.10	99.0
UNNAMED TRIB		9.3	8.00	8.07	12.40	108.0

COND. us	DISS. IRON mg/l	TOTAL IRON mg/l	DISS. Al. mg/l	TOTAL Al. mg/l	DISS. SULPHATE mg/l	TOTAL SULPHATE mg/l	ALKALINITY mg/l CaCO	SUS. SOLIDS mg/l
165	0.198	0.355	0.111	0.405	46.60	47.0	24.16	15
379	0.941	0.941	0.039	0.149	110.20	110.2	67.82	6
161	0.268	0.441	0.068	0.312	43.40	43.9	33.92	11
411	0.035	0.532	0.023	0.083	86.90	86.9	106.93	3
540	0.389	0.573	0.008	0.060	77.70	77.7	121.30	4
450	0.084	0.397	0.018	0.068	83.10	88.3	105.75	3
375	0.021	0.102	0.019	0.045	64.20	64.2	81.90	3
846	0.588	2.398	0.004	0.011	230.50	230.5	195.13	6
526	0.220	0.639	0.017	0.043	108.20	108.2	113.17	4
569	0.071	0.330	0.012	0.016	146.40	148.0	151.57	3
595	0.033	0.180	0.004	0.030	128.10	128.1	123.55	7
525	0.890	0.930	0.050	0.068	140.60	140.7	132.29	3
469	0.220	0.400	0.042	0.130	125.00	125.0	87.19	5
1336	5.680	6.140	0.006	0.013	613.80	616.7	227.12	18
754	1.500	1.800	0.028	0.069	256.00	256.0	119.21	17
410	0.180	0.210	0.046	0.070	72.60	72.6	95.05	21
1321	5.000	5.100	0.760	1.500	796.00	796.0	100.79	18
720	1.400	1.400	0.250	0.370	263.40	269.6	97.64	5
479	0.139	0.313	0.032	0.061	114.40	116.2	99.19	3
1615	15.440	20.250	0.031	0.045	791.40	795.4	296.24	38
476	0.137	0.420	0.018	0.164	116.00	166.1	96.46	3
539	3.400	3.400	0.008	0.011	167.00	168.9	109.32	6
400	0.052	0.275	0.020	0.196	92.10	92.1	97.24	3
585	0.458	1.468	0.007	0.030	220.90	220.9	50.32	3
514	0.190	0.692	0.013	0.142	154.50	155.6	85.77	4
462	0.120	0.200	0.010	0.026	21.00	21.0	219.26	4
312	12.900	13.100		0.013	83.70	86.1	26.81	5
433	2.500	2.500	0.006	0.019	41.10	44.7	167.49	15
494	64.000	67.000	0.290	1.210	1,332.00	1,347.0	23.84	113
517	0.150	0.360	0.019	0.041	139.80	141.5	115.70	3
1564	6.300	6.300	0.004	0.006	808.00	808.0	210.74	4
997	6.500	6.700	0.004	0.004	358.80	359.5	227.90	4
776	2.000	2.600	0.013	0.035	284.60	284.6	141.90	6
324	4.100	4.460	0.006	0.008	60.40	60.4	87.74	6
394	0.040	0.084	0.100	0.150	55.00	55.0	137.54	3
444	0.360	0.680	0.006	0.120	70.00	70.0	104.86	33
381	0.110	0.240	0.079	0.140	59.00	59.0	126.44	7

Appendix 2. Table showing Physicochemical data for Ferruginous Inputs to Welsh Rivers in the South East Area

NAME OF RECEIVING WATER	LAB. REF.	LOCATION	NATIONAL GRID REFERENCE	DATE	TIME	WEATHER	FLOW
TAFF	E 247252	U/S	ST 05350 95360	11-Feb-93	11:30	DRY	MED
UNNAMED TRIB	T 247253	DISC	ST 05375 95320				
CLYDACH, PWLL HELYH	E 247254	D/S	ST 05360 95270				
TAFF							
UNNAMED TRIB	E 250777	U/S	ST 05350 95360	04-Mar-93	15:30	DRY	LOW
CLYDACH, PWLL HELYH	T 250778	DISC	ST 05340 95710				
DISC 2	E 250779	D/S	ST 05360 95270				
TAFF	E 247249	U/S	ST 06405 92580	11-Feb-93	10:15	DRY	LOW
UNNAMED TRIB OF LLYS	T 247250	DISC	ST 06325 92600				
NANT AT TAI HEOL	E 247251	D/S	ST 06405 92670				
TAFF							
Y-FFRWD	E 247255	U/S	ST 03560 94340	11-Feb-93	12:30	DRY	LOW
TRIB NANT CLYDACH	T 247256	DISC	ST 03585 94330				
PWLL HELYH	E 247257	D/S	ST 03690 94400				
TAFF	E 247258	U/S	ST 04495 93570	11-Feb-93	14:50	DRY	LOW
LLYS NANT	T 247259	DISC	ST 04550 93560				
AT TWYN-Y-GLOG	E 247260	D/S	ST 04590 93550				
TAFF	E 249921	U/S	SN 97990 02920	01-Mar-93	10:30	DRY	MED
	E 249922	DISC	SN 98000 02910				
TRIB OF CYNON	E 249923	D/S	SN 98055 02910				
@ DARE VALLEY PARK							
TAFF/CYNON	E 249924	U/S	SN 97260 02550	01-Mar-93	11:15	DRY	LOW
UNNAMED TRIB OF	T 249925	DISC	SN 97190 02860				
CYNON AT CWMDARE	E 249926	D/S	SN 97390 02600				
TAFF/RHONDDA	E 249928	U/S	SS 99100 97690		15:00	DRY	LOW
RHONDDA FACH	T 249929	DISC	SS 99150 97670				
@ FERNDALE	E 249930	D/S	SS 99220 97660				
TAFF/RHONDDA							
RHONDDA	E 250771	U/S	ST 05720 90470	04-Mar-93	13:30	DRY	LOW
AT HOPKINSTOWN	T 250772	DISC	ST 05750 90730				
DISC 1	E 250773	D/S	ST 05760 90690				
TAFF/RHONDDA							
RHONDDA	E 250774	U/S	ST 05920 05640	04-Mar-93	13:30	DRY	LOW
AT HOPKINSTOWN	T 250775	DISC	ST 05940 90590				
DISC 2	E 250776	D/S	ST 05950 90590				
TAFF/RHONDDA							
UNNAMED TRIB	T 251083	DISC	SS 96560 93665	05-Mar-93	11:00	DRY	MED
AT BWLLFA FARM							
TAFF/CYNON							
TRIB OF CYNON	T 249927	DISC	ST 04180 99710	01-Mar-93	13:00	DRY	LOW
@ ABERDARE SCHOOL							
UNNAMED TRIB OF	T 251082	DISC	ST 07270 88225	05-Mar-93	10:00	DRY	LOW
TAFF AT UNIVERSITY							
OF GLAMORGAN							
TAFF	E 256851	U/S	ST 10480 99920	15-Apr-93	12:00	DRY	MED
	T 256852	DISC	ST 10470 99950				
NANT CAEACH	E 256853	D/S	ST 10440 99930				

DISCHARGE RATIO	WIDTH m	COLOUR	DEPOSIT	RIVER AFFECTED Km	AREA AFFECTED m2	BED AFFECTED %
50:1	4	MED	HIGH	1.1	4400	100
100:1	1	LOW	LOW	0.01	10	100
10:1	2	HIGH	HIGH	0.35	700	100
10:1	2-3	HIGH	HIGH	2	6000	100
10:1	2	HIGH	HIGH	0.4	600	100
100:1	RIVER - 3 DISCH - 50 cms	MED	RIVER - LOW	0.02	RIVER - 60	100
10:1	TRIB - 2	HIGH	HIGH	0.3	600	100
100:1	7	LOW	LOW	7 m	2.45	5
1000:1	10	HIGH	LOW	0.25	2500	100
1000:1	10	MED	MED	0.25	2500	100
-	2	LOW	LOW	0.1	200	100
1000:1	TRIB - 2-4m	HIGH	MED	TRIB - 1	2000	100
10:1	2	HIGH	PATCHY HIGH/LOW	0.6	1200	100
10:1	3	HIGH	HIGH	0.25	750	100

Appendix 2. Table showing Physicochemical data for Ferruginous Inputs to Welsh Rivers in the South East Area

NAME OF RECEIVING WATER	DOMINANT SUBSTRATE	TEMP. deg. C	pH	FIELD pH	DO mg/l	DO %
TAFF	ROCKS/BOULDERS	5.2	7.80	7.91	13.10	103.0
UNNAMED TRIB		10.0	6.20	6.14	6.80	78.1
CLYDACH, PWLL HELYH		6.2	7.60	7.14	13.00	105.0
TAFF						
UNNAMED TRIB	GRAVEL/STONES	3.6	7.70	8.95	13.50	102.0
CLYDACH, PWLL HELYH		4.0	6.10	6.57	12.30	94.0
DISC 2		3.7	7.80	8.45	13.00	98.5
TAFF	ROCKS/GRAVEL	5.3	7.90	7.97	12.90	102.0
UNNAMED TRIB OF LLYS		10.1	7.10	7.25	9.90	86.1
NANT AT TAI HEOL		9.6	7.60	7.80	13.40	118.0
TAFF						
Y-FFRWD	ROCKS/GRAVEL	4.7	6.50	7.70	14.60	114.0
TRIB NANT CLYDACH		7.5	7.30	7.70	12.40	104.0
PWLL HELYH		6.5	7.20	7.80	13.50	110.0
TAFF	GRAVEL	5.3	7.20	7.70	13.90	110.0
LLYS NANT		7.0	6.60	6.70	8.60	72.6
AT TWYN-Y-GLOG		6.4	7.30	7.54	13.60	111.0
TAFF	GRAVEL/STONES/	8.3	7.70	7.49	11.10	94.6
	SILT	10.4	7.60	6.98	9.80	87.6
TRIB OF CYNON		8.9	7.50	7.45	11.20	96.6
@ DARE VALLEY PARK						
TAFF/CYNON	ROCKS/GRAVEL	4.3	7.90	8.01	12.80	98.5
UNNAMED TRIB OF		10.9	6.90	6.44	3.90	35.4
CYNON AT CWMDARE		4.7	7.90	7.08	13.30	103.0
TAFF/RHONDDA	BOULDERS/ROCKS	2.4	7.70	8.35	14.90	109.0
RHONDDA FACH		6.2	7.40	7.92	12.90	104.0
@ FERNDALE		5.9	7.70	7.99	13.20	106.0
TAFF/RHONDDA						
RHONDDA	BOULDERS/BEDROCK	5.4	8.10	8.70	15.70	124.0
AT HOPKINSTOWN		10.0	7.90	8.85	13.90	123.0
DISC 1		5.0	8.00	8.95	14.80	116.0
TAFF/RHONDDA						
RHONDDA	BOULDERS/BEDROCK	5.1	8.10	9.17	13.80	108.0
AT HOPKINSTOWN		8.0	5.90	7.01	11.10	93.9
DISC 2		5.5	7.90	7.48	14.10	112.0
TAFF/RHONDDA						
UNNAMED TRIB	ROCKS/COBBLES	8.6	7.20	7.95	12.70	109.0
AT BWLLFA FARM						
TAFF/CYNON	FLAT ROCKS/COBBLES	3.8	7.70	8.07	14.20	108.0
TRIB OF CYNON						
@ ABERDARE SCHOOL						
UNNAMED TRIB OF	STONES/ROCKS/	11.0	7.60	7.55	9.50	86.3
TAFF AT UNIVERSITY	GRAVEL					
OF GLAMORGAN						
TAFF	ROCKS/GRAVEL	7.9	7.70	7.56	11.30	95.3
		11.1	7.10	6.54	0.10	0.9
NANT CAEACH		8.6	7.51	7.09	10.40	89.3

CONO. us	DISS. IRON mg/l	TOTAL IRON mg/l	DISS. Al. mg/l	TOTAL Al. mg/l	DISS. SULPHATE mg/l	TOTAL SULPHATE mg/l	ALKALINITY mg/l CaCO	SUS. SOLIDS mg/l
226	0.059	0.141	0.037	0.068	49.20	49.2	56.26	3
277	1.120	1.190	0.416	0.663	102.30	103.0	17.99	3
238	0.265	0.361	0.109	0.202	62.40	62.4	46.79	3
226	0.095	0.160	0.020	0.026	38.10	38.1	70.29	3
1931	0.003	4.600	0.004	0.070	1,001.00	1,001.0	241.37	47
247	0.093	0.093	0.021	0.021	43.00	43.0	69.97	3
340	0.003	0.010	0.004	0.008	54.70	55.4	126.49	3
380	2.100	2.990	0.009	0.050	105.30	105.7	61.46	4
379	1.630	2.130	0.011	0.022	105.70	106.4	83.49	3
77	0.113	0.141	0.130	0.153	14.60	14.6	3.92	3
160	0.666	2.040	0.031	0.058	26.60	26.6	32.69	15
145	0.654	1.060	0.049	0.069	23.60	23.6	26.27	3
118	0.045	0.092	0.135	0.168	19.50	19.6	20.89	8
130	5.300	5.300	0.006	0.006	31.10	31.1	48.84	3
141	0.265	0.666	0.070	0.190	23.60	23.6	26.22	3
486	0.003	0.004	0.004	0.004	62.30	62.3	222.14	3
595	0.691	0.851	0.004	0.004	84.90	86.1	267.17	9
533	0.206	0.254	0.004	0.004	69.80	09.8	232.87	13
204	0.196	0.236	0.004	0.004	26.10	26.2	60.95	9
598	0.367	0.460	0.004	0.039	196.30	196.8	99.69	4
229	0.336	0.637	0.004	0.005	46.10	46.1	69.27	6
264	0.036	0.079	0.060	0.158	33.10	33.1	86.40	4
403	0.519	0.647	0.016	0.071	20.90	20.9	31.57	5
322	0.169	0.314	0.050	0.123	29.00	29.0	77.97	5
304	0.290	0.710	0.019	0.042	50.70	51.1	95.62	3
450	1.600	2.300	0.004	0.008	247.80	275.6	237.97	6
317	0.470	1.700	0.023	0.073	57.00	57.0	93.05	4
313	0.330	1.600	0.025	0.100	54.90	54.9	96.10	5
496	27.600	29.200	0.052	1.900	216.40	216.4	4.35	24
326	0.570	2.300	0.027	0.130	59.70	59.7	90.47	5
335	0.046	0.050	0.004	0.004	99.30	99.3	66.67	3
505	0.344	1.070	0.025	0.159	191.00	195.8	54.50	6
1975	19.590	24.240	0.041	0.054	2.70	2.8	1,044.36	65
279	0.397	0.636	0.013	0.078	41.00	41.0	75.05	5
639	7.160	7.430	0.004	0.004	163.40	163.4	163.85	4
338	1.390	1.560	0.017	0.060	60.30	60.7	84.00	5

Appendix 3. Table showing Physicochemical data for Ferruginous Inputs to Welsh Rivers in the South West Area

NAME OF RECEIVING WATER	LAB. REF.	LOCATION	NATIONAL GRID REFERENCE	DATE	TIME	WEATHER	FLOW
OGMORE	E 245143	U/S	SS 90160 90145	01-Feb-93	12:30	DRY	LOW
	T 245144	DISC	SS 90185 90110				
GARW FECHAN	E 245145	D/S	SS 90190 90070				
OGMORE FACH	T 245142	DISC 1	SS 97760 90515	01-Feb-93	10:55	DRY	HIGH
	T 251084	DISC 2	SS 98190 90470				
OGMORE :	E 245146	U/S	SS 89360 87670	02-Feb-93	13:30	DRY	MED
UNNAMED TRIB	T 245147	DISC	SS 89360 87620				
OF LLYNFI	E 245148	D/S	SS 89340 87560				
AFAN/PELENNA	E 248110	U/S	SN 88150 00840	17-Feb-93	10:30	DRY	LOW
AFON	T 248111	DISC	SN 88135 00780				
CORRWG FECHAN	E 248112	D/S	SN 88115 00720				
AFAN/PELENNA	E 248113	U/S	SN 88960 00725	17-Feb-93	12:00	DRY	LOW
	T 248114	DISC	SN 88925 00690				
AFON CORRWG	E 248115	D/S	SN 88870 00610				
AFAN/PELENNA	E 248116	U/S	SS 86385 97660	17-Feb-93	13:15	DRY	LOW
	T 248117	DISC	SS 86290 97580				
AFON CORRWG	E 248118	D/S	SS 86385 97570				
AFAN/PELENNA	E 248119	U/S	SS 79920 97325	17-Feb-93	15:15	DRY	LOW
	T 248120	DISC 1	SS 79960 97300				
TRIB OF	T 248121	DISC 2	SS 80060 96915				
GWENFFRWD	E 248122	D/S	SS 79940 97190				
AFAN/PELENNA	E 248123	U/S	SS 81585 97275	17-Feb-93	14:45	DRY	LOW
NANT BLAEN PELENNA	T 248124	DISC	SS 81615 97230				
DISC 1	E 248125	D/S	SS 81620 97125				
AFAN/PELENNA	E 251691	U/S	SS 81590 97550	08-Mar-93	12:30	DRY	LOW
NANT BLAEN PELENNA	T 251692	DISC	SS 81540 97515				
DISC 2	E 251693	D/S	SS 81585 97500				
AFAN/PELENNA	E 248824	U/S	SS 78720 89775	23-Feb-93	14:00	DRY	LOW
FFRWD WYLLT	T 248825	DISC	SS 78720 89750				
AT GOYTRE	E 248826	D/S	SS 78690 89740				
AFAN/PELENNA	E 251694	U/S	SS 81890 92210	08-Mar-93	13:15	DRY	LOW
FFRWD WYLLT	T 251695	DISC	SS 81715 92135				
AT BRYN	E 251696	O/S	SS 81665 92160				
AFAN/PELENNA	E 251085	U/S	SS 89215 97365	05-Mar-93	13:00	DRY	LOW
	T 251086	DISC	SS 89230 97300				
NANT GWYNFI	E 251087	D/S	SS 89180 97290				
AFAN/PELENNA	E 251088	U/S	SS 87180 96340	05-Mar-93	14:00	DRY	LOW
A.AFAN	T 251089	DISC	SS 87200 96300				
AT GELLI FARM	E 251090	D/S	SS 87190 96270				
AFAN/PELENNA	E 251682	U/S	SS 87770 95600	08-Mar-93	10:30	DRY	LOW
	T 251683	DISC	SS 87840 95790				
NANT-Y-FEDW	E 251684	D/S	SS 87890 95820				
AFAN/PELENNA	E 251685	U/S	SS 86360 96135	08-Mar-93	11:00	DRY	LOW
A.AFAN	T 251686	DISC	SS 86360 96160				
AT CYMER	E 251687	D/S	SS 86360 96165				

DISCHARGE RATIO	WIDTH m	COLOUR	DEPOSIT	RIVER AFFECTED Km	AREA AFFECTED m2	BED AFFECTED %
10:1	2	HIGH	HIGH/MED	0.4	800	100
-	3-4	HIGH	MED	1.25	4375	100
10:1	1.5-2.5	HIGH	HIGH	2.7	5400	100
50:1	3-5	HIGH	HIGH	1.7	5100	100
50:1	3-5	HIGH	HIGH	3.2	12800	100
100:1	4-5	HIGH	HIGH	1.2	5400	100
10:1	2-3	HIGH	HIGH	1.1	2750	100
10:1	3	HIGH	HIGH	5	15000	100
50:1	3-4	HIGH	HIGH	0.01	30	100
10:1	4	HIGH	HIGH	0.75	3000	100
1:1	2-3	MED	MED	0.25	750	100
10:1	2.5-3	HIGH	HIGH	2.1	5250	100
1000:1	3	HIGH	LOW	0.01	15	50
10:1	2-3	HIGH	HIGH	0.7	2100	100
1000:1	3-4	MED	MED	15m	30	30

Appendix 3. Table showing Physicochemical data for Ferruginous Inputs to Welsh Rivers in the South West Area

NAME OF RECEIVING WATER	DOMINANT SUBSTRATE	TEMP. deg. C	pH	FIELD pH	DO mg/l	DO %
OGMORE	ROCKS/COBBLES/	7.3	7.10	7.50	12.60	105.0
	STONES	10.4	7.00	6.75	0.90	8.1
GARW FECHAN		8.1	7.00	7.25	12.20	103.0
OGMORE FACH	ROCKS/	9.1	7.40	7.10	11.10	96.4
	LARGE STONES	9.8	6.90	7.75	11.50	102.0
OGMORE	STONES/	7.7	6.80	7.53	12.00	101.0
UNNAMED TRIB	GRAVEL/	10.2	6.30	6.65	9.60	85.6
OF LLYNFI	LARGE ROCKS	7.7	6.80	7.08	11.60	97.4
AFAN/PELENNA	BOULDERS/ROCKS/	5.9	7.00	6.50	14.40	116.0
AFON	COBBLES	9.7	7.30	7.05	2.10	18.5
CORRWG FECHAN		7.1	6.90	7.38	12.20	101.0
AFAN/PELENNA	BEDROCK/BOULDERS	7.3	7.50	6.30	13.40	111.0
		9.4	6.60	6.66	2.40	21.0
AFON CORRWG		7.7	7.40	7.55	12.50	105.0
AFAN/PELENNA	BOULDERS/ROCKS/	7.9	7.50	6.11	12.40	105.0
	GRAVEL	11.6	7.50	7.66	10.10	93.1
AFON CORRWG		8.2	7.60	8.09	12.90	110.0
AFAN/PELENNA	ROCKS/GRAVEL	8.9	8.70	7.13	12.30	106.0
		10.5	5.10	6.19	1.20	10.8
TRIB OF		10.1	4.00	4.95	10.00	89.0
GWENFFRWD		9.1	5.70	7.02	11.60	103.0
AFAN/PELENNA	ROCKS/GRAVEL/	8.6	7.00	6.15	12.30	106.0
NANT BLAEN PELENNA	FEW BOULDERS	10.5	5.70	6.15	8.50	76.3
DISC 1		9.3	5.80	6.68	11.00	96.0
AFAN/PELENNA	ROCKS/GRAVEL/	5.5	6.90	6.12	12.60	102.0
NANT BLAEN PELENNA	FEW BOULDERS	8.9	7.20	7.43	11.40	96.5
DISC 2		6.5	7.01	7.73	12.30	100.0
AFAN/PELENNA	ROCKS/GRAVEL	6.5	7.20	7.62	13.60	111.0
FFRWD WYLLT		10.2	6.60	6.78	9.50	84.7
AT GOYTRE		7.1	6.90	7.36	12.50	103.0
AFAN/PELENNA	GRAVEL/SOME ROCKS	5.7	7.30	6.00	12.90	103.0
FFRWD WYLLT		8.9	7.20	7.59	12.10	99.6
AT BRYN		5.9	7.30	7.95	12.60	103.0
AFAN/PELENNA	BOULDERS/ROCKS/	5.6	7.50	6.36	15.60	124.0
	GRAVEL	9.8	6.60	7.24	11.10	98.1
NANT GWYNFI		6.5	7.00	7.56	14.10	115.0
AFAN/PELENNA	ROCKS/GRAVEL	6.7	7.60	6.16	14.20	116.0
A.AFAN		9.7	7.60	7.85	12.60	111.0
AT GELLI FARM		8.9	7.60	6.01	12.90	106.0
AFAN/PELENNA	ROCKS/GRAVEL/	5.0	6.65	6.62	12.90	101.0
	BOULDERS	9.2	7.40	7.03	3.80	33.1
NANT-Y-FEDW		6.3	6.76	7.49	12.10	98.1
AFAN/PELENNA	ROCKS/BOULDERS	5.6	7.16	6.14	13.60	110.0
A.AFAN		9.4	7.00	7.29	9.30	81.4
AT CYMER		6.1	7.16	7.60	12.60	102.0

COND. us	DISS. IRON mg/l	TOTAL IRON mg/l	DISS. Al. mg/l	TOTAL Al. mg/l	DISS. SULPHATE mg/l	TOTAL SULPHATE mg/l	ALKALINITY mg/l CaCO	SUS. SOLIDS mg/l
116	0.096	0.096	0.110	0.120	14.70	14.8	16.62	3
344	3.400	3.400	0.004	0.004	49.70	49.7	113.39	3
160	0.540	0.540	0.014	0.100		16.9	26.10	17
244	0.600	0.600	0.004	0.004	21.90	21.9	83.31	3
238	0.575	0.677	0.004	0.004	42.30	42.3	73.90	3
112	0.140	0.190	0.044	0.110	13.30	13.6	6.79	5
335	9.900	9.900	0.005	0.005	98.40	103.0	27.63	7
170	0.500	0.600	0.027	0.340	29.40	29.4	10.80	5
78.3	0.017	0.054	0.065	0.110	9.80	9.8	16.35	3
526	10.490	10.490	0.018	0.018	141.90	142.2	123.39	21
230		2.709	0.360	0.052	52.70	52.7	48.66	9
150	0.038	0.065	0.270	0.031	14.10	14.1	54.09	3
507	1.366	15.260	0.022	0.031	35.40	202.6	44.02	5
198		1.696	0.030	0.032		36.0	52.77	5
173	0.041	0.126	0.025	0.035	32.20	32.2	42.29	3
1018	15.710	27.970	0.028	0.092	370.20	367.0	207.12	58
194	0.304	0.750	0.022	0.042	38.60	38.6	45.91	3
148	0.046	0.120	0.129	0.273	38.10	38.3	8.66	4
974	101.400	103.200	0.179	0.190	512.20	519.3	1.19	13
355	12.150	12.260	1.491	1.514	145.20	145.2		3
258	9.260	9.590	0.037	0.262	93.60	93.8	1.34	7
124	0.034	0.220	0.048	0.365	24.20	24.2	15.14	3
565	25.210	25.630	0.189	0.353	265.60	267.6	5.32	5
303	9.190	11.610	0.067	0.915	121.90	122.4	3.09	5
98	0.003	0.111	0.035	0.328	19.40	19.8	11.90	3
239	0.606	1.126	0.018	0.640	46.30	46.9	55.47	6
152	0.149	0.626	0.035	0.576	29.20	29.2	23.50	6
179	0.060	0.099	0.030	0.079	29.50	29.7	26.16	3
399	4.000	4.400	0.009	0.026	92.70	92.7	65.95	6
222	0.930	0.930	0.022	0.046	46.10	47.0	41.20	3
160	0.027	0.059	0.026	0.046	20.60	20.8	32.50	3
261	0.364	0.442	0.032	0.046	19.00	19.1	34.92	3
171	0.324	0.569	0.036	0.062	19.40	19.5	35.68	3
106	0.066	0.122	0.042	0.043	11.30	11.3	27.85	3
447	8.700	9.540	0.027	0.043	163.40	163.4	52.87	10
194	2.100	2.100	0.027	0.043	53.60	53.6	34.74	10
169	0.038	0.083	0.030	0.030	30.90	31.0	35.55	3
224	0.129	0.756	0.004	0.011	27.60	27.8	83.42	15
173	0.054	0.187	0.024	0.037	30.80	31.0	36.69	3
57	0.017	0.017	0.007	0.009	8.50	8.5	7.90	3
299		1.522	0.004	0.015	70.90	70.9	74.56	6
156	0.646	0.646	0.004	0.015	34.20	34.6	10.40	5
181	0.049	0.070	0.006	0.015	33.30	33.3	26.10	3
266	0.119	0.458	0.004	0.004	20.10	20.1	41.55	9
176	0.055	0.122	0.006	0.012	30.30	31.5	36.77	3

Appendix 3. Table showing Physicochemical data for Ferruginous Inputs to Welsh Rivers in the South West Area

NAME OF RECEIVING WATER	LAB. REF.	LOCATION	NATIONAL GRID REFERENCE	DATE	TIME	WEATHER	FLOW
AFAN/PELENNA	E 251688	U/S	SS 84420 97360	08-Mar-93	12:00	DRY	LOW
	T 251689	DISC	SS 89445 97330				
TRIB OF NANT CREGAN	E 251690	D/S	SS 84770 97315				
CYNFFIG	E 251697	U/S	SS 85640 85140	08-Mar-93	14:30	DRY	LOW
	E 251698	DISC	SS 85670 85120				
NANT CRAIG YR ABER	E 251699	D/S	SS 85685 85050				
NANT CYNFFIG	T 251700	DISC	SS 86425 83500	08-Mar-93	15:40	DRY	LOW
LOUGHOR	E 253007	U/S	SN 53920 09920	16-Mar-93	14:30	DRY	LOW
TRIB OF AFON MORLAIS	T 253008	DISC	SN 53700 09680				
LOUGHOR	E 253200	U/S	SN 50990 02000	17-Mar-93	12:45	DRY	LOW
	T 253201	DISC	SN 57230 02260				
MORLAIS	E 253202	D/S	SN 57025 01970				
LOUGHOR	E 252760	U/S	SN 60090 14120	15-Mar-93	16:30	DRY	LOW
UNAMED TRIB OF	T 252761	DISC	SN 60135 14120				
AFON LASH	E 252762	D/S	SN 60190 14140				
LOUGHOR	E 253389	U/S	SN 63260 09630	16-Mar-93	15:30	DRY	LOW
	T 253390	DISC	SN 63250 09630				
R. CATHAN	E 253391	D/S	SN 63230 09665				
LOUGHOR	E 253543	U/S	SN 63750 09670	19-Mar-93	09:00	DRY	LOW
UNNAMED TRIB OF	T 253544	DISC	SN 64040 09820				
CATHAN	E 253545	D/S	SN 63720 09680				
LOUGHOR							
UNNAMED TRIB OF	E 253546	U/S	-	19-Mar-93	10:30	DRY	LOW
NANT GARRNING	T 253547	DISC	SN 67385 12285				
AT GLANAMAN	E 253548	D/S	-				
UNNAMED TRIB	E 253549	U/S	SN 60220 12230	19-Mar-93	11:15	DRY	LOW
OF LOUGHOR AT	T 253550	DISC	SN 60250 12200				
SARON AMMANFORD	E 253551	DIS	SN 60260 12180				
UNNAMED TRIB	E 253552	U/S	SN 59450 11670	19-Mar-93	12:00	DRY	LOW
OF LOUGHOR	T 253553	DISC	SN 59470 11620				
AT CAPEL HENDRE	E 253554	D/S	SN 59450 11565				
AMMANFORD							
	E 254177	U/S	SN 61970 11960	24-Mar-93	10:00	DRY	LOW
R.LOUGHOR	T 254178	DISC	SN 62000 11960				
AT AMMANFORD	E 254179	D/S	SN 62010 11930				
UNNAMED TRIB	E 254175	U/S	"	24-Mar-93	10:30	DRY	LOW
OF LOUGHOR	T 254176	DISC/STREA	"				
AT AMMANFORD							
LOUGHOR							
NANT MELYN	E 254346	DISC	SN 70350 10110	25-Mar-93	11:40	DRY	LOW
GWENDRAETH	E 253004	U/S	SN 53685 12475	16-Mar-93	12:00	DRY	LOW
TRIB OF	T 253005	DISC	SN 53660 12450				
GWENDRAETH FAWR	E 253006	D/S	SN 53640 12440				

DISCHARGE RATIO	WIDTH m	COLOUR	DEPOSIT	RIVER AFFECTED Km	AREA AFFECTED m2	BED AFFECTED %
100:1	2	HIGH	MED	0.1	200	100
10:1	2-3	HIGH	HIGH	4.5	13500	100
-	2	MED	MED	-	-	100
NOT MEASURABLE	1	MED/LOW	MED/LOW	2.5	2500	100
10:1	5	HIGH	HIGH	1	5000	100
1:1	1.5	HIGH	HIGH	0.5	750	100
1000:1	3	HIGH	HIGH	1.2	3600	100
10:1	2	HIGH	HIGH	0.6	1200	100
10:1	2.5	MED/LOW	MED/LOW	0.5	1250	100
1:1	1	HIGH	HIGH	0.4	400	100
100:1	2	HIGH	HIGH	0.6	1200	100
1000:1	6	HIGH/MED	MED/LOW	0.01	0.01	5
-	0.2	-	-	-	-	-
-	1.5	MED	MED/LOW	1.6	2400	100
10:1	1	HIGH	HIGH	0.3	300	100

Appendix 3. Table showing Physicochemical data for Ferruginous Inputs to Welsh Rivers in the South West Area

NAME OF RECEIVING WATER	DOMINANT SUBSTRATE	TEMP. deg. C	pH	FIELD pH	DO mg/l	DO %
AFAN/PELENNA	GRAVEL/ROCKS	5.0	5.39	6.00	12.60	98.8
		9.7	6.70	7.34	11.40	100.0
TRIB OF NANT CREGAN		7.5	7.17	7.51	12.10	101.0
CYNFFIG	ROCKS/GRAVEL	7.1	6.90	6.26	12.10	100.0
		7.6	6.60	7.43	11.10	92.9
NANT CRAIG YR ABER		7.3	7.10	7.60	11.80	98.1
NANT CYNFFIG	SMALL ROCKS/GRAVEL/ SILT	8.0	7.60	7.54	11.30	95.6
LOUGHOR	GRAVEL/SILT	8.5	7.50	7.48	13.80	118.0
TRIB OF AFON MORLAIS		9.0	4.83	7.54	13.00	113.0
LOUGHOR	GRAVEL/STONES/ SILT BANKS	9.8	7.30	8.17	12.00	106.0
		14.5	6.70	6.90	0.20	2.0
MORLAIS		11.4	6.90	7.32	10.40	95.4
LOUGHOR	COBBLES/GRAVEL	9.0	8.00	8.03	9.70	84.1
UNAMED TRIB OF		10.3	7.20	6.80	5.80	51.8
AFON LASH		10.1	7.60	7.06	8.70	77.4
LOUGHOR	ROCKS/COBBLES	8.6	7.70	7.98	11.30	97.0
		11.0	5.80	5.50	1.00	9.1
R. CATHAN		8.9	7.20	6.84	10.70	92.5
LOUGHOR	LARGE ROCKS/GRAVEL	4.5	7.50	7.66	11.50	89.0
UNNAMED TRIB OF		10.5	6.40	6.25	0.30	2.7
CATHAN		9.2	7.40	7.59	11.00	95.6
LOUGHOR						
UNNAMED TRIB OF	GRAVEL/SMALL ROCKS	4.7	8.30	8.42	12.00	93.4
NANT GARRNING		5.6	7.10	7.90	10.10	80.4
AT GLANAMAN		5.4	6.20	6.42	12.10	95.6
UNNAMED TRIB	STONES/GRAVEL	6.5	8.10	7.94	11.80	96.1
OF LOUGHOR AT		9.8	7.30	7.41	10.30	91.0
SARON AMMANFORD		8.0	7.60	7.61	11.00	93.0
UNNAMED TRIB	BEDROCK/GRAVEL	5.5	7.40	7.46	12.30	97.7
OF LOUGHOR		9.8	6.50	6.46	4.60	42.4
AT CAPEL HENDRE		8.0	7.00	6.62	10.90	92.2
AMMANFORD						
	ROCKS/GRAVEL	6.7	6.20	6.26	14.10	115.0
R.LOUGHOR		10.7	7.40	6.67	0.90	8.1
AT AMMANFORD		7.6	7.60	7.44	11.70	98.0
UNNAMED TRIB	-	5.4	6.30	6.26	13.50	107.0
OF LOUGHOR		9.0	7.10	7.16	6.30	54.6
AT AMMANFORD						
LOUGHOR						
NANT MELYN	GRAVEL	6.2	6.90	7.92	12.30	99.4
GWENDRAETH	GRAVEL/SMALL STONES	6.7	6.10	6.25	13.10	113.0
TRIB OF		10.5	4.67	6.56	1.20	10.8
GWENDRAETH FAWR		9.5	7.20	6.94	9.30	81.6

COND. us	DISS. IRON mg/l	TOTAL IRON mg/l	DISS. Al. mg/l	TOTAL Al. mg/l	DISS. SULPHATE mg/l	TOTAL SULPHATE mg/l	ALKALINITY mg/l CaCO	SUS. SOLIDS mg/l
105	0.010	0.011	0.011	0.011	16.60	16.6	1.76	3
394	3.230	3.320	0.063	0.123	150.60	153.7	36.13	6
265	1.680	2.470	0.053	0.238	86.40	86.8	28.25	17
106	0.153	0.283	0.007	0.022	14.70	14.7	11.22	3
234		1.990	0.010	0.013	19.90	19.9	17.75	5
156	0.537	0.699	0.006	0.011	25.30	25.3	22.60	3
526	0.761	0.851	0.016	0.031	125.50	125.5	125.30	7
81	0.526	0.685	0.058	0.135	6.90	6.9	12.34	3
106	0.913	1.331	0.032	0.062	7.50	7.5	20.14	5
169	0.262	0.416	0.026	0.056	24.10	24.1	32.88	3
2230	63.130	73.080	0.166	0.175	985.00	1,057.0	222.62	73
1011		10.360		0.034	390.60	400.4	103.62	50
725	0.003	0.041	0.004	0.004	214.50	214.5	190.55	3
1162	2.096	2.116	0.004	0.004	304.00	304.0	246.15	3
1070	0.546	1.138	0.004	0.004	272.20	275.0	345.86	6
212	0.046	0.096	0.011	0.029	42.20	42.5	50.03	3
900	61.100	61.630	0.746	1.203	488.70	488.7	18.18	4
235	1.900	1.951	0.026	0.060	54.80	54.9	47.62	6
155	0.042	0.066	0.017	0.020	13.70	13.7	42.20	4
897	24.600	25.500	0.200	0.613	406.70	406.7	66.10	45
515	0.565	2.610	0.007	0.139	144.60	207.9	45.65	12
296	0.076	0.116	0.012	0.061	34.50	35.2	121.97	3
461	0.047		0.004		179.40		52.40	23
310	0.070	0.117	0.016	0.056	46.90	46.9	116.62	3
214	0.117	0.152	0.014	0.057	10.70	10.8	93.03	3
610	2.920	4.110	0.004	0.028	169.90	169.9	132.47	14
458	1.620	1.710	0.004	0.026	115.20	117.1	116.13	9
184	0.360	0.546	0.005	0.029	14.50	14.5	59.13	10
310	6.480	13.000	0.019	0.021	25.80	34.9	98.40	28
205	2.430	2.430	0.009	0.033	17.70	17.7	62.96	36
337	0.059	0.200	0.046	0.130	42.50	42.5	123.52	3
1063	5.100	7.200	0.006	0.006	144.10	145.2	576.04	15
530	1.200	1.300	0.026	0.120		50.5	184.72	32
555	0.074	0.183	0.005	0.005	101.90	102.2	213.49	3
504	3.800	4.600	0.011	0.011	53.00	53.0	224.44	8
98	0.742	0.860	0.011	0.016	7.60	7.9	23.64	3
397	0.293	0.429	0.010	0.030	60.80	60.8	120.17	4
921	2.923	3.006	0.004	0.006	243.40	243.4	339.80	7
676	1.373	2.481	0.004	0.022	165.70	167.1	227.47	3

Appendix 3. Table showing Physicochemical data for Ferruginous Inputs to Welsh Rivers in the South West Area

NAME OF RECEIVING WATER	LAB. REF.	LOCATION	NATIONAL GRID REFERENCE	DATE	TIME	WEATHER	FLOW
GWENDRAETH FAWR	E 252757	U/S	SN 50165 11210	15-Mar-93	13:30	DRY	LOW
	T 252758	DISC	SN 50150 11180				
	E 252759	D/S	SN 50130 11185				
GOWER							
UNNAMED TRIB AT	E 253203	U/S	SS 55350 95080	17-Mar-93	16:00	DRY	LOW
BLUE ANCHOR	T 253204	DISC	SS 55330 95060				
GOWER	E 253382	U/S	SS 55160 91370	16-Mar-93	09:00	DRY	LOW
UNNAMED TRIB OF	T 253383	DISC	SS 55200 91360				
PENARD PIL	E 253384	D/S	SS 55200 91330				
GOWER	E 253385	U/S	SS 58760 94260	16-Mar-93	11:40	DRY	LOW
	T 253386	DISC 1	SS 58760 94270				
TRIB OF CLYNE	T 253387	DISC 2					
	E 253388	D/S	SS 58610 94250				
PEMBROKESHIRE	E 253947	U/S	SM 89520 23610	23-Mar-93	10:00	DRY	LOW
UNNAMED TRIB OF	T 253948	DISC	SM 89500 23590				
BRADY BROOK	E 253949	D/S	SM 89485 23590				
PEMBROKESHIRE	E 253950	U/S	SN 11675 06990	23-Mar-93	16:30	DRY	LOW
	T 253951	DISC	SN 11640 06985				
CRESWELL RIVER	E 253952	D/S	SN 11790 06980				
PEMBROKESHIRE	E 253953	U/S	SN 12410 04865	23-Mar-93	17:15	DRY	LOW
UNNAMED TRIB AT	T 253954	DISC	SN 12490 04860				
SAUNDERSFOOT STW	E 253955	D/S	SN 12555 04860				
NEATH	E 254180	U/S	SN 74140 00055	24-Mar-93	16:00	DRY	LOW
	T 254181	DISC	SN 74140 00040				
CLYDACH	E 254182	D/S	SN 74110 00020				
NEATH	E 256692	U/S	SN 83430 02530	13-Apr-93	10:30	V.WET	HIGH
	T 256693	DISC	SN 83390 02530				
CLYDACH BROOK	E 256694	D/S	SN 83360 02510				
NEATH	E 256695	U/S	SN 81350 02840	13-Apr-93	11:30	WET	HIGH
GARWED BROOK	T 256696	DISC	SN 81370 02825				
AT ABERGARWED	E 256697	D/S	SN 81360 02805				
NEATH	E281137	U/S	SN 8110 0190	23-Sep-93	09:30	DRY	LOW
	T281138	DISC	SN 8080 0175				
NEATH CANAL	E281139	D/S	SN 8035 0110				
NEATH	E 256698	U/S					
	T 256699	DISC	SN 86900 05070	13-Apr-93	13:30	DRY/WET	HIGH
RIVER GWRACH	E 256700	D/S					
NEATH	E 256701	U/S	SN 79480 04620	14-Apr-93	11:30	DRY	MED
CRYNANT	T 256702	DISC	SN 79470 04700				
TRIB OF DULAIS	E 256703	D/S	SN 79450 04700				
TAWE	E 254347	U/S	SN 75465 12010	25-Mar-93	13:30	DRY	LOW
	T 254348	DISC	SN 75470 11990				
A.TWRCH	E 254349	D/S	SN 75460 11980				
TAWE	E 254515	U/S	SN 70020 05365	26-Mar-93	11:00	DRY	LOW
UNNAMED TRIB OF	T 254516	DISC	SN 70020 05330				
LOWER CLYDACH	E 254517	D/S	SN 70010 05300				

DISCHARGE RATIO	WIDTH m	COLOUR	DEPOSIT	RIVER AFFECTED Km	AREA AFFECTED m2	BED AFFECTED %
1000:1	3-4	LOW	LOW	-	2	1
NOT MEASURABLE	0.5	MED/LOW	LOW	0.1	500	100
1000:1	4	MED/LOW	LOW	-	2	-
1:1	CLINE - 2 TRIB - 1-2	HIGH	HIGH	1.75	3500	100
10:1	1	MED	MED/LOW	0.01	5	50
100:1	1	MED	MED	0.4	400	100
1:1	1	MED	MED	0.15	150	100
1000:1	5	MED	LOW	0.01	10	1
1000:1	4	HIGH	HIGH	0.4	1600	100
1:1	3	HIGH	HIGH	0.4	1200	100
1000:1	4-5	HIGH	HIGH	2	10000	100
1000:1	2-3	LOW	-	-	-	-
100:1	4	HIGH	HIGH	0.5	2000	100
1000:1	8	MED/LOW	MED/LOW	20m	160	100
100:1	1-2	HIGH	HIGH/MED	1.5	3000	100

Appendix 3. Table showing Physicochemical data for Ferruginous Inputs to Welsh Rivers in the South West Area

NAME OF RECEIVING WATER	DOMINANT SUBSTRATE	TEMP. deg. C	pH	FIELD pH	DO mg/l	DO %
GWENDRAETH FAWR	ROCKS/GRAVEL	9.2	6.20	6.40	11.90	104.0
		10.3	7.50	7.32	4.00	35.8
		8.8	7.50	7.42	9.40	81.1
GOWER UNNAMED TRIB AT BLUE ANCHOR	SMALL ROCKS/GRAVEL/ SILT	10.0	7.50	7.58	6.50	75.4
		10.0	7.50	7.47	8.80	76.1
GOWER UNNAMED TRIB OF PENARD PIL	COBBLES/GRAVEL	8.5	7.40	7.26	9.50	81.3
		9.0	6.40	6.39	3.40	29.5
		8.9	7.40	7.26	8.90	76.9
GOWER TRIB OF CLYNE	GRAVEL/ROCKS	9.3	7.50	6.19	10.20	89.0
		11.4	7.00	6.75	1.00	9.2
		11.4	6.30	6.79	7.30	67.0
		10.6	7.10	6.91	6.20	55.6
PEMBROKESHIRE UNNAMED TRIB OF BRADY BROOK	GRAVEL/SMALL STONES	7.4	7.00	6.80	13.90	116.0
		8.6	6.70	5.76	10.90	94.0
		8.0	5.20	6.76	11.50	97.3
PEMBROKESHIRE CRESWELL RIVER	SMALL STONES/SILT	8.2	7.40	7.83	12.20	104.0
		10.0	6.70	6.84	0.80	7.1
		8.4	7.10	7.13	10.90	93.1
PEMBROKESHIRE UNNAMED TRIB AT SAUNDERSFOOT STW	GRAVEL/SMALL STONES	8.2	7.50	7.65	11.60	98.6
		9.6	6.90	6.60	1.80	15.9
		9.2	6.80	6.95	4.50	39.2
NEATH CLYDACH	GRAVELS/STONES	7.5	7.40	7.99	12.10	101.0
		8.0	7.20	6.96	1.30	11.0
		7.5	7.20	7.14	12.70	106.0
NEATH CLYDACH BROOK	BOULDERS/ROCKS/ GRAVEL	7.0	6.90	6.00	12.10	99.6
		12.5	7.40	6.62	0.10	0.9
		7.1	6.80	7.12	11.90	98.4
NEATH GARWED BROOK AT ABERGARWED	BOULDERS/ROCKS/ GRAVEL	9.0	6.80	5.73	11.20	97.1
		10.6	2.90	3.07	10.00	90.0
		9.6	3.10	3.59	11.10	97.6
NEATH NEATH CANAL		10.5	7.30	6.69	10.30	92.5
		13.3	3.20	6.39	3.53	33.6
		11.2	7.10	7.01	8.60	76.5
NEATH RIVER GWRACH		8.7	7.40	7.46	11.30	97.2
		12.2	7.80	6.86	0.90	8.4
		9.3	6.30	7.45	11.20	97.8
NEATH CRYNANT TRIB OF DULAIS	ROCKS/GRAVEL/ BOULDERS	7.1	6.70	6.10	11.20	92.8
		8.8	4.90	6.50	12.20	105.0
		7.1	6.30	6.66	12.20	101.0
TAWE A.TWRCH	ROCKS/BEDROCK	7.1	7.70	6.74	11.90	98.4
		10.3	6.80	6.39	0.90	8.1
		7.1	7.40	7.49	12.70	105.0
TAWE UNNAMED TRIB OF LOWER CLYDACH	GRAVEL/STONES	8.6	6.90	6.29	12.00	95.5
		9.5	5.60	6.08	0.20	1.8
		8.0	6.20	6.25	12.00	96.5

COND. us	DISS. IRON mg/l	TOTAL IRON mg/l	DISS. Al. mg/l	TOTAL Al. mg/l	DISS. SULPHATE mg/l	TOTAL SULPHATE mg/l	ALKALINITY mg/l CaCO	SUS. SOLIDS mg/l
379		0.360	0.004	0.023	57.20	57.4	130.15	3
605	0.274	0.429	0.004	0.004	67.30	67.6	418.80	3
440	0.233	0.277	0.004	0.007	64.10	66.1	162.27	3
476	0.341	0.470	0.015	0.079	100.80	103.1	106.32	6
566	0.854	1.306	0.008	0.052	92.80	94.7	112.27	10
220	0.593	0.764	0.034	0.122	14.30	14.3	52.72	6
240		6.250		0.014	12.70	12.6	35.55	7
221	0.536	0.716	0.029	0.111	14.30	14.3	50.65	4
207	0.168	0.411	0.014	0.062	13.00	20.7	66.70	6
541	7.617	8.175	0.008	0.010	73.70	76.7	199.80	12
455	27.800	27.800	0.057	0.059	129.60	129.9	50.00	5
469		4.777	0.010	0.022	49.70	56.4	150.10	50
240	0.180	0.220	0.044	0.068	22.40	22.4	27.87	3
254	0.230	2.000	0.360	0.840	12.10	17.5	13.31	5
261	0.200	0.220	0.260	0.360		13.5	1.58	3
244	0.560	1.040	0.024	0.130	13.50	13.6	75.37	6
360	18.600	19.200	0.043	0.049	0.40	0.4	91.41	23
270	2.000	2.900	0.028	0.140	12.20	12.2	77.87	16
235	0.560	2.100	0.017	0.060	13.30	13.3	67.01	5
362	0.410	0.770	0.004	0.004	20.60	20.6	149.12	3
347	0.390	1.100	0.004	0.014	19.50	19.5	135.84	3
200	0.330	0.420	0.041	0.075	40.30	40.4	40.62	3
237	1.400	1.400	0.008	0.035	33.20	35.9	54.51	3
200	0.310	2.500	0.038	0.160	39.60	39.6	42.27	37
93	0.052	0.374	0.082	0.615	21.40	21.4	7.50	12
946	22.630	22.630	0.058	0.168	460.00	460.0	84.10	4
138	1.084	1.102	0.106	0.761	36.20	36.2	9.49	24
83	0.056	0.199	0.092	0.448	14.00	14.0	6.66	4
1583	100.600	102.900	22.360	22.940	1,022.00	1,032.0		15
316	22.090	22.090	6.900	7.040	314.70	314.7		23
224		0.340		0.090	30.50	30.5		4
3380	130.000	136.000	0.130	0.330	1,274.00	1,274.0		27
450	4.400	5.800	0.054	0.190	136.00	142.3		16
91	0.056	0.094	0.023	0.097	11.20	11.2	21.90	3
416	0.810	7.760	0.014	0.045	7.70	7.7	234.20	29
109	0.026	0.061	0.004	0.036	103.70	103.7	148.00	3
70	0.016	0.025	0.078	0.103	12.00	12.1	5.11	3
327	2.840	3.020	0.159	0.780	133.30	143.6	1.42	16
155	0.338	0.760	0.078	0.350	26.20	40.6	6.20	5
120	0.031	0.045	0.032	0.074	6.30	6.3	47.90	3
640	3.910	4.290	0.004	0.004	42.90	42.9	354.00	8
141	0.160	0.191	0.047	0.047	7.80	7.6	59.50	3
312	0.136	0.224	0.009	0.042	132.00	132.0	11.70	3
556	30.300	44.700	0.061	0.421	204.00	204.0	47.60	79
331	1.490	2.120	0.016	0.041	136.00	136.0	13.60	10

Appendix 4. Table showing Physicochemical data for Ferruginous Inputs to Welsh Rivers in the North Area

NAME OF RECEIVING WATER	LAB. REF.	LOCATION	NATIONAL GRID REFERENCE	DATE	TIME	WEATHER	FLOW
DEE	E 165669	U/S					
	T 165670	DISC	SJ 24370 60200	21-Apr-93	11:40	DRY	MED
R.TERRIG	E 165671	D/S					
DEE	E 165594	U/S		20-Apr-93	15:30	DRY	MED
	T 165596	DISC	SJ 27330 67450				
WEPRE BROOK	E 165595	D/S					
DEE	E 165666	U/S		21-Apr-93	10:30	DRY	MED
	T 165667	DISC	SJ 27450 61060				
R.ALYN	E 165668	D/S					
DEE	E 165672	U/S		21-Apr-93	14:00	DRY	MED
	T 165673	DISC	SJ 29290 54960				
R.CEGIDOG	E 165674	D/S					
DEE	E 165765	U/S	SJ 30650 65700	23-Apr-93	09:00	DRY	MED
	T 165766	DISC	SJ 30660 65710				
BROUGHTON BROOK	E 165767	D/S	SJ 30660 65720				
DEE	E 165762	U/S	SJ 27300 61890	22-Apr-93	14:50	WET	MED
AT MONSANTO	T 165763	DISC	SJ 27340 61880				
	E 165764	D/S	SJ 27320 61850				
DEE	E 165678	U/S	SJ 31430 55340	21-Apr-93	15:15	DRY	MED
	T 165679	DISC	SJ 31440 55290				
R.ALYN	E 165680	D/S	SJ 31450 55340				
DEE	E 165675	U/S					
	T 165676	DISC	SJ 32520 54310	21-Apr-93	16:00	DRY	MED
R.ALYN	E 165677	D/S					

DISCHARGE RATIO	WIDTH m	COLOUR	DEPOSIT	RIVER AFFECTED Km	AREA AFFECTED m2	BED AFFECTED %
100:1	2	HIGH	MED	1m	2	20
100:1	1	HIGH	MED	-	-	-
1000:1	3	LOW	LOW	-	1	1
100:1	3	MED	LOW	0.1	100	100
10:1	1	HIGH	HIGH	0.15	150	100
1000:1	12	HIGH	STREAM - HIGH	STREAM - 0.1	STREAM - 100 DEE - 0.02	STREAM - 100
1000:1	5	MED	LOW	0.02	20	5
1000:1	5	MED/LOW	LOW	-	-	-

Appendix 4. Table showing Physicochemical data for Ferruginous Inputs to Welsh Rivers in the North Area

NAME OF RECEIVING WATER	DOMINANT SUBSTRATE	TEMP. deg. C	pH	FIELD pH	DO mg/l	DO %	COND. us
DEE		9.3	8.30	7.94	11.10	96.9	
	SMALL ROCKS	8.9	7.00	6.67	0.30	2.6	
R.TERRIG		9.2	7.90	7.60	8.60	74.9	
DEE	SILT GRAVEL	12.0	7.70	7.95	10.10	93.9	
		11.2	6.80	6.25	2.10	19.2	
WEPRE BROOK		12.0	7.20	7.92	10.10	93.9	
DEE	GRAVEL	9.8	8.00	7.85	10.50	92.8	
		8.6	7.40	7.40	8.10	69.5	
R.ALYN		9.1	7.50	7.90	7.70	66.9	
DEE	GRAVEL/ROCKS	10.0	8.30	8.19	11.20	99.4	
		11.5	6.70	6.82	8.10	74.5	
R.CEGIDOG		10.1	7.60	7.15	10.80	96.1	
DEE	GRAVEL/SILT	9.7	7.70	8.06	8.50	74.9	
		10.7	6.70	6.34	0.20	1.8	
BROUGHTON BROOK		10.5	6.90	7.00	1.50	13.5	
DEE	RIVER - SILT	10.1	8.00	7.49	11.50	102.0	
AT MONSANTO	STREAM - GRAVEL	11.2	7.00	6.32	0.90	8.2	
		10.5	7.90	7.52	8.80	79.0	
DEE	BEDROCK	11.1	8.40	8.04	11.20	102.0	
		10.0	6.50	6.28	2.40	21.3	
R.ALYN		10.6	6.10	7.98	10.80	97.7	
DEE		11.0	8.40	8.32	11.40	104.0	
	GRAVEL	9.8	7.50	7.31	7.50	65.9	
R.ALYN		11.0	8.50	8.34	11.50	105.0	

	DISS. IRON mg/l	TOTAL IRON mg/l	DISS. Al. mg/l	TOTAL Al. mg/l	DISS. SULPHATE mg/l	TOTAL SULPHATE mg/l	ALKALINITY mg/l CaCO	SUS. SOLIDS mg/l
463	0.900	0.930	0.316	0.339	26.79		205.00	7.2
658	4.770	6.040	0.381	0.381	67.58		294.00	12
533	0.176	0.214	0.315	0.315	26.63		215.00	13.2
706	0.010	0.310	0.026	0.267	74.49		203.50	6.8
1733	2.980	3.480	0.662	0.704	746.64	1,331.0	405.00	11
912	0.030	2.950	0.032	0.414	219.50	262.0	252.50	25
594	0.060	0.191	0.344	0.358	47.55		202.00	6.8
634	0.600	14.310	0.326	1.000	84.55		252.00	22
620	1.030	3.440	0.034	0.389	83.40		246.00	109
432	0.084	0.195	0.267	0.277	37.95		165.00	6
962	8.590	6.690	0.265	0.268	316.33		300.00	15
463	0.449	0.597	0.261	0.293	49.89		166.00	4.8
326	0.361	0.504	0.193	0.260	44.86		89.00	4.8
978	10.270	10.360	0.260	0.270	242.20	253.0	232.00	11
667	9.420	9.420	0.255	0.264	215.51	221.0	211.00	13.2
93	0.102	0.125	0.074	0.109	6.72	9.2	17.40	4
1044	0.060	10.300	0.141	0.336	256.42		298.00	10
459	0.208	2.371	0.135	0.208	31.68	73.6	51.00	3.6
606	0.105	0.393	0.314	0.323	73.57		204.00	7.6
646	11.160	23.130	0.265	0.270	230.62	237.0	116.00	16
615	1.140	3.460	0.312	0.333	83.03	87.1	200.00	13.2
619	0.117	0.431	0.329	0.337	75.76		216.00	6.8
767	0.786	7.970	0.284	0.414	53.77		332.00	48
620	0.168	0.896	0.332	0.346	75.22		216.00	4

Appendix 4a

Ferruginous Sites not Sampled

Catchment	Receiving Water	Site Location	Comments
Rhymney	Rhymney	ST 1538 9948	Low flow minewater passing over a trunk sewer.
Ogmore	Cwm Garw	SS 9138 8767	Discharge from culvert negligible effect on Garw
Neath	Clydach	SS 7392 9876	Minewater staining at foot of drain
Neath	Dulais	SN 7833 0300	Several areas of bankside staining below Blaenant Drift Mine.
Neath	Neath	SN 7776 0063	Low level of bankside staining.
Dee	Alyn	SJ 2335 6496	Bankside staining, no flow.
Dee	Trib Cedidog	SJ 2719 5811	Marshy area and stream affected by minewater.
Dee	Alyn	SJ 3348 5387	Spoil tip causes bankside staining.

Appendix 5. Chemical Data for 12 S.E. discharges (selected for stage 2 assessment) on all sampling occasions.

SITE NO.	NAME OF RECEIVING WATER	LAB. REF.	LOCATION	NATIONAL GRID REFERENCE	DATE	TIME	WEATHER
10	LLWYD	E234126	U/S	SO 2341 0962	16-Nov-92	11:40	DRY
	UNNAMED TRIB	T233775	DISC	SO 2443 0897	11-Nov-92		
		E233777	D/S	SO 2484 0869	11-Nov-92		
		E265724	U/S	SO 2341 0962	14-Jun-93	10:30	WET
		T265725	DISC	SO 2443 0897			
		E265726	D/S	SO 2484 0869			
		E279569	UPS	SO 2341 0962	14-Sep-93	09:15	WET
		T279570	DISC	SO 2443 0897			
		E279571	D/S	SO 2484 0869			
3	LLWYD	E245759	U/S	SO 2859 0062	02-Feb-93	11:30	DRY
	AT PONTYPOOL	T245760	DISC	SO 2860 0058			
		E245761	D/S	SO 2868 0057			
		E265727	U/S	SO 2859 0062	14-Jun-93	11:30	DRY
		T265728	DISC	SO 2860 0058			
		E265729	D/S	SO 2868 0057			
		E279575	U/S	SO 2859 0062	14-Sep-93	10:35	WET
		T279576	DISC	SO 2860 0058			
		E279577	D/S	SO 2868 0057			
1	LLWYD	E245756	U/S	SO 2707 0320	02-Feb-93	15:00	DRY
	AT ABERSYCHAN	T245757	DISC	SO 2705 0315			
		E245758	D/S	SO 2702 0310			
		E264059	U/S	SO 2707 0320	03-Jun-93		DRY
		T264060	DISC	SO 2705 0315			
		E264061	D/S	SO 2702 0310			
		E278379	U/S	SO 2707 0320	07-Sep-93	11:30	DRY
		T278380	DISC	SO 2705 0315			
		E278381	D/S	SO 2702 0310			
2	LLWYD	E250289	U/S	SO 2763 0182	01-Mar-93	15:00	DRY
	AT PONTNEWYDD	T250290	DISC	SO 2763 0181			
		E250291	D/S	SO 2766 0173			
		E264062	U/S	SO 2763 0182	03-Jun-93		DRY
		T264063	DISC	SO 2763 0181			
		E264064	D/S	SO 2766 0173			
		E279572	U/S	SO 2763 0182	14-Sep-93	09:55	DRY
		T279573	DISC	SO 2763 0181			
		E279574	D/S	SO 2766 0173			
6	SIRHOWY	E246318	U/S	SO 1801 9565	08-Feb-93	13:00	DRY
	AT PONTLLANFRAITH	T234133	DISC	SO 1801 9568	16-Nov-92		
		E246320	D/S	SO 1801 9555	08-Feb-93		
		E264503	U/S	SO 1801 9565	04-Jun-93	14:30	DRY
		T264504	DISC	SO 1801 9568			
		E264505	D/S	SO 1801 9555			
		E278670	U/S	SO 1801 9565	06-Sep-93	10:50	DRY
		T278671	DISC	SO 1801 9568			
		E278672	D/S	SO 1801 9555			
5	SIRHOWY	E250285	U/S	ST 1760 9737	01-Mar-93	12:00	DRY
	AT BLACKWOOD	T250286	DISC	ST 1757 9736			
		E250287	D/S	ST 1758 9742			
		E264500	U/S	ST 1760 9737	04-Jun-93	13:30	DRY
		T264501	DISC	ST 1757 9736			
		E264502	D/S	ST 1758 9742			
		E278673	U/S	ST 1760 9737	06-Sep-93	12:10	DRY
		T278674	DISC	ST 1757 9736			
		E278675	D/S	ST 1758 9742			

TEMP. deg. C	pH	FIELD pH	DO mg/l	DO %
6.0	7.10	6.40	10.50	84.5
6.1	7.30	7.14	11.30	95.6
6.9	7.20	7.93	12.20	100.0
12.4	7.60	8.41	9.80	92.0
11.2	7.20	7.64	10.30	94.0
12.6	7.60	7.89	11.50	108.0
10.7	7.10	7.20	10.50	94.6
11.2	7.20	7.04	10.10	92.2
10.9	7.30	7.39	10.23	92.7
8.2	6.10	6.33	11.30	96.0
9.0	7.90	7.86	11.40	96.8
8.3	6.00	6.21	11.10	94.6
11.6	7.60	8.20	12.60	116.0
10.8	7.70	8.06	12.50	113.0
11.4	7.60	8.21	12.00	110.0
10.9	7.60	7.59	10.53	95.5
10.8	7.90	7.46	10.64	95.8
10.9	7.50	7.76	10.66	96.6
8.6	8.00	8.49	12.00	96.0
10.3	8.10	8.10	11.20	100.0
7.7	6.10	6.34	11.40	95.7
10.7	7.86	8.31	14.20	128.0
11.3	7.70	8.05	14.10	129.0
11.2	7.86	8.11	14.20	130.0
10.7	8.00	8.38	11.20	101.0
13.4	7.70	7.91	9.99	95.9
12.1	8.00	8.11	10.60	96.8
8.5	8.30	8.45	11.80	96.1
11.7	8.00	8.07	11.80	109.0
8.6	8.10	8.41	11.60	95.2
10.8	7.83	7.98	11.50	104.0
11.1	7.50	7.69	11.10	101.0
10.9	7.78	7.75	10.10	91.6
10.7	7.50	7.45	10.84	97.6
11.2	7.50	7.61	10.49	95.8
11.0	7.40	7.39	10.82	96.5
8.8	7.70	8.11	11.60	100.0
10.4	7.00	6.78	3.80	34.0
8.4	7.50	7.55	11.00	93.9
14.2	7.90	7.71	10.40	102.0
10.6	7.00	6.82	9.30	84.1
13.3	7.50	10.60	10.60	102.0
13.8	7.30	7.89	9.65	93.5
11.2	6.90	6.83	7.87	71.9
12.5	7.10	6.85	8.79	82.7
3.7	8.00	7.51	13.10	99.3
10.5	6.80	6.29	8.40	75.4
5.3	7.50	6.86	12.60	99.6
13.8	8.10	8.05	10.80	104.0
10.7	6.70	6.41	9.00	81.2
13.5	7.90	7.87	11.10	107.0
13.7	7.40	7.70	9.65	93.3
10.9	6.60	6.37	6.86	62.2
13.7	7.40	7.86	9.70	93.7

Appendix 5. cntd.

SITE NO.	NAME OF RECEIVING WATER	LAB. REF.	LOCATION	COND. us	DISS. IRON mg/l	TOTAL IRON mg/l	DISS. Al. mg/l	TOTAL Al. mg/l	DISS. SULPHATE mg/l	TOTAL SULPHATE mg/l	ALKALINITY mg/l CaCO	SUS. SOLIDS mg/l
10	LLWYD	E234126	U/S	165	0.198	0.355	0.111	0.405	46.60	47.0	24.16	15
	UNNAMED TRIB	T233775	DISC	379	0.941	0.941	0.039	0.149	110.20	110.2	67.82	6
		E233777	D/S	161	0.266	0.441	0.068	0.312	43.40	43.9	33.92	11
		E265724	U/S	141	0.261	0.393	0.065	0.142	26.60	26.6	37.05	<3
		T265725	DISC	560	2.730	2.950	0.017	0.203		225.1	111.20	7
		E265726	D/S	363	0.814	0.980	0.026	0.097	107.00	107.6	72.00	<3
		E279569	UPS	176	0.150	0.186	0.066	0.123	35.60	37.1	38.50	<3
		T279570	DISC	576	0.980	1.020	0.021	0.075	92.14	110.0	106.00	5
		E279571	D/S	354	0.270	0.341	0.048	0.098	66.12	90.2	66.00	<3
3	LLWYD	E245759	U/S	411	0.035	0.532	0.023	0.063	66.90	66.9	106.93	3
	AT PONTYPOOL	T245760	DISC	540	0.389	0.573	0.008	0.060	77.70	77.7	121.30	4
		E245761	D/S	450	0.064	0.397	0.016	0.066	63.10	66.3	105.75	3
		E265727	U/S	316	0.099	0.500	0.019	0.067	61.90	61.9	102.50	<3
		T265728	DISC	398	0.351	0.626	0.005	0.033	77.30	77.3	127.50	<3
		E265729	D/S	363	0.101	0.443	0.015	0.075	60.80	60.8	111.00	4
		E279575	U/S	316	0.139	0.309	0.063	0.166	54.78	58.1	61.00	5
		T279576	DISC	490	0.304	0.512	0.025	0.045	69.06	69.1	145.00	<3
		E279577	D/S	330	0.150	0.319	0.060	0.155	59.27	59.3	66.00	4
1	LLWYD	E245756	U/S	375	0.021	0.102	0.019	0.045	64.20	64.2	61.90	3
	AT ABERSYCHAN	T245757	DISC	646	0.588	2.398	0.004	0.011	230.50	230.5	195.13	6
		E245758	D/S	526	0.220	0.839	0.017	0.043	106.20	106.2	113.17	4
		E264059	U/S	224	0.098	0.248	0.061	0.152	40.90	41.1	56.00	6
		T264060	DISC	609	0.773	2.440		0.052	205.00	205.0	178.00	10
		E264061	D/S	312	0.234	0.678	0.055	0.115	70.90	71.4	76.00	5
		E278379	U/S	516	<0.003	<0.003	0.012	0.012	116.00	125.0	123.00	<3
		T278380	DISC	1258	<0.003	6.200	<0.004	0.026	429.00	429.0	299.00	16
		E278381	D/S	698	0.004	1.700	0.004	0.009	286.00	291.0	221.00	11
2	LLWYD	E250289	U/S	569	0.071	0.330	0.012	0.016	146.40	146.0	151.57	3
	AT PONTNEWYDD	T250290	DISC	595	0.033	0.180	0.004	0.030	126.10	126.1	123.55	7
		E250291	D/S	525	0.690	0.930	0.050	0.068	140.60	140.7	132.29	3
		E264062	U/S	300	0.142	0.426	0.044	0.102	59.30	59.8	72.00	4
		T264063	DISC	392	0.225	0.384	0.007	0.060	93.50	94.1	87.00	2
		E264064	D/S	364	0.210	0.463	0.021	0.091	87.00	87.0	79.00	3
		E279572	U/S	302	0.123	0.268	0.092	0.168	53.41	53.4	76.00	4
		T279573	DISC	422	0.244	0.300	0.032	0.032	91.81	91.8	92.00	4
		E279574	D/S	374	0.590	0.747	0.063	0.206	81.05	83.0	81.00	5
6	SIRHOWY	E246318	U/S	469	0.220	0.400	0.042	0.130	125.00	125.0	87.19	5
	AT PONTLLANFRAITH	T234133	DISC	1336	5.660	6.140	0.006	0.013	613.60	616.7	227.12	18
		E246320	D/S	754	1.500	1.800	0.026	0.069	258.00	258.0	119.21	17
		E264503	U/S	377	0.132	0.174	0.021	0.044	71.20	71.6	81.00	<3
		T264504	DISC	1326		7.310	0.016	0.016		646.2	213.00	29
		E264505	D/S	654		1.160	0.016	0.016	213.70	230.0	115.00	7
		E278670	U/S	370	0.098	0.290	0.016	0.160	69.00	69.0	83.00	14
		T278671	DISC	1542	7.200	7.600	0.013	0.026	840.00	857.0	221.00	13
		E278672	D/S	1000	3.500	4.300	0.009	0.092	467.00	539.0	172.00	100
5	SIRHOWY	E250285	U/S	410	0.180	0.210	0.046	0.070	72.60	72.6	95.05	21
	AT BLACKWOOD	T250286	DISC	1321	5.000	5.100	0.760	1.500	796.00	796.0	100.79	18
		E250287	D/S	720	1.400	1.400	0.250	0.370	263.40	269.6	97.64	5
		E264500	U/S	277	0.066	0.100	0.018	0.037	50.00	50.9	109.00	<3
		T264501	DISC	1207		2.290	0.320	0.437		614.6	117.00	18
		E264502	D/S	277		0.065	0.019	0.023	52.60	52.6	79.00	<3
		E278673	U/S	312	0.100	0.250	0.016	0.160	64.00	64.0	87.00	6
		T278674	DISC	1230	1.300	1.600	0.067	0.120	666.00	666.0	151.00	4
		E278675	D/S	316	0.100	0.230	0.016	0.140	62.00	62.0	87.00	15

Appendix 5. Chemical Data for 12 S.E. discharges (selected for stage 2 assessment) on all sampling occasions.

SITE NO.	NAME OF RECEIVING WATER	LAB. REF.	LOCATION	NATIONAL GRID REFERENCE	DATE	TIME	WEATHER
4	EBBW	E246783	U/S	ST 2120 9762	10-Feb-93	12:00	DRY
	AT NEWBRIDGE	T234130	DISC	ST 2121 9758	16-Nov-92		
		E246784	D/S	ST 2123 9742	10-Feb-93		
		E264497	U/S	ST 2120 9762	04-Jun-93	10:30	DRY
		T264498	DISC	ST 2121 9758			
		E264499	D/S	ST 2123 9742			
7	RHYMNEY	E250767	U/S	ST 1551 9635	04-Mar-93	10:30	DRY
	AT FLEUR-DE-LIS	T250768	DISC 1	ST 1547 9632			
		T250769	DISC 2				
		E250770	D/S	ST 1547 9629			
		E268454	U/S	ST 1551 9635	30-Jun-93		DRY
		T268455	DISC 1	ST 1547 9632			
		T268456	DISC 2	ST 1547 9632			
		E268457	D/S	ST 1547 9629			
		E282145	U/S	ST 1551 9635	29-Sep-93	10:55	DRY
		T282146	DISC	ST 1547 9632			
		E282147	D/S	ST 1547 9629			
11	TAFF	E247252	U/S	ST 0535 9536	11-Feb-93	11:30	DRY
	UNNAMED TRIB OF	T247253	DISC	ST 0537 9532			
	R. CLYDACH	E247254	D/S	ST 0536 9527			
		E266074	U/S	ST 0535 9536	15-Jun-93	13:00	DRY
		T266075	DISC	ST 0537 9532			
		E266076	D/S	ST 0536 9527			
		E282148	U/S	ST 0535 9536	29-Sep-93	13:45	DRY
		T282149	DISC	ST 0537 9532			
		E282150	D/S	ST 0536 9527			
12	TAFF	E247255	U/S	ST 0356 9434	11-Feb-93	12:30	DRY
	Y FFRWD	T247256	DISC	ST 0358 9433			
	TRIB OF NANT	E247257	D/S	ST 0369 9440			
	CLYDACH	E266070	U/S	ST 0356 9434	15-Jun-93	10:30	DRY
		T266071	DISC 1	ST 0358 9433			
		T266072	DISC 2	ST 0411 9462			
		E266073	D/S	ST 0369 9440			
		E282315	U/S	ST 0356 9434	01-Oct-93	10:50	DRY
		T282316	DISC 1	ST 0358 9433			
		T282317	DISC 2	ST 0350 9429			
		E282318	D/S	ST 0369 9440			
9	TAFF/CYNON	E249924	U/S	SN 9726 0255	01-Mar-93	11:15	DRY
	UNNAMED TRIB OF	T249925	DISC	SN 9719 0266			
	CYNON AT	E249926	D/S	SN 9739 0260			
	CWMDARE	E264664	U/S	SN 9726 0255	08-Jun-93	13:30	DRY
		T264665	DISC	SN 9719 0266			
		E264666	D/S	SN 9739 0260			
		E279578	U/S	SN 9726 0255	14-Sep-93	12:00	DRY
		T279579	DISC	SN 9719 0266			
		E279580	D/S	SN 9739 0260			
13	TAFF/RHONDDA	E250774	U/S	ST 0592 0564	04-Mar-93	13:30	DRY
	AT HOPKINSTOWN	T250775	DISC	ST 0594 9059			
	DISC 2	E250776	D/S	ST 0595 9059			
		E266077	U/S	ST 0592 0564	15-Jun-93	14:00	DRY
		T266078	DISC	ST 0594 9059			
		E266079	D/S	ST 0595 9059			
		E279581	U/S	ST 0592 0564	14-Sep-93	13:00	WET
		T279582	DISC	ST 0594 9059			
		E279583	D/S	ST 0595 9059			

TEMP. deg. C	pH	FIELD pH	DO mg/l	DO %
8.3	7.90	8.48	13.40	114.0
11.0	6.90	6.59	1.80	16.7
8.2	7.60	8.19	14.30	122.0
12.1	6.50	6.42	11.40	106.0
12.2	6.90	6.94	4.40	41.1
12.7	6.10	7.57	9.40	86.8
4.2	7.90	8.51	13.80	106.0
10.6	7.00	6.75	0.40	3.6
10.6	7.20	6.93	0.20	1.8
6.0	7.40	7.56	14.00	113.0
16.4	7.00	6.25	10.70	110.0
11.0	6.90	7.12	6.30	75.4
10.9	7.10	7.03	0.30	2.7
15.2	7.00	7.47	10.90	109.0
11.3	7.50	7.67	10.50	96.1
10.9	7.10	6.30	0.10	0.9
11.4	7.10	6.92	9.06	83.3
5.2	7.80	7.91	13.10	103.0
10.0	6.20	6.14	6.80	78.1
6.2	7.60	7.14	13.00	105.0
11.6	7.70	7.71	12.20	113.0
9.9	6.20	6.55	11.00	97.4
11.4	7.32	7.06	12.50	115.0
10.6	7.10	6.84	10.57	95.2
10.2	6.20	7.80	8.26	73.6
10.6	6.60	7.40	10.36	93.3
4.7	6.50	7.70	14.60	114.0
7.5	7.30	7.70	12.40	104.0
6.5	7.20	7.80	13.50	110.0
12.4	6.90	7.95	13.00	122.0
9.3	7.40	8.10	15.60	136.0
13.6	6.80	7.96	11.20	106.0
10.6	7.30	8.14	12.40	112.0
9.5	6.16	6.98	10.52	92.3
8.9	6.60	7.70	10.62	91.6
10.0	6.30	7.33	10.40	92.3
9.2	6.70	7.01	10.56	92.0
4.3	7.90	8.01	12.80	98.5
10.9	6.90	6.44	3.90	35.4
4.7	7.90	7.08	13.30	103.0
11.2	7.70	7.05	11.60	106.0
12.1	6.20	7.02	4.80	44.7
11.6	7.60	7.20	11.10	102.0
10.3	7.10	7.72	10.51	94.0
11.6	7.70	7.62	10.13	93.8
10.3	7.20	8.09	10.69	95.6
5.1	8.10	9.17	13.80	108.0
6.0	5.90	7.01	11.10	93.9
5.5	7.90	7.48	14.10	112.0
16.8	7.92	8.51	11.10	115.0
11.4	7.00	7.50	14.10	129.0
16.5	7.90	8.34	12.10	124.0
11.0	7.40	7.40	10.56	96.0
11.0	7.10	7.27	10.55	95.9
11.1	7.00	7.59	10.13	92.3

Appendix 5. cntd.

SITE NO.	NAME OF RECEIVING WATER	LAB. REF.	LOCATION	COND. us	DISS. IRON mg/l	TOTAL IRON mg/l	DISS. Al. mg/l	TOTAL Al. mg/l	DISS. SULPHATE mg/l	TOTAL SULPHATE mg/l	ALKALINITY mg/l CaCO	SUS. SOLIDS mg/l
4	EBBW	E246783	U/S	479	0.139	0.313	0.032	0.061	114.40	116.2	99.19	3
	AT NEWBRIDGE	T234130	DISC	1615	15.440	20.250	0.031	0.045	791.40	795.4	296.24	38
		E246784	D/S	476	0.137	0.420	0.018	0.164	116.00	166.1	96.46	3
		E264497	U/S	415	0.145	0.222	0.029	0.063	95.10	95.1	89.00	<3
		T264498	DISC	1556		18.95	0.041	0.042	742.30	747.6	266.00	12
		E264499	D/S	464		0.562	0.025	0.029	144.30	144.8	109.00	5
7	RHYMNEY	E250767	U/S	517	0.150	0.360	0.019	0.041	139.60	141.6	115.70	3
	AT FLEUR-DE-LIS	T250768	DISC 1	1564	6.300	6.300	0.004	0.008	606.00	606.0	210.74	4
		T250769	DISC 2	997	6.500	6.700	0.004	0.004	358.80	359.5	227.90	4
		E250770	D/S	776	2.000	2.600	0.013	0.035	264.60	264.6	141.90	6
		E268454	U/S	457	0.205	0.205	0.025	0.026	117.00	117.0	112.00	5
		T268455	DISC 1	1799		3.390	0.016	0.016	736.00	736.0	210.00	7
		T268456	DISC 2	1133	3.530	3.950	0.017	0.111	405.00	405.0	232.00	8
		E268457	D/S	754	1.270	1.270	0.030	0.030	256.00	256.0	135.00	7
		E282145	U/S	466	0.147	0.187	0.012	0.022	94.30	98.0	120.00	<3
		T282146	DISC	1254	6.400	6.600	<0.004	<0.004	450.90	452.4	229.00	
		E282147	D/S	894	2.220	3.900	0.006	0.020	292.30	294.4	159.00	11
11	TAFF	E247252	U/S	226	0.059	0.141	0.037	0.066	49.20	49.2	56.26	3
	UNNAMED TRIB OF	T247253	DISC	277	1.120	1.190	0.416	0.663	102.30	103.0	17.99	3
	R. CLYDACH	E247254	D/S	238	0.285	0.361	0.109	0.202	62.40	62.4	46.79	3
		E266074	U/S	185	0.101	0.127	0.046	0.072	37.40	37.0	45.02	3
		T266075	DISC	276	1.030	1.060	0.307	0.469		96.0	16.97	<3
		E266076	D/S	198	0.252	0.268	0.094	0.143	48.90	49.0	40.10	<3
		E282148	U/S	230	0.008	0.131	0.032	0.046	41.70	41.7	60.40	<3
		T282149	DISC	298	0.730	0.750	0.340	0.460	101.20	101.2	21.90	3
		E282150	D/S	242	0.183	0.266	0.078	0.134	52.60	52.6	54.90	6
12	TAFF	E247255	U/S	77	0.113	0.141	0.130	0.153	14.60	14.6	3.92	3
	Y FFRWD	T247256	DISC	160	0.688	2.040	0.031	0.058	26.60	26.6	32.69	15
	TRIB OF NANT	E247257	D/S	145	0.654	1.080	0.049	0.069	23.60	23.8	26.27	3
	CLYDACH	E266070	U/S	74	0.213	0.262	0.138	0.162	14.40	14.5	7.70	<3
		T266071	DISC 1	267	1.130	2.030	<0.004	0.009	27.80	27.8	37.50	6
		T266072	DISC 2	52	0.813	0.737	0.169	0.236	9.30	9.3	10.34	<3
		E266073	D/S	137	0.528	0.961	0.041	0.046	23.70	23.7	28.35	<3
		E282315	U/S	78	0.200	0.240	0.150	0.160	16.00	16.0	9.38	5
		T282316	DISC 1	178	1.300	2.300	0.025	0.051	30.70	30.7	36.80	
		T282317	DISC 2	58	0.460	0.510	0.220	0.260	13.00	13.0	12.90	15
		E282316	D/S	136	0.650	0.840	0.072	0.083	23.70	23.7	27.90	4
9	TAFF/CYNON	E249924	U/S	204	0.196	0.238	0.004	0.004	26.10	26.2	80.95	9
	UNNAMED TRIB OF	T249925	DISC	598	0.367	0.460	0.004	0.039	196.30	196.6	99.59	4
	CYNON AT	E249926	D/S	229	0.336	0.637	0.004	0.005	46.10	46.1	69.27	6
	CWMDARE	E264664	U/S	153	<0.003	<0.003	<0.004	0.009	51.90	51.9	38.00	<3
		T264665	DISC	380	12.20	13.00	0.030	0.053	127.60	127.6	89.00	8
		E264666	D/S	157	0.190	0.240	0.011	0.013	29.90	29.9	45.00	<3
		E279578	U/S	138		0.019	0.017	0.017	22.65	22.9	40.00	<3
		T279579	DISC	308	0.031	0.035	0.013	0.013	43.56	45.3	109.00	5
		E279580	D/S	140	0.020	0.020	0.013	0.026	22.31	22.3	40.00	<3
13	TAFF/RHONDDA	E250774	U/S	313	0.330	1.600	0.025	0.100	54.90	54.9	96.10	5
	AT HOPKINSTOWN	T250775	DISC	496	27.800	29.200	0.052	1.900	216.40	216.4	4.35	24
	DISC 2	E250776	D/S	326	0.570	2.300	0.030	0.130	59.70	59.7	90.47	5
		E266077	U/S	91	0.319	0.499	0.010	0.039	40.90	41.0	77.00	3
		T266078	DISC	315	6.720	7.470	0.025	0.441	62.40	62.4	41.00	14
		E266079	D/S	68	0.372	0.626	0.011	0.048	39.90	39.9	75.50	5
		E279581	U/S	224	0.220	0.270	0.021	0.043	32.48	32.6	64.00	<3
		T279582	DISC	218	2.910	2.910	0.038	0.206	38.69	38.9	46.00	14
		E279583	D/S	222		2.190	0.033	0.176	36.89	36.9	51.00	8

Appendix 6. Chemical Data for 20 S.W. discharges (selected for stage 2 assessment) on all sampling occasions.

SITE NO.	NAME OF RECEIVING WATER	LAB. REF.	LOCATION	NATIONAL GRID REFERENCE	DATE	TIME	WEATHER
14	OGWR FACH	T245142	DISC 1	SS 9776 9051	01-Feb-93	10:55	DRY
		T251064	DISC 2	SS 9619 9047			
		T265730	DISC 1	SS 9776 9051	14-Jun-93	14:00	WET
		T265731	DISC 2	SS 9619 9047			
		E265732	D/S	SS 9760 9055			
		T279564	DISC 1	SS 9776 9051	14-Sep-93	13:50	WET
15	OGMORE UNNAMED TRIB OF LLYNFI	E245146	U/S	SS 8936 8767	02-Feb-93	13:30	DRY
		T245147	DISC	SS 8936 8762			
		E245148	D/S	SS 8934 8756			
		E266725	U/S	SS 8936 8767	17-Jun-93	11:00	DRY
		T266726	DISC	SS 8936 8762			
		E266727	D/S	SS 8934 8756			
		E273600	U/S	SS 8936 8767	03-Aug-93	14:00	DRY
		T273604	DISC	SS 8936 8762			
		E273605	D/S	SS 8934 8756			
16	AFAN/PELENNA AFON CORRWG FECHAN	E246110	U/S	SN 6815 0064	17-Feb-93	10:30	DRY
		T246111	DISC	SN 6813 0078			
		E246112	D/S	SN 6811 0072			
		E266765	U/S	SN 6815 0064	16-Jun-93	11:30	WET
		T266766	DISC	SN 6813 0078			
		E266767	D/S	SN 6811 0072			
		E273600	U/S	SN 6815 0064	04-Aug-93	11:00	WET
		T273601	DISC	SN 6813 0078			
		E273602	D/S	SN 6811 0072			
17	AFAN/PELENNA AFON CORRWG	E246113	U/S	SN 6696 0072	17-Feb-93	12:00	DRY
		T246114	DISC	SN 6692 0069			
		E246115	D/S	SN 6687 0061			
		E266728	U/S	SN 6696 0072	17-Jun-93	14:30	DRY
		T266729	DISC 1	SN 6692 0069			
		T266730	DISC 2	SN 6666 0067			
		E266731	D/S	SN 6687 0061			
		E272330	U/S	SN 6696 0072	23-Jul-93	10:30	WET
		T272331	DISC 1	SN 6692 0069			
		T272332	DISC 2	SN 6666 0067			
		E272333	D/S	SN 6687 0061			
21	AFAN AFON CORRWG	E246116	U/S	SS 8638 9766	17-Feb-93	13:15	DRY
		T246117	DISC	SS 8629 9768			
		E246118	D/S	SS 8638 9757			
		E267403	U/S	SS 8638 9766	23-Jun-93	10:30	DRY
		T267404	DISC	SS 8629 9768			
		E267405	D/S	SS 8638 9757			
		E272650	U/S	SS 8638 9766	26-Jul-93	10:00	
		T272651	DISC	SS 8629 9768			
		E272652	D/S	SS 8638 9757			
26	AFAN/PELENNA TRIB OF CWM GWENFFRWD	E246119	U/S	SS 7992 9732	17-Feb-93	15:15	DRY
		T246120	DISC 1	SS 7996 9730			
		T246121	DISC 2	SS 8006 9691			
		E246122	D/S	SS 7994 9719			
		E266441	U/S	SS 7992 9732	30-Jun-93	10:30	DRY
		T266442	DISC 1	SS 7996 9730			
		T266443	DISC 2	SS 8006 9691			
		E266444	D/S	SS 7994 9719			
		E273235	U/S	SS 7992 9732	30-Jul-93	11:00	DRY
		T273236	DISC 1	SS 7996 9730			
		T273237	DISC 2	SS 8006 9691			
		E273238	D/S	SS 7994 9719			

TEMP. deg. C	pH	FIELD pH	DO mg/l	DO %
9.1	7.40	7.10	11.10	96.4
9.6	6.90	7.75	11.50	102.0
9.3	7.40	7.60	12.70	111.0
9.8	7.00	7.01	11.50	101.0
	7.90	8.00	12.80	
9.9	7.20	7.30	10.09	89.3
7.7	6.80	7.53	12.00	101.0
10.20	6.30	6.85	9.60	85.6
7.7	6.80	7.08	11.60	97.4
12.4	7.20	7.84	12.70	119.0
12.0	6.90	7.54	0.10	0.9
12.4	7.00	7.75	11.50	108.0
11.8	6.50	6.87	12.70	118.0
11.6	6.80	6.90	7.90	72.8
12.9	6.50	6.82	12.20	116.0
5.9	7.00	6.50	14.40	116.0
9.7	7.30	7.05	2.10	18.5
7.1	6.90	7.36	12.20	101.0
10.8	6.10	7.46	13.80	125.0
10.0	6.60	6.65	2.60	23.1
11.1	6.70	6.62	11.40	104.0
11.2	6.50	7.52	10.40	95.0
10.0	6.70	6.58	8.70	77.2
11.0	6.70	7.21	10.10	91.8
7.3	7.50	6.30	13.40	111.0
9.4	6.60	6.66	2.40	21.0
7.7	7.40	7.55	12.50	105.0
10.9	7.60	7.99	15.00	136.0
9.6	6.10	5.64	2.80	24.6
9.9	6.60	6.68	0.90	8.0
11.7	7.60	7.65	13.00	120.0
11.6	7.10	7.46	10.54	97.1
9.4	6.30	6.00	2.48	21.5
10.2	6.70	6.36	0.43	3.8
12.0	7.00	7.45	10.48	97.3
7.9	7.50	6.11	12.40	105.0
11.6	7.50	7.66	10.10	93.1
8.2	7.60	6.09	12.90	110.0
12.6	7.50	7.99	13.40	126.0
13.2	7.10	7.40	12.10	116.0
12.7	7.70	7.86	13.40	127.0
11.9	6.90	7.36	10.20	94.6
12.9	6.90	7.10	9.45	89.7
12.0	6.60	7.11	10.00	93.0
8.9	6.70	7.13	12.30	106.0
10.5	5.10	6.19	1.20	10.8
10.1	4.00	4.95	10.00	89.0
9.1	6.70	7.02	11.80	103.0
15.9	6.90	7.00	13.80	140.0
10.7	5.34	6.29	1.90	17.1
12.1	4.31	5.24	13.80	129.0
16.6	6.40	7.41	13.60	140.0
13.5	5.10	4.90	9.73	93.6
10.3	6.10	5.50	3.60	32.2
11.4	5.60	5.72	9.09	83.4
13.4	5.90	5.95	9.73	93.4

Appendix 6. cntd.

SITE NO.	NAME OF RECEIVING WATER	LAB. REF.	LOCATION	COND. us	DISS. IRON mg/l	TOTAL IRON mg/l	DISS. Al. mg/l	TOTAL Al. mg/l	DISS. SULPHATE mg/l	TOTAL SULPHATE mg/l	ALKALINITY mg/l CaCO	SUS. SOLIDS mg/l
14	OGWR FACH	T245142	DISC 1	244	0.800	0.800	0.00	0.00	21.90	21.9	83.31	3
		T251084	DISC 2	238	0.580	0.877	0.00	0.00	42.30	42.3	73.90	3
		T265730	DISC 1	334	1.160	1.160	<0.004	<0.004	21.90	21.9	107.00	<3
		T265731	DISC 2	214	0.460	0.630	<0.004	<0.004	37.40	37.5	71.00	<3
		E265732	D/S	260	0.120	0.265	<0.004	<0.004	28.70	28.7	105.70	<3
		T279584	DISC 1	196	0.776	0.776	<0.004	<0.004		12.9	74.00	6
15	OGMORE	E245146	U/S	112	0.140	0.190	0.040	0.110	13.30	13.6	8.70	5
	UNNAMED TRIB OF	T245147	DISC	335	9.900	9.900	0.005	0.010	98.40	103.0	27.83	7
	LLYNFI	E245148	D/S	170	0.500	0.600	0.027	0.340	29.40	29.4	10.80	5
		E266725	U/S	67	0.310	0.590	0.041	0.130	13.70	13.7	18.50	6
		T266726	DISC	428	6.600	7.500	0.030	0.055	48.80	49.4	33.50	21
		E266727	D/S	109	1.070	2.070	0.009	0.160	17.50	17.5	14.50	13
		E273803	U/S	105	0.169	0.379	0.036	0.125	12.70	13.1	9.16	10
		T273804	DISC	216	6.590	6.850	0.023	0.558	59.80	63.2	46.60	270
		E273805	D/S	111	0.573	0.912	0.035	0.166	15.60	15.6	10.68	18
16	AFAN/PELENNA	E248110	U/S	78.3	0.017	0.054	0.065	0.110	9.60	9.6	16.35	3
	AFON CORRWG	T248111	DISC	526	10.490	10.490	0.016	0.018	141.90	142.2	123.39	21
	FECHAN	E248112	D/S	230	NO RESUL	2.709	0.360	0.052	52.70	52.7	46.66	9
		E266765	U/S	46	0.063	0.100	0.190	0.380	9.90	10.0	2.60	<3
		T266766	DISC	657	11.800	12.900	0.013	0.044	145.00	145.0	127.00	10
		E266767	D/S	62	0.420	0.510	0.180	0.370	13.60	14.0	6.30	4
		E273800	U/S	60	0.050	0.060	0.120	0.157	9.30	9.3	11.66	<3
		T273801	DISC	547	10.550	11.150	0.019	0.019	121.40	121.4	131.00	13
		E273802	D/S	140	1.530	1.540	0.111	0.134	26.00	26.0	23.70	<3
17	AFAN/PELENNA	E248113	U/S	150	0.038	0.085	0.270	0.031	14.10	14.1	54.09	3
	AFON CORRWG	T248114	DISC	507	1.366	15.260	0.022	0.031	35.40	202.6	44.02	5
		E248115	D/S	198	NO RESUL	1.896	0.030	0.032	NO RESUL	36.0	52.77	5
		E266728	U/S	94	0.071	0.099	0.071	0.082	11.60	11.6	25.60	<3
		T266729	DISC 1	551	16.500	16.700	0.050	0.050	242.00	242.0	39.60	10
		T266730	DISC 2	575		9.500	0.016	0.044	216.00	221.0	90.40	49
		E266731	D/S	127	0.590	0.690	0.057	0.071	23.10	23.4	24.95	<3
		E272330	U/S	126	0.054	0.074	0.026	0.034	11.90	12.6	39.30	4
		T272331	DISC 1	578	10.820	11.330	0.041	0.046		102.1	47.20	4
		T272332	DISC 2	682	6.370	10.850	<.004	<.004	229.40	229.4	82.00	13
		E272333	D/S	180	0.646	0.952	0.016	0.033	33.60	33.6	40.40	<3
21	AFAN	E248116	U/S	173	0.041	0.126	0.025	0.035	32.20	32.2	42.29	3
	AFON CORRWG	T248117	DISC	1018	15.710	27.970	0.026	0.092	370.20	387.0	207.12	58
		E248118	D/S	194	0.304	0.750	0.022	0.042	38.60	38.6	45.91	3
		E267403	U/S	129	0.065	0.102	0.045	0.078	22.40	22.7	35.30	<3
		T267404	DISC	880	21.250	24.780		0.020	231.60	335.6	177.00	71
		E267405	D/S	149	0.309	0.503	0.044	0.052	29.50	29.5	62.40	28
		E272850	U/S	106	0.091	0.106	0.104	0.187	17.00	17.0	23.30	<3
		T272851	DISC	388	4.440	5.260	0.008	0.020	89.00	97.3	68.00	13
		E272852	D/S	132	0.329	0.350	0.095	0.154	21.30	22.4	25.70	<3
26	AFAN/PELENNA	E248119	U/S	148	0.046	0.120	0.129	0.273	38.10	38.3	6.86	4
	TRIB OF CWM	T248120	DISC 1	974	101.400	103.200	0.179	0.190	512.20	519.3	1.19	13
	GWENFFRWD	T248121	DISC 2	355	12.150	12.260	1.491	1.514	145.20	145.2	NO RESUL	3
		E248122	D/S	258	0.260	9.590	0.037	0.262	93.80	93.8	1.34	7
		E268441	U/S	150	0.045	0.088	0.103	0.211	36.00	36.0	0.30	<3
		T268442	DISC 1	764	32.050	38.450		0.028	340.00	340.0	6.30	14
		T268443	DISC 2	330	2.540	2.930	0.969	0.976	130.00	130.0		12.1
		E268444	D/S	196	2.120	2.690	0.031	0.236	64.00	67.0	5.14	7
		E273235	U/S	102	0.179	0.194	0.359	0.407	22.70	23.0	1.67	3
		T273236	DISC 1	146	0.956	3.050	0.015	0.022	25.30	25.3	15.80	10
		T273237	DISC 2	210	2.310	2.310	0.177	0.264	64.80	65.6	3.70	4
		E273238	D/S	112	0.329	0.340	0.219	0.313	26.20	26.2	3.03	9

Appendix 6. Chemical Data for 20 S.W. discharges (selected for stage 2 assessment) on all sampling occasions.

SITE NO.	NAME OF RECEIVING WATER	LAB. REF.	LOCATION	NATIONAL GRID REFERENCE	DATE
25	AFAN/PELENNA	E248123	U/S	SS 8158 9727	17-Feb-93
	NANT BLAEN	T248124	DISC	SS 8161 9723	
	PELENNA DISC 1	E248125	D/S	SS 8162 9712	
		E267655	U/S	SS 8158 9727	24-Jun-93
		T267656	DISC	SS 8161 9723	
		E267657	D/S	SS 8162 9712	
		E273557	U/S	SS 8158 9727	02-Aug-93
		T273558	DISC	SS 8161 9723	
		E273559	D/S	SS 8162 9712	
24	AFAN/PELENNA	E251691	U/S	SS 8159 9755	08-Mar-93
	NANT BLAEN	T251692	DISC	SS 8154 9751	
	PELENNA DISC 2	E251693	D/S	SS 8158 9750	
		E267658	U/S	SS 8159 9755	24-Jun-93
		T267659	DISC	SS 8154 9751	
		E267660	D/S	SS 8158 9750	
		E273560	U/S	SS 8159 9755	02-Aug-93
		T273561	DISC	SS 8154 9751	
		E273562	D/S	SS 8158 9750	
23	FFRWD WYLLT	E248824	U/S	SS 7872 8977	23-Feb-93
	AT GOYTRE	T248825	DISC	SS 7872 8975	
		E248826	D/S	SS 7869 8974	
		E267409	U/S	SS 7872 8977	23-Jun-93
		T267410	DISC	SS 7872 8975	
		E267411	D/S	SS 7869 8974	
		E274510	U/S	SS 7872 8977	06-Aug-93
		T274511	DISC	SS 7872 8975	
		E274512	D/S	SS 7869 8974	
22	FFRWD WYLLT	E251694	U/S	SS 8169 9221	08-Mar-93
	AT BRYN	T251695	DISC	SS 8171 9218	
		E251696	D/S	SS 8168 9218	
		E267406	U/S	SS 8169 9221	23-Jun-93
		T267407	DISC	SS 8171 9218	
		E267408	D/S	SS 8168 9218	
		E280026	U/S	SS 8169 9221	15-Sep-93
		T280027	DISC	SS 8171 9218	
		E280028	D/S	SS 8168 9218	
19	AFAN	E251065	U/S	SS 8921 9736	05-Mar-93
	NANT GWYNFI	T251066	DISC	SS 8923 9730	
		E251067	D/S	SS 8918 9729	
		E267355	U/S	SS 8921 9736	21-Jun-93
		T267356	DISC 1	SS 8923 9730	
		E267357	D/S	SS 8918 9729	
		E267352	U/S	SS 8945 9761	
		T267353	DISC 2	SS 8940 9774	
		E267354	D/S	SS 8936 9767	
		E274507	U/S	SS 8921 9736	05-Aug-93
		T274508	DISC	SS 8923 9730	
		E274509	D/S	SS 8918 9729	

TIME	WEATHER	TEMP. deg. C	pH	FIELD pH	DO mg/l	DO %
14:50	DRY	6.6	7.00	8.15	12.30	106.0
		10.5	5.70	8.15	8.50	76.3
		9.3	5.80	8.68	11.00	96.0
10:30	DRY	13.7	7.10	7.97	14.90	144.0
		11.4	5.39	6.32	12.80	117.0
		13.6	6.90	8.51	16.50	159.0
10:00	DRY	13.6	6.20	7.06	11.60	114.0
		11.4	5.40	5.52	12.30	113.0
		12.9	5.40	5.86	11.60	112.0
12:30	DRY	5.5	6.90	8.12	12.60	102.0
		6.9	7.20	7.43	11.40	98.5
		6.5	7.01	7.73	12.30	100.0
11:30	DRY	12.7	6.80	7.66	15.90	150.0
		9.8	6.90	7.46	15.80	140.0
		11.1	7.00	7.79	16.90	154.0
11:00	DRY	13.4	6.10	6.85	12.50	120.0
		10.4	6.70	7.46	11.90	107.0
		13.2	6.50	6.62	12.90	123.0
14:00	DRY	6.5	7.20	7.62	13.60	111.0
		10.2	6.60	6.78	9.50	84.7
		7.1	6.90	7.36	12.50	103.0
13:30	DRY	13.0	7.00	7.69	14.10	134.0
		11.6	6.70	7.21	12.30	113.0
		12.6	7.10	7.75	12.70	120.0
14:00	DRY	13.3	7.10	7.65	9.72	93.1
		11.6	6.90	8.15	8.00	73.7
		13.3	6.90	6.43	9.80	93.9
13:15	DRY	5.7	7.30	8.00	12.90	103.0
		6.9	7.20	7.89	12.10	99.6
		5.9	7.30	7.95	12.60	103.0
12:00	DRY	12.2	7.30	8.10	15.50	145.0
		12.1	7.40	7.94	14.50	135.0
		11.9	7.50	7.83	15.40	143.0
09:30	DRY	10.4	7.10	7.51	10.41	93.3
		10.6	7.10	7.46	10.53	94.6
		10.5	7.00	7.48	10.50	94.3
13:00	DRY	5.6	7.50	8.36	15.60	124.0
		9.8	6.60	7.24	11.10	96.1
		6.5	7.00	7.58	14.10	115.0
11:55	DRY	10.9	7.24	7.91	12.10	110.0
		9.3	6.50	6.93	9.30	81.2
		10.8	7.02	7.27	12.00	109.0
		9.9	6.00	6.62	10.20	90.3
		8.0	7.20	6.62	8.90	75.3
		9.7	7.17	7.08	10.10	89.0
14:00	DRY	11.9	6.80	7.54	11.10	103.0
		10.3	6.60	6.79	7.80	69.7
		11.6	6.80	7.30	10.80	99.5

Appendix 6. cntd.

SITE NO.	NAME OF RECEIVING WATER	LAB. REF.	LOCATION	COND. us	DISS. IRON mg/l
25	AFAN/PELENNA	E248123	U/S	124	0.034
	NANT BLAEN	T248124	DISC	565	25.210
	PELENNA DISC 1	E248125	D/S	303	9.190
		E267655	U/S	114	0.133
		T267656	DISC	565	
		E267657	D/S	207	0.732
		E273557	U/S	61	0.292
		T273558	DISC	490	15.240
		E273559	D/S	218	
24	AFAN/PELENNA	E251691	U/S	98	0.003
	NANT BLAEN	T251692	DISC	239	0.806
	PELENNA DISC 2	E251693	D/S	152	0.149
		E267658	U/S	67	0.105
		T267659	DISC	223	0.641
		E267660	D/S	117	0.154
		E273560	U/S	64	0.317
		T273561	DISC	200	0.349
		E273562	D/S	108	0.341
23	FFRWD WYLLT	E248824	U/S	179	0.060
	AT GOYTRE	T248825	DISC	399	4.000
		E248826	D/S	222	0.930
		E267409	U/S	142	0.028
		T267410	DISC	277	2.060
		E267411	D/S	148	0.159
		E274510	U/S	150	0.075
		T274511	DISC	254	3.157
		E274512	D/S	160	
22	FFRWD WYLLT	E251694	U/S	160	0.027
	AT BRYN	T251695	DISC	261	0.384
		E251696	D/S	171	0.324
		E267406	U/S	123	0.023
		T267407	DISC	144	
		E267408	D/S	132	0.184
		E280026	U/S	166	0.066
		T280027	DISC	136	0.248
		E280028	D/S	164	0.242
19	AFAN	E251085	U/S	106	0.066
	NANT GWYNFI	T251086	DISC	447	6.700
		E251087	D/S	194	2.100
		E267355	U/S	78	0.056
		T267356	DISC 1	339	7.270
		E267357	D/S	95	1.023
		E267352	U/S	56	0.308
		T267353	DISC 2	158	
		E267354	D/S	115	1.103
		E274507	U/S	60	0.121
		T274508	DISC	310	4.027
		E274509	D/S	89	0.589

TOTAL IRON mg/l	DISS. Al. mg/l	TOTAL Al. mg/l	DISS. SULPHATE mg/l	TOTAL SULPHATE mg/l	ALKALINITY mg/l CaCO	SUS. SOLIDS mg/l
0.220	0.048	0.365	24.20	24.2	15.14	3
25.630	0.169	0.353	265.60	267.8	5.32	5
11.810	0.067	0.915	121.90	122.4	3.09	5
0.218	0.192	0.402	27.30	27.9	13.60	<3
18.560	0.175	0.212	268.90	279.6	3.73	4
0.841	0.171	0.410	35.00	36.3	12.27	3
0.364	0.254	0.407	18.00	18.3	5.35	5
15.240	0.416	0.564	185.50	190.2	3.62	6
4.788	0.252	0.381	62.10	62.1	2.70	7
0.111	0.035	0.328	19.40	19.8	11.90	3
1.126	0.018	0.640	46.30	46.9	55.47	6
0.628	0.035	0.576	29.20	29.2	23.50	6
0.154	0.222	0.308	20.00	20.1	7.60	<3
0.777	0.086	0.780		54.3	40.72	5
0.661	0.155	0.410	28.40	28.8	14.60	12
0.411	0.282	0.361	13.80	14.1	3.20	5
0.705	0.056	0.971	52.30	52.3	25.51	8
0.456	0.210	0.485	25.40	25.4	9.97	<3
0.099	0.030	0.079	29.50	29.7	26.16	3
4.400	0.009	0.026	92.70	92.7	85.95	8
0.930	0.022	0.048	46.10	47.0	41.20	3
0.046	0.011	0.025	18.90	18.9	9.70	4
2.490		0.013	50.60	50.8	60.60	4
0.298	0.043	0.113	24.60	25.4	21.40	3
0.075	0.055	0.062	21.30	21.4	17.50	<3
3.745	0.006	0.039	74.00	74.4	78.00	7
0.400	0.047	0.079	29.60	29.9	26.60	3
0.059	0.026	0.046	20.60	20.8	32.50	3
0.442	0.032	0.046	19.00	19.1	34.92	3
0.569	0.036	0.062	19.40	19.5	35.68	3
0.077	0.080	0.095	17.20	17.4	18.40	<3
0.143	0.061	0.061	18.60	18.6	30.60	3
0.235	0.074	0.076	18.30	18.7	29.30	21
0.068	0.034	0.046	16.60	19.3	38.20	4
0.276	0.064	0.075	20.00	20.0	40.00	<3
0.258	0.063	0.074	17.50	22.1	41.00	4
0.122	0.042	0.043	11.30	11.3	27.65	3
9.540	0.027	0.043	163.40	163.4	52.67	10
2.100	0.027	0.043	53.60	53.6	34.74	10
0.104		0.066	10.00	10.1	16.90	<3
7.270	0.027	0.035	112.20	112.2	36.00	3
1.032	0.071	0.074	27.30	27.5	20.50	4
0.374	0.138	0.371	10.40	10.6	3.60	4
3.470	0.092	0.162	11.60	11.9	57.20	42
1.178	0.036	0.082	11.10	11.1	36.50	4
0.152	0.157	0.174	9.00	9.2	8.31	3
5.233	0.029	0.046	98.60	101.1	31.00	5
0.589	0.136	0.145	20.00	20.4	8.31	<3

Appendix 6. Chemical Data for 20 S.W. discharges (selected for stage 2 assessment) on all sampling occasions.

SITE NO.	NAME OF RECEIVING WATER	LAB. REF.	LOCATION	NATIONAL GRID REFERENCE	DATE	TIME	WEATHER
20	AFAN	E251088	U/S	SS 8716 9634	05-Mar-93	14:00	DRY
	AAFAN	T251089	DISC	SS 8720 9630			
	AT GELLI FARM	E251090	D/S	SS 8719 9627			
		E267358	U/S	SS 8716 9634	21-Jun-93	14:30	DRY
		T267359	DISC	SS 8720 9630			
		E267360	D/S	SS 8719 9627			
		E280029	U/S	SS 8716 9634	15-Sep-93	10:45	DRY
		T280030	DISC	SS 8720 9630			
		E280031	D/S	SS 8719 9627			
26	AFAN	E251682	U/S	SS 8777 9580	08-Mar-93	10:30	DRY
	NANT Y FEDW	T251683	DISC	SS 8784 9579			
		E251684	D/S	SS 8789 9582			
		E268448	U/S	SS 8777 9580	30-Jun-93	10:15	DRY
		T268449	DISC	SS 8784 9579			
		E268450	D/S	SS 8789 9582			
		E274504	U/S	SS 8777 9580	05-Aug-93	10:30	DRY
		T274505	DISC	SS 8784 9579			
		E274506	D/S	SS 8789 9582			
27	AFAN	E251686	U/S	SS 8442 9736	08-Mar-93	12:00	DRY
	TRIB OF NANT	T251689	DISC	SS 8944 9733			
	CREGAN	E251690	D/S	SS 8477 9731			
		E268445	U/S	SS 8442 9736	30-Jun-93	14:00	DRY
		T268446	DISC	SS 8944 9733			
		E268447	D/S	SS 8477 9731			
		E272853	U/S	SS 8442 9736	26-Jul-93	14:00	DRY
		T272854	DISC	SS 8944 9733			
		E272855	D/S	SS 8477 9731			
16	CYNFFIG	E251697	U/S	SS 8564 8514	08-Mar-93	14:30	DRY
	N. CRAIG YR ABER	E251698	DISC	SS 8555 8455			
		E251699	D/S	SS 8568 8505			
		E268451	U/S	SS 8564 8514	30-Jun-93	13:00	DRY
		T268452	DISC	SS 8555 8455			
		E268453	D/S	SS 8568 8505			
		E273606	U/S	SS 8564 8514	03-Aug-93	15:00	DRY
		T273607	DISC	SS 8555 8455			
		E273608	D/S	SS 8568 8505			
32	LOUGHOR	E254346	DISC/ STREAM	SN 7030 1011	25-Mar-93	11:40	DRY
	NANT MELYN	E269913	U/S	SN 7023 1104	06-Jul-93	11:00	DRY
		T269914	DISC	SN 7022 1106			
		E269915	D/S	SN 7021 1107			
		E271985	U/S	SN 7023 1104	22-Jul-93	10:15	DRY
		T271986	DISC	SN 7022 1106			
		E271987	D/S	SN 7021 1107			
30	LOUGHOR	E253200	U/S	SN 5699 0200	17-Mar-93	12:45	DRY
	MORLAIS	T253201	DISC	SN 5723 0226			
		E253202	D/S	SN 5702 0197			
		E269505	U/S	SN 5699 0200	07-Jul-93	11:00	DRY
		T269506	DISC	SN 5723 0226			
		E269507	D/S	SN 5702 0197			
		E271766	U/S	SN 5699 0200	21-Jul-93	11:30	DRY
		T271767	DISC	SN 5723 0226			
		E271768	D/S	SN 5702 0197			

TEMP. deg. C	pH	FIELD pH	DO mg/l	DO %
8.7	7.60	8.16	14.20	116.0
9.7	7.60	7.85	12.60	111.0
6.9	7.60	8.01	12.90	106.0
13.2	7.40	7.91	10.20	97.5
12.0	7.70	7.71	10.10	93.9
13.3	7.40	7.92	10.70	102.0
10.1	6.90	7.22	10.69	95.1
10.6	7.20	7.42	10.32	93.3
10.2	7.00	7.20	10.67	95.2
5.0	6.65	6.62	12.90	101.0
9.2	7.40	7.03	3.80	33.1
6.3	6.78	7.49	12.10	98.1
13.9	7.00	7.80	11.30	110.0
9.6	6.50	7.51	2.70	23.9
12.9	7.30	7.66	11.50	109.0
12.1	6.70	6.90	12.60	119.0
10.1	6.70	6.36	3.80	33.6
11.6	6.90	7.10	12.10	112.0
5.0	5.39	6.00	12.60	98.6
9.7	6.70	7.34	11.40	100.0
7.5	7.17	7.51	12.10	101.0
15.4	7.20	7.37	13.90	139.0
9.9	6.70	6.88	15.50	137.0
12.9	7.20	6.92	15.10	143.0
12.1	5.20	5.42	10.90	102.0
10.0	6.60	6.41	10.20	90.5
11.8	6.20	5.72	10.04	92.9
7.1	6.90	6.25	12.10	100.0
7.8	6.60	7.43	11.10	92.9
7.3	7.10	7.60	11.80	98.1
13.6	7.00	7.06	11.30	109.0
12.4	6.30	6.44	2.80	26.3
12.9	6.40	6.73	10.20	96.8
12.6	6.50	6.63	11.60	111.0
12.4	6.40	5.92	3.30	31.0
12.5	6.40	6.36	11.10	104.0
8.2	6.90	7.92	12.30	99.4
14.3	7.00	6.27	9.50	93.0
11.6	6.90	5.39	0.70	6.5
13.6	7.10	5.94	7.80	75.5
12.3	6.70	7.52	9.46	88.6
11.8	6.80	6.49	1.70	15.7
12.3	7.00	6.63	8.23	77.1
9.6	7.30	8.17	12.00	106.0
14.5	6.70	6.90	0.20	2.0
11.4	6.90	7.32	10.40	95.4
14.0	7.30	8.27	11.30	111.0
14.4	6.70	7.66	0.10	1.0
14.8	7.00	7.80	7.90	76.2
14.6	7.00	7.52	10.90	107.0
14.6	6.60	6.83	0.10	1.0
14.8	6.80	7.21	9.80	96.6

Appendix 6. cntd.

SITE NO.	NAME OF RECEIVING WATER	LAB. REF.	LOCATION	COND. us	DISS. IRON mg/l
20	AFAN	E251086	U/S	169	0.038
	A.AFAN	T251089	DISC	224	0.129
	AT GELLI FARM	E251090	D/S	173	0.054
		E267358	U/S	112	0.039
		T267359	DISC	186	0.154
		E267360	D/S	164	0.049
		E280029	U/S	116	0.044
		T280030	DISC	192	0.177
		E280031	D/S	122	0.060
26	AFAN	E251682	U/S	57	0.017
	NANT Y FEDW	T251683	DISC	299	NO RESUL
		E251684	D/S	156	0.646
		E268448	U/S	54	
		T268449	DISC	265	0.900
		E268450	D/S	132	0.447
		E274504	U/S	48	0.044
		T274505	DISC	322	1.383
		E274506	D/S	100	
27	AFAN	E251688	U/S	105	0.010
	TRIB OF NANT	T251689	DISC	394	3.230
	CREGAN	E251690	D/S	265	1.680
		E268445	U/S	93	0.026
		T268446	DISC	321	0.820
		E268447	D/S	200	
		E272853	U/S	74	
		T272854	DISC	302	1.150
		E272855	D/S	96	0.068
16	CYNFFIG	E251697	U/S	106	0.153
	N. CRAIG YR ABER	E251698	DISC	234	NO RESUL
		E251699	D/S	156	0.537
		E268451	U/S	131	0.293
		T268452	DISC	1414	10.410
		E268453	D/S	498	4.760
		E273806	U/S	131	0.295
		T273807	DISC	1376	14.900
		E273808	D/S	331	3.190
32	LOUGHOR	E254346	DISC/ STREAM	98	0.742
	NANT MELYN	E269013	U/S	74	0.211
		T269014	DISC	1037	5.450
		E269015	D/S	615	2.137
		E271985	U/S	110	1.240
		T271986	DISC	1080	5.760
		E271987	D/S	456	2.190
30	LOUGHOR	E253200	U/S	169	0.262
	MORLAIS	T253201	DISC	2230	63.130
		E253202	D/S	1011	NO RESUL
		E269505	U/S	204	0.275
		T269506	DISC	2000	
		E269507	D/S	1239	22.570
		E271766	U/S	169	0.318
		T271767	DISC	2120	74.910
		E271768	D/S	720	12.600

TOTAL IRON mg/l	DISS. Al. mg/l	TOTAL Al. mg/l	DISS. SULPHATE mg/l	TOTAL SULPHATE mg/l	ALKALINITY mg/l CaCO	SUS. SOLIDS mg/l
0.083	0.030	0.030	30.90	31.0	35.55	3
0.756	0.004	0.011	27.60	27.6	83.42	15
0.167	0.024	0.037	30.60	31.0	36.89	3
0.060	0.032	0.053	17.60	17.7	23.40	<3
0.243	0.006	0.026	25.00	25.0	65.80	<3
0.078	0.032	0.039	18.20	18.4	27.10	<3
0.056	0.040	0.052	25.10	25.2	25.90	<3
3.370	0.005	0.119	25.20	25.2	81.00	21
0.092	0.032	0.045	29.70	31.4	26.70	4
0.017	0.007	0.009	6.50	6.5	7.90	3
1.522	0.004	0.015	70.90	70.9	74.58	6
0.646	0.004	0.015	34.20	34.6	10.40	5
0.024	0.012	0.014	4.70	4.7	9.50	<3
1.170	0.006	0.142	59.00	59.0	72.00	22
0.447	0.012	0.094	24.30	24.8	29.10	35
0.044	0.034	0.038	6.80	6.9	7.07	<3
2.809	0.009	1.005	56.90	57.8	71.00	195
0.230	0.027	0.099	15.90	19.1	21.20	29
0.011	0.011	0.011	16.60	16.6	1.78	3
3.320	0.063	0.123	150.80	153.7	36.13	6
2.470	0.053	0.238	66.40	66.6	26.25	17
0.026	0.019	0.019	11.00	14.0	14.60	<3
1.010	0.060	0.107	114.00	118.0	30.97	3
0.566	0.062	0.070	66.00	68.0	22.50	3
0.025	0.319	0.345	14.00	14.4	1.69	4
1.530	0.087	0.169	89.80	100.6	29.30	<3
0.068	0.203	0.265	20.70	21.0	4.59	4
0.283	0.007	0.022	14.70	14.7	11.22	3
1.990	0.010	0.013	19.90	19.9	17.75	5
0.699	0.006	0.011	25.30	25.3	22.80	3
0.385	0.018	0.020	18.30	19.2	16.50	<3
16.640	0.034	0.050	560.00	573.0	117.00	12
4.760	0.011	0.019	169.00	174.0	43.00	7
0.443	0.025	0.038	16.00	16.0	11.69	5
15.330	0.020	0.077		536.7	39.80	29
4.060	0.020	0.086	101.90	101.9	27.00	8
0.880	0.011	0.018	7.60	7.9	23.64	<3
0.345	0.004	0.010	5.30	5.4	21.00	<3
6.190		<0.004	254.00	269.0	315.00	8
2.282	<0.004	0.009	145.00	151.0	188.00	5
2.060	0.010	0.041	6.50	6.9	34.30	6
8.090	0.006	0.006	248.80	253.2	315.00	11
2.540	0.005	0.018	92.00	92.0	126.00	7
0.416	0.026	0.056	24.10	24.1	32.88	3
73.080	0.166	0.175	985.00	1,057.0	222.82	73
10.360	NO RESUL	0.034	390.80	400.4	103.82	50
0.345	0.035	0.035	29.50	29.5	42.00	<3
31.770		0.061	723.00	729.0	254.00	101
26.420	0.029	0.029	456.00	456.0	159.00	74
0.397	0.024	0.055	20.10	20.4	38.00	4
61.120	0.176	0.189	911.20	916.8	244.00	90
12.800	0.021	0.033	249.80	249.8	66.00	39

Appendix 8. Chemical Data for 20 S.W. discharges (selected for stage 2 assessment) on all sampling occasions.

SITE NO.	NAME OF RECEIVING WATER	LAB. REF.	LOCATION	NATIONAL GRID REFERENCE	DATE
29	LOUGHOR	E253389	U/S	SN 6328 0963	18-Mar-93
	CATHAN	T253390	DISC	SN 6325 0963	
		E253391	D/S	SN 6323 0966	
		E256934	U/S	SN 6328 0963	02-Jul-93
		T256935	DISC	SN 6325 0963	
		E256936	D/S	SN 6323 0966	
		E271988	U/S	SN 6328 0963	22-Jul-93
		T271989	DISC	SN 6325 0963	
		E271990	D/S	SN 6323 0966	
31	TRIB OF CLYNE	E253385	U/S	SS 5873 9434	18-Mar-93
		T253386	DISC 1	SS 5878 9427	
		T253387	DISC 2	SS 5927 9382	
		E253388	D/S	SS 5931 9369	
		E269508	U/S	SS 5873 9434	07-Jul-93
		T269509	DISC 1	SS 5878 9427	
		T269510	DISC 2	SS 5927 9382	
		E269511	D/S	SS 5931 9369	
		E271782	U/S	SS 5873 9434	20-Jul-93
		T271783	DISC 1	SS 5878 9427	
		T271784	DISC 2	SS 5927 9382	
		E271785	D/S	SS 5931 9369	
33	TAWE	E254515	U/S	SN 7002 0536	26-Mar-93
	UNNAMED TRIB OF	T254516	DISC	SN 7002 0533	
	LOWER CLYDACH	E254517	D/S	SN 7001 0530	
		E269916	U/S	SN 7002 0536	08-Jul-93
		T269917	DISC	SN 7002 0533	
		E269918	D/S	SN 7001 0530	
		E280032	U/S	SN 7002 0536	15-Sep-93
		T280033	DISC	SN 7002 0533	
		E280034	D/S	SN 7001 0530	

TIME	WEATHER	TEMP. deg. C	pH	FIELD pH	DO mg/l	DO %
15:30	DRY	6.6	7.70	7.96	11.30	97.0
		11.0	5.80	5.50	1.00	9.1
		8.9	7.20	6.64	10.70	92.5
12:30	DRY	14.1	6.20	7.41	10.90	106.0
		11.3	5.70	6.36	1.10	10.1
		13.9	6.70	7.62	10.20	99.0
11:00	DRY	13.1	7.10	7.66	10.40	99.2
		11.6	5.50	5.81	4.72	43.5
		13.1	7.00	7.13	10.23	97.5
11:40	DRY	9.3	7.50	6.19	10.20	89.0
		11.4	7.00	6.75	1.00	9.2
		11.4	6.30	6.79	7.30	67.0
		10.6	7.10	6.91	6.20	55.8
14:00	DRY	13.7	7.80	6.90	9.30	89.9
		12.3	7.00	7.52	6.20	56.1
		12.6	6.30	7.41	6.70	62.0
		12.5	7.00	7.70	7.80	73.4
15:00	DRY	14.5	7.10	8.20	8.70	85.6
		13.1	7.00	7.65	7.00	66.7
		12.5	6.10	7.52	6.50	61.1
		12.7	6.90	7.80	8.90	84.1
11:00	DRY	5.6	6.90	6.29	12.00	95.5
		9.5	5.80	6.08	0.20	1.8
		6.0	6.20	6.25	12.00	96.5
13:00	DRY	16.5	6.90	6.48	9.00	92.4
		11.4	5.80	5.47	0.70	6.4
		15.1	6.10	6.37	6.90	68.7
11:30	DRY	12.3	6.70	7.50	9.95	93.2
		11.3	5.70	5.75	1.01	9.2
		12.3	6.30	5.96	6.79	62.3

Appendix 6. cntd.

SITE NO.	NAME OF RECEIVING WATER	LAB. REF.	LOCATION	COND. us	DISS. IRON mg/l	TOTAL IRON mg/l	DISS. Al. mg/l	TOTAL Al. mg/l	DISS. SULPHATE mg/l	TOTAL SULPHATE mg/l	ALKALINITY mg/l CaCO	SUS. SOLIDS mg/l
29	LOUGHOR	E253389	U/S	212	0.048	0.096	0.011	0.029	42.20	42.5	50.00	3
	CATHAN	T253390	DISC	900	81.100	81.630	0.746	1.203	468.70	468.7	16.16	4
		E253391	D/S	235	1.900	1.951	0.028	0.060	54.80	54.9	47.82	8
		E256934	U/S	168	0.048	0.120	0.017	0.022	32.00	32.0	49.00	12
		T256935	DISC	916	73.000	73.000	0.480	1.000	444.00	444.0	24.58	<3
		E256936	D/S	210	1.200	1.200	0.024	0.042	42.00	42.0	43.00	6
		E271988	U/S	214	0.159	0.159	0.013	0.018		38.4	46.40	<3
		T271989	DISC	982	56.700	61.000	0.506	0.657	502.20	515.0	15.70	4
		E271990	D/S	234	1.680	1.750	0.018	0.037		47.2	46.20	9
31	TRIB OF CLYNE	E253385	U/S	207	0.170	0.410	0.010	0.060	13.00	20.7	66.70	8
		T253386	DISC 1	541	7.620	8.180	0.010	0.010	73.70	76.7	199.80	12
		T253387	DISC 2	455	27.800	27.800	0.060	0.060	129.80	129.9	50.00	5
		E253388	D/S	469	NO RESU	4.780	0.010	0.020	49.70	56.4	150.10	50
		E256506	U/S	230	0.172	0.173	0.012	0.036	6.00	6.9	94.00	3
		T256509	DISC 1	493	6.620	6.620	0.044	0.066	68.00	77.0	205.00	23
		T256510	DISC 2	342	22.170	22.260	0.069	0.075	121.00	121.0	52.00	27
		E256511	D/S	449	5.470	7.170	0.057	0.074	87.00	87.0	113.00	19
		E271762	U/S	213	0.313	0.392	0.043	0.066	15.50	15.6	63.00	6
		T271763	DISC 1	423	5.353	8.483	0.006	0.056	46.50	50.7	153.00	10
		T271764	DISC 2	440	26.415	30.084	0.055	0.070	118.60	119.9	52.60	16
		E271765	D/S	400		4.160	<0.004	<0.004	82.30	82.3	106.00	14
33	TAWE	E254515	U/S	312	0.140	0.220	0.010	0.040	132.00	132.0	11.70	3
	UNNAMED TRIB OF	T254516	DISC	556	30.300	44.700	0.060	0.420	204.00	204.0	47.60	79
	LOWER CLYDACH	E254517	D/S	331	1.490	2.120	0.020	0.040	138.00	138.0	13.60	10
		E259916	U/S	548	0.037	0.094	0.009	0.022	284.00	284.0	15.30	6
		T259917	DISC	507	21.310	21.310	0.004	0.042	163.00	163.0	49.00	24
		E259918	D/S	610	2.369	4.066	<0.004	0.044	274.00	274.0	16.70	34
		E260032	U/S	324	0.159	0.334	0.041	0.107	147.20	148.4	22.30	7
		T260033	DISC	914	20.450	42.790	0.006	0.113	366.00	366.0	73.00	267
		E260034	D/S	390	2.960	3.000	0.036	0.095	160.30	163.6	26.60	13

Appendix 7. Chemical Data for the N. discharge (selected for stage 2 assessment) on all sampling occasions.

SITE NO.	NAME OF RECEIVING WATER	LAB. REF.	LOCATION	NATIONAL GRID REFERENCE	DATE	TIME	WEATHER	TEMP. deg. C	pH	FIELD pH	DO mg/l	DO %
34	DEE	E165765	U/S	SJ 3065 6570	23-Apr-93	09:00	DRY	9.7	7.70	8.06	8.50	74.9
		T165766	DISC	SJ 3068 6571				10.7	6.70	6.34	0.20	1.8
	BROUGHTON BROOK	E165767	D/S	SJ 3068 6572				10.5	6.90	7.00	1.50	13.5
		E281140	U/S	SJ 3065 6570	22-Sep-93	12:30	DRY	11.9	7.90	7.35	10.05	93.3
		T281141	DISC	SJ 3068 6571				10.8	7.60	6.31	0.78	7.1
		E281142	D/S	SJ 3068 6572				11.0	7.80	6.66	6.39	58.1

Appendix 7. cntd.

SITE NO.	NAME OF RECEIVING WATER	LAB. REF.	LOCATION	COND. us	DISS. IRON mg/l	TOTAL IRON mg/l	DISS. Al. mg/l	TOTAL Al. mg/l	DISS. SULPHATE mg/l	TOTAL SULPHATE mg/l	ALKALINITY mg/l CaCO3	SUS. SOLIDS mg/l
34	DEE	E165765	U/S	326	0.381	0.504	0.193	0.260	44.86	NO RESULT	89.00	4.8
		T165766	DISC	978	10.270	10.360	0.260	0.270	242.20	253.0	232.00	11
	BROUGHTON BROOK	E165767	D/S	867	9.420	9.420	0.255	0.264	215.51	221.0	211.00	13.2
		E281140	U/S	570	0.390	0.400	0.046	0.046	75.80	75.8		<3
		T281141	DISC	1070	13.100	13.100	0.043	0.082	271.10	275.6		
		E281142	D/S	1018		3.100	0.010	0.010	237.80	237.8		20

Appendix 8.

Water Quality Data Summary

Site		MEAN VALUES Temp ^{0}C	D.O. %	pH	total Fe mg/l	total SO_4 mg/l
1 Llwyd	u/s	9.3	109	7.96	0.117	76.8
at Abersychan	disc	11.7	108	7.83	3.68	288.2
	d/s	10.3	108	7.99	1.073	156.9
2 Llwyd	u/s	9.3	99	7.88	0.348	86.9
at Pontnewydd	disc	11.3	102	7.67	0.288	104.7
	d/s	9.6	94	7.76	0.713	103.6
3 Llwyd	u/s	10.2	103	7.83	0.446	75.6
at Pontypool	disc	10.1	103	7.83	0.569	81.4
	d/s	10.2	100	7.77	0.387	76.1
4 Ebbw	u/s	10.2	110	8.2	0.266	105.7
at Newbridge	disc	12.0	29	6.9	19.6	771.5
	d/s	10.5	105	7.95	0.982	155.5
5 Sirhowy	u/s	10.3	99	7.83	0.187	62.6
at Blackwood	disc	10.7	70	6.7	4.997	692.9
	d/s	10.8	100	7.6	0.565	128.1
6 Sirhowy	u/s	12.3	99	7.6	0.288	88.5
at Pontllanfraith	disc	10.8	63	6.97	2.275	706.6
	d/s	11.4	93	7.37	2.42	342.3
7 Rhymney	u/s	10.6	104	7.47	0.251	118.8
at Fleur de Lys	disc	10.9	17	7.06	5.788	665.5
	d/s	10.9	102	7.17	2.59	278.3

Appendix 8 continued.

Site		Temp ^{0}C	D.O. %	pH	total Fe mg/l	total SO_4 mg/l
			MEAN VALUES			
9 Dare Trib.	u/s	8.6	100	7.57	0.087	33.7
at Cwmdare	disc	11.6	58	6.93	4.498	123.2
	d/s	8.9	100	7.57	0.300	32.8
10 Llwyd	u/s	9.7	90	7.27	0.313	36.9
at Blaenavon	disc	10.2	94	7.23	1.637	148.4
	d/s	10.1	100	7.37	0.587	80.6
11 Clydach Trib.	u/s	9.2	104	7.27	0.133	42.9
at Ynysybwl	disc	10.0	83	6.2	1.000	100.1
	d/s	9.4	104	7.17	0.305	54.7
12 Y Ffrwd	u/s	8.9	107	6.5	0.214	15.1
at Ynysybwl	disc	9.9	106	6.92	1.523	28.4
	d/s	8.8	105	7.07	0.967	23.7
13 Rhondda	u/s	11.0	106	7.81	0.856	42.9
at Hopkinstown	disc	10.1	106	6.67	13.193	105.9
	d/s	11.0	109	7.6	1.705	45.5
14 Ogwr Fach	disc	9.4	99	7.33	0.919	18.9
at Evanstown	d/s	9.7	102	6.95	0.755	39.9
15 Llynfi Trib.	u/s	10.6	113	6.83	0.386	13.5
near Bettws	disc	11.5	53	6.67	8.75	71.9
	d/s	11.0	107	6.77	1.194	20.8
16 Nant Craig y Aber	u/s	11.1	107	6.8	0.369	17.3
Nr. Aberbaiden	disc	10.8	50	6.43	11.32	377.2
farm	d/s	10.9	100	6.63	3.173	100.4
17 Afon Corrwg	u/s	9.9	115	7.4	0.088	12.8
Nr Glyncorrwg	disc	9.7	16	6.46	14.437	217.7
	d/s	10.5	107	7.33	1.181	31

Appendix 8 continued.

Site		Temp ^{0}C	D.O. %	pH	total Fe mg/l	total SO_4 mg/l
				MEAN VALUES		
18 Corrwg Fechan	u/s	9.3	112	6.53	0.07	9.7
Nr.Glyncorrwg	disc	9.9	40	6.93	11.513	136.2
	d/s	9.7	99	6.77	1.587	30.9
19 Nant Gwynfi	u/s	9.5	112	7.18	0.125	10.2
at Blaengwynfi	disc	9.8	83	6.57	7.348	125.6
	d/s	9.3	101	6.99	1.289	33.8
20 Afon Afan	u/s	10.0	103	7.3	0.065	25
Nr. Gelli farm	disc	10.8	99	7.5	1.458	25.9
	d/s	10.1	103	7.33	0.12	26.9
21 Afon Corrwg	u/s	10.8	109	7.3	0.113	24.0
Nr. Glyncorrwg	disc	12.6	100	7.17	19.337	273.3
	d/s	11.0	110	7.37	0.534	30.2
22 Ffrwd Wyllt	u/s	9.4	114	7.23	0.068	19.2
at Bryn	disc	9.9	110	7.23	0.286	19.2
	d/s	9.4	113	7.27	0.354	20.1
23 Ffrwd Wyllt	u/s	10.9	113	7.1	0.074	23.3
at Goytre	disc	11.1	90	6.8	3.545	72.6
	d/s	11.1	106	6.97	0.543	34.1
24 Nant Blaenpelenna	u/s	10.5	124	6.6	0.225	18
Nr. Tonmawr	disc	9.7	119	6.93	0.871	51.2
	d/s	10.3	126	6.8	0.582	27.8
25 Nant Blaenpelenna	u/s	12.0	121	6.77	0.267	23.5
Nr. Tonmawr	disc	11.1	102	5.5	19.81	245.8
	d/s	11.9	122	6.03	5.813	80.3
26 Cwm Gwenffrwd	u/s	12.8	113	6.23	0.134	32.4
Nr. Tonmawr	disc	10.5	20	5.51	48.233	294.9
	d/s	13.0	112	6.0	4.207	62.3

Appendix 8 continued.

Site		Temp ^{0}C	D.O. %	pH	total Fe mg/l	total SO_4 mg/l
			MEAN VALUES			
27 Nant Cregan Trib.	u/s	10.8	113	5.93	0.020	15
at Troed y rhiw	disc	9.9	109	6.67	1.953	124.1
	d/s	10.7	112	6.86	1.041	58.5
28 Nant y Fedw	u/s	10.3	110	6.78	0.029	6.7
at Gelli farm	disc	9.7	30	6.87	1.833	62.6
	d/s	10.3	106	6.99	0.442	26.2
29 Cwm Cathan	u/s	11.9	101	7.0	0.126	37.6
Nr Garnswllt	disc	11.3	42	5.67	71.877	482.6
	d/s	12.0	96	6.97	1.633	48.0
30 Afon Morlais	u/s	13.0	108	7.2	0.387	24.7
at Llangennech	disc	14.5	1	6.67	61.99	901.5
	d/s	13.6	90	6.9	16.46	368.7
31 Clyne	u/s	12.5	72	7.47	0.325	14.4
at Dunvant	disc	12.4	45	7	26.715	123.6
	d/s	11.9	71	7	5.37	75.2
32 Nant Melyn	u/s	13.3	91	6.85	1.203	6.2
at Cwmgors	disc	11.7	11	6.85	6.14	261.1
	d/s	10.8	84	6.97	1.894	83.6
33 Tawe Trib.	u/s	11.5	94	6.83	0.216	188.1
Nr. Llechart	disc	10.7	6	5.77	36.267	244.3
farm.	d/s	11.1	89	6.17	3.063	191.9
34 Broughton Brook	u/s	10.8	84	7.8	0.452	75.8
at Hawarden.	disc	10.8	4	7.2	11.74	264.3
	d/s	10.8	36	7.4	6.26	229.4

Appendix 9. Flow data for the minewaters assessed in stage 2 over the period June - October 1993.

Site		N.G.R. of discharges	Flow (Cumecs)
1	R. Llwyd (Abersychan)	SO 2705 0315	0.1143
2	R. Llwyd (Pontnewydd)	SO 2763 0181	0.0932
3	R. Llwyd (Pontypool)	SO 2860 0058	0.2277
10	R. Llwyd (Blaenavon)	SO 2443 0897	0.0265
4	R. Ebbw (Newbridge)	ST 2121 9758	0.0507
5	R. Sirhowy (Blackwood)	ST 1757 9736	0.0182
6	R. Sirhowy (P'llanfraith)	ST 1801 9568	0.0552
7	R. Rhymney (Hengoed)	ST 1547 9632	0.1589
11	Clydach Trib (Ynysybwl)	ST 0537 9532	0.0126
12	Y Ffrwd (Ynysybwl)	ST 0358 9433	0.0082
13	R. Rhondda (Hopkinstown)	ST 0594 9059	0.0126
14	Ogwr Fach	SS 9776 9051	0.1139
		SS 9819 9047	0.0074
15	Llynfi Trib	SS 8936 8762	0.0028
16	N. Craig yr Aber	SS 8555 8455	0.0327
17	A. Corrwg	SN 8892 0069	0.0095
		SN 8888 0067	0.0154
18	A. Corrwg Fechan	SN 8813 0078	0.0051
19	N. Gwynfi	SS 8923 9730	0.0169
20	R. Afan (Nr. Gelli farm)	SS 8720 9630	0.0122
21	R. Corrwg (W.D.A Site)	SS 8629 9768	0.0018
23	Ffrwd Wyllt	SS 7872 8975	0.0116
24	N. Blaenpelenna	SS 8154 9751	0.0318
25	N. Blaenpelenna	SS 8161 9723	0.0265
26	Gwenffrwd	SS 7996 9730	0.0180
		SS 8006 9691	0.0171
28	Nant y Fedw	SS 8784 9579	0.0298
29	R. Cathan	SN 6325 0963	0.0031
30	R. Morlais	SN 5723 0228	0.162
31	R. Clyne trib (Dunvant)	SS 5878 9427	0.0083
32	N. Melyn	SN 7022 1106	0.0223
33	Tawe tributary	SN 7002 0533	0.0027

Appendix 10. Biological survey data for the minewater sites assessed in stage 2 including observed (O) and expected (E) BMWP scores and reduction in BMWP scores.

Site		Sample	NGR.	BMWP (O)	BMWP (E)	% Redn. in (O)		No. Taxa (O)	No. Taxa (E)	
1	A. Llwyd	ups	SO 270 031	91	130.7	--		16	21.2	
	Abersychan	d/s1	SO 270 030	116	132.9	--		19	21.6	**
		d/s2	SO 272 021	71	-----	12		12	----	
2	A. Llwyd	ups	SO 276 018	114	132.3	--		20	21.6	
	Pontnewydd	d/s1	SO 276 017	63	133.4	45	*	12	21.8	**
		d/s2	SO 278 016	124	-----	--		21	----	
3	A. Llwyd	ups	SO 286 005	111	135.4	--		21	22.1	
	Pontypool	d/s1	SO 286 005	96	136	14		17	22.2	**
		d/s2	SO 289 004	69	-----	38		13	----	
4	R. Ebbw	ups	ST 212 976	65	132.6	--		13	22.1	
	Newbridge	d/s1	ST 212 974	65	133.7	--		13	22.3	**
		d/s2	ST 211 969	49	-----	25		10	----	
		d/s3	ST 217 955	60	-----	8		12	----	
5	R. Sirhowy	ups	ST 176 973	106	136.4	--		19	22.7	
	Blackwood	d/s1	ST 175 973	81	135.4	24		15	22.5	**
		d/s2	ST 177 969	88	-----	17		15	----	
6	R. Sirhowy	ups	ST 180 956	83	135.6	--		15	22.5	
	P'lanfraith	d/s1	ST 180 955	61	136.7	27		12	22.8	**
		d/s2	ST 180 954	73	-----	12		14	----	
		d/s3	ST 178 947	72	-----	13		13	----	
7	R. Rhymney	ups	ST 155 963	87	135.5	--		16	22.5	
	Hengoed	d/s1	ST 154 962	55	136.3	37		11	22.5	**
		d/s2	ST 955 949	78	-----	10		14	----	
		d/s3	ST 148 927	86	-----	1		16	----	
9	R. Dare	ups	SN 971 028	146	132.3	--		22	20.8	
	trib	d/s1	SN 972 028	115	133.6	21		19	21.1	
		d/s2	SN 973 025	127	-----	13		19	----	
10	A. Llwyd	ups	SO 234 095	166	126.4	--		25	19.9	
	Blaenavon	d/s1	SO 244 089	3	130.7	98	*	2	20.8	**
		d/s2	SO 247 088	55	-----	67	*	10	----	
		d/s3	SO 253 084	56	-----	66	*	12	----	

* Indicates a significant reduction in BMWP score

** Indicates a significant reduction in $\log_{10}$ abundance of ≥ 6 taxa

Appendix 10 Continued.

Site	Sample	NGR	BMWP (O)	BMWP (E)	% Redn in (O)		No. taxa. (O)	No. taxa. (E)	
11 R. Clydach	ups	ST 053 953	113	133.8	--		17	21.4	
Ynysybwl	d/s1	ST 053 952	70	134.8	38		12	21.7	**
	d/s2	ST 055 951	113	-----	--		17	----	
12 Y Ffrwd	ups	ST 041 945	89	89.3	--		14	15.2	
Nr Ynysybwl	d/s1	ST 042 944	34	127.1	62	*	6	20.2	**
	d/s2	ST 044 943	86	-----	3		14	----	
	d/s3	ST 052 949	134	-----	--		21	----	
13 R. Rhondda	ups	ST 059 906	60	124.6	--		12	21.4	
Hopkinstown	d/s1	ST 059 905	42	125.6	30		9	21.5	
	d/s2	ST 059 905	48	-----	20		11	----	
14 Ogwr Fach	---	----------	---	-----	--		--	----	
Evanstown	d/s1	SS 977 905	34	-----	--		7	----	
	d/s2	SS 978 904	64	-----	--		12	----	
	d/s3	SS 979 892	120	-----	--		21	----	
15 R. Llynffi	ups	SS 893 876	136	127.3	--		22	17.8	
trib	d/s1	SS 893 875	88	105.9	35		13	17.9	**
	d/s2	SS 893 873	103	-----	24		16	----	
	d/s3	SS 891 865	133	-----	2		22	----	
16 N. Craig yr-	ups	SS 855 845	100	124.4	--		17	20.0	
aber	d/s1	SS 855 845	39	134.2	61	*	7	21.2	**
	d/s2	SS 831 833	106	-----	--		17	----	
	d/s3	SS 825 831	115	-----	--		19	----	
17 R. Corrwg	ups	SN 889 007	56	126.4	--		10	20.0	
	d/s1	SN 888 006	27	125.3	52	*	5	19.8	
	d/s2	SS 879 993	59	-----	--		10	----	
	d/s3	SS 866 979	83	-----	--		13	----	
18 A. Corrwg	ups	SN 881 008	35	90.4	--		6	15.3	
Fechan	d/s1	SN 881 007	11	94.4	69	*	2	15.8	
	d/s2	SS 875 995	41	-----	--		8	----	
	d/s3	SS 875 992	89	-----	--		15	----	
19 N. Gwynfi	ups	SS 892 973	73	122.2	--		11	19.3	
	d/s1	SS 891 972	41	123.8	44	*	8	19.6	**
	d/s2	SS 879 968	100	-----	--		15	----	

* Indicates a significant reduction in BMWP score

** Indicates a significant reduction in log$_{10}$ abundance of $\geq$6 taxa

Appendix 10 Continued.

Site	Sample	N.G.R.	B.M.W.P. (O)	B.M.W.P. (E)	% Redn in (O)		No. of taxa (O)	No. of taxa (E)	
20 R. Afan	ups	SS 871 963	98	113.3	--		15	17.9	
Nr. Gelli fm	d/s1	SS 871 962	92	114.2	6		16	18.0	
	d/s2	SS 872 962	84	-----	14		15	----	
21 R. Afan	ups	SS 863 976	98	120.0	--		15	19.2	
W.D.A site	d/s1	SS 863 975	95	125.4	3		15	20.1	
	d/s2	SS 862 966	88	-----	10		14	----	
22 Ffrwd Wyllt	ups	SS 817 924	127	96.6	--		19	16.3	
Bryn	d/s1	SS 816 921	125	135.6	2		19	21.5	
	d/s2	SS 813 921	97	-----	25		16	----	
23 Ffrwd Wyllt	ups	SS 787 898	136	117.9	--		20	19.7	
Goytre	d/s1	SS 786 897	127	135.6	7		21	22.1	
	d/s2	SS 785 897	109	-----	20		17	----	
24 Blaenpelenna	ups	SS 815 975	63	115.2	--		11	18.2	
	d/s1	SS 815 974	34	111.1	46	*	7	17.9	
	d/s2	SS 816 973	49	-----	22		9	----	
25 Blaenpelenna	ups	SS 816 972	58	92.1	--		10	15.6	
	d/s1	SS 816 971	18	117.6	69	*	4	18.8	**
	d/s2	SS 809 961	44	-----	24		8	----	
	d/s3	SS 787 953	66	-----	--		11	----	
R. Afan	d/s4	SS 793 940	94	-----	--		15	----	
	d/s5	SS 781 919	93	-----	--		15	----	
26 Gwenffrwd	ups	SS 799 973	58	108.1	--		10	17.8	
	d/s1	SS 799 961	20	90.0	66	*	5	15.3	**
	d/s2	SS 787 953	47	-----	19		9	----	
27 Trib. of N.	ups	SS 844 973	145	108.7	--		23	17.5	
Cregan	d/s1	SS 847 973	93	123.3	36		14	19.5	
	d/s2	SS 844 971	65	-----	55	*	11	----	
28 Nant y Fedw	ups	SS 878 958	111	91.1	--		17	15.4	
Gelli farm	d/s1	SS 877 958	91	122.6	18		14	19.4	
	d/s2	SS 871 960	117	-----	--		18	----	
29 R. Cathan	ups	SN 632 096	123	134.6	--		19	21.3	
	d/s1	SN 632 096	108	135.2	12		18	21.4	**
	d/s2	SN 621 102	129	-----	--		22	----	

* Indicates a significant reduction in BMWP score

** Indicates a significant reduction in $\log_{10}$ abundance of ≥ 6 taxa

Appendix 10 Continued.

Site	Sample	N.G.R.	B.M.W.P. (O)	B.M.W.P. (E)	% Redn in (O)		No. of taxa (O)	No. of taxa (E)	
30 R. Morlais	ups	SN 570 020	117	144.8	--		19	24.3	
	d/s1	SN 570 019	21	135.9	82	*	5	24.3	**
31 Clyne Trib	ups	SS 587 943	99	112.2	--		17	19.7	
	d/s1	SS 593 936	18	136.3	82	*	4	22.2	**
	d/s2	SS 593 931	110	-----	--		18	----	
	d/s3	SS 598 924	122	-----	--		22	----	
32 N. Melyn	ups	SN 700 102	111	139.6	--		20	23.6	
	d/s1	SN 702 111	95	133.3	14		16	24.1	
	d/s2	SN 700 120	78	-----	30		15	----	
33 Tawe trib.	ups	SN 700 053	89	90.7	--		15	15.4	
	d/s1	SN 700 053	22	91.7	75	*	6	15.7	**
	d/s2	SN 698 048	20	-----	78	*	4	----	
	d/s3	SN 688 043	52	-----	42	*	10	----	
34 Broughton	ups	SJ 306 657	43	134.8	--		10	21.6	
Brook	d/s1	SJ 306 657	14	133.6	67	*	4	21.2	
	d/s2	SJ 318 302	34	-----	11		9	----	

* Indicates a significant reduction in BMWP score

** Indicates a significant reduction in $\log_{10}$ abundance of ≥ 6 taxa

Appendix 10A Summary of invertebrate taxa lost or reduced in abundance at the first downstream site below a minewater discharge.

Taxa	BMWP SCORE	No. of d/s sites at which taxa were: LOST	(%)	REDUCED	(%)	No. of U/S sites at which taxa were PRESENT
Heptageniidae	10	7	35	6	30	20
Ephemerellidae	10	5	21	8	35	23
Leptophlebiidae	10	1	100			1
Perlodidae	10	6	75			8
Chloroperlidae	10	10	66	1	6.6	15
Leuctridae	10	7	24	6	21	29
Sericostomatidae	10	10	77			13
Goeridae	10	4	100			4
Odontoceridae	10	1	100			1
Lepidostomatidae	10	3	100			3
Cordulegasteridae	8	7	87.5			8
Philopotamidae	8	7	77	1	11	9
Caenidae	7	3	27	2	18	11
Nemouridae	7	8	53			15
Rhyacophilidae	7	9	31	5	17	29
Polycentropidae	7	10	40	2	8	25
Limnephilidae	7	7	63			11
Ancylidae	6	3	75			4
Hydroptilidae	6	5	83			6
Gammaridae	6	4	26	5	33	15
Mesoveliidae	5	2	100			2
Gerridae	5	1	100			1
Dytiscidae	5	7	87.5			8
Gyrinidae	5	1	100			1
Hydrophilidae	5	2	50	2	50	4
Helodidae	5	4	100			4
Dryopidae	5	3	100			3
Elminthidae	5	6	31	3	16	19
Hydropsychidae	5	6	31	6	31	19
Tipulidae	5	10	41	3	12.5	24
Simuliidae	5	7	28	7	28	25
Planariidae	5	8	61.5			13
Baetidae	4	6	18	9	28	32
Hydrobiidae	3	7	43.7	5	31	16
Lymnaeidae	3	5	100			5
Planorbiidae	3	2	100			2
Sphaeriidae	3	4	100			4
Erpobdellidae	3	3	43	1	14	7
Asellidae	3	2	22	1	11	9
Chironomidae	2			10	30	33
Oligochaeta	1	1	3.1	9	28	32

Appendix 10B Specimen copy of BMWP score sheet as used for recording stage 2 biological survey details

RIVER : _____ REG.NO. : _____
SITE : _____ SAMPLE TYPE : _____
N.G.R. : _____ PURPOSE : _____
DATE : _____ ANALYST : _____

FAMILY	:	:	FAMILY	:	:	FAMILY	:
SCORE 10	: A/P		SCORE 7	A/P		SCORE 4	: A/P
HEPTAGENIIDAE	:	:	CAENIDAE	:	:	BAETIDAE	:
EPHEMERELLIDAE	:	:	NEMOURIDAE	:	:	SIALIDAE	:
EPHEMERIDAE	:	:	RHYACOPHILIDAE	:	:	PISCICOLIDAE	:
LEPTOPHLEBIIDAE	:	:	POLYCENTROPIDAE	:	:		:
SIPHLONURIDAE	:	:	LIMNEPHILIDAE	:	:	SCORE 3	:
POTAMANTHIDAE	:	:			:		:
PERLIDAE	:	:	SCORE 6		:	VALVATIDAE	:
PERLODIDAE	:	:			:	HYDROBIIDAE	:
CHLOROPERLIDAE	:	:	ANCYLIDAE	:	:	LYMNAEIDAE	:
LEUCTRIDAE	:	:	VIVIPARIDAE	:	:	PHYSIDAE	:
TAENIOPTERYGIDAE	:	:	NERITIDAE	:	:	PLANORBIIDAE	:
CAPNIIDAE	:	:	HYDROPTILIDAE	:	:	SPHAERIIDAE	:
SERICOSTOMATIDAE	:	:	GAMMARIDAE	:	:	GLOSSIPHONIIDAE	:
GOERIDAE	:	:	UNIONIDAE	:	:	HIRUDIDAE	:
BRACHYCENTRIDAE	:	:	COROPHIDAE	:	:	ERPOBDELLIDAE	:
ODONTOCERIDAE	:	:	COENAGRIIDAE	:	:	ASELLIDAE	:
PHRYGANEIDAE	:	:	PLATYCNEMIDIDAE	:	:		:
MOLANNIDAE	:	:			:	SCORE 2	:
BERAEIDAE	:	:	SCORE 5		:		:
LEPTOCERIDAE	:	:			:	CHIRONOMIDAE	:
LEPIDOSTOMATIDAE	:	:	MESOVELIDAE	:	:		:
APHELOCHEIRIDAE	:	:	HYDOMETRIDAE	:	:	SCORE 1	:
			GERRIDAE	:	:		:
SCORE 8	:		NEPIDAE	:	:	OLIGOCHAETA	:
			NAUCORIDAE	:	:		:
ASTACIDAE	:	:	NOTONECTIDAE	:	:	SCORE 0	:
LESTIDAE	:	:	PLEIDAE	:	:		:
AGRIIDAE	:	:	CORIXIDAE	:	:		:
GOMPHIDAE	:	:	HALIPLIDAE	:	:		:
CORDULEGASTERIDAE	:	:	HYGROBIIDAE	:	:		:
AESHNIDAE	:	:	DYTISCIDAE	:	:		:
LIBELLULIDAE	:	:	GYRINIDAE	:	:		:
CORDULIIDAE	:	:	HYDROPHILIDAE	:	:		:
PSYCHOMYIDAE	:	:	CLAMIDAE	:	:		:
PHILOPOTAMIDAE	:	:	HELODIDAE	:	:		:
		:	DRYOPIDAE	:	:		:
ABUND.CATEGORIES		:	ELMINTHIDAE	:	:		:
1 - 1-9 organisms		:	CHRYSOMELIDAE	:	:		:
2 - 10-99		:	CURCULIONIDAE	:	:		:
3 - 100-999		:	HYDROPSYCHIDAE	:	:		:
4 - 1,000-9,999		:	TIPULIDAE	:	:	NO OF FAMILIES	:
5 - >10,000		:	SIMULIIDAE	:	:	BMWP SCORE	:
		:	PLANARIIDAE	:	:	CLASS	:
A/P - ABUNDANCE / PRESENCE		:	DENDROCOELIDAE	:	:	A.S.P.T.	:

Appendix 10 C

This is a worked example of the calculation of biological impact using BMWP Score and reduction in $\log_{10}$ abundance criteria. If the following were the results of two biological samples, taken upstream and downstream of a discharge, the following assessment would be made.

FAMILIES RECORDED	BMWP SCORE PER FAMILY	$\log_{10}$ ABUNDANCE U/S	ABUNDANCE D/S	LOSS/INCREASE IN ABUNDANCE
Heptageniidae	10	2	0	-
Ephemerellidae	10	2	1	-
Perlodidae	10	1	1	*
Leuctridae	10	1	1	*
Sericostomatidae	10	2	1	-
Lepidostomatidae	10	1	0	-
Philopotamidae	8	1	0	-
Nemouridae	7	1	2	+
Rhyacophilidae	7	2	0	-
Limnephilidae	7	1	0	-
Gammaridae	6	3	3	*
Ancylidae	6	1	0	-
Haliplidae	5	1	1	
Dytiscidae	5	0	1	
Elminthidae	5	2	1	
Simulidae	5	2	0	
Baetidae	4	3	1	
Hydrobiidae	3	2	1	
Asellidae	3	0	1	
Erpobdellidae	3	1	0	
Chironomidae	2	2	2	
Oligochaeta	1	2	1	
	BMWP SCORE	129	81	

(-) = Reduction in abundance
(+) = Increase in abundance
(*) = No change in abundance

The % reduction in BMWP Score between upstream and downstream is 37% which is less than the critical 40% value and therefore not quite significant.

Of the families scoring 6 or more on the BMWP score (ie. those above the dotted line) 8 showed a decrease in abundance of one or more on the $\log_{10}$ scale, 2 showed no change and 1 showed an increase of one or more in $\log_{10}$ abundance. The net number of families which showed a reduction in $\log_{10}$ abundance was therefore 7, which is significant (ie. >4 families).

The result of this impact assessment according to the scheme used for biological assessment would therefore be B, Medium Impact.

Appendix 11.

Fisheries Data from Electrofishing Surveys with R.J.S.M.P Classification

	Site	Upstream Area (m^2)	Upstream No. of Fish 0+	Upstream No. of Fish >0+	Upstream RJSMP Class	Downstream Area (m^2)	Downstream No. of Fish 0+	Downstream No. of Fish >0+	Downstream RJSMP Class
1	Llwyd @ Abersychan	102	4	18	B	153	7	19	C **
	Llwyd recovery site					209	9	27	C
6	Sirhowy	277	0	14	D	210	1	14	C
7	Rhymney	297	0	14	D	245	0	8	D
11	Clydach Trib.	131	3	3	C	121	2	18	C
15	Llynfi Trib.	55	39	12	A	111	14	9	C **
16	Nant Craig yr Aber	91	4	11	C	79	1	3	D **
17	Afon Corrwg	191	20	14	C	272	10	6	D **
18	Afon Corrwg Fechan			no fish caught					E
19	Nant Gwynfi	114	4	0	D	151	7	6	D
21	Afon Corrwg	412	27	36	C	268	30	11	D **
23	Ffrwd Wyllt(Goytre)	155	8	9	C	204	3	18	C
25	Nant Blaenpelenna	163	0	2	D	197	0	1	D
26	Cwm Gwenffrwd			no fish caught					E
27	Nant Cregan Trib.	151	2	1	D	155	2	8	C
28	Nant y Fedw	110	6	4	D	85	0	4	D
29	R. Cathan	117	8	43	B	163	5	23	C **
30	R. Morlais	281	6	23	C	296	0	0	E **
31	Clyne	113	22	13	C	94	35	18	B
32	Nant Melyn	50	4	12	B	71	0	5	D **

** Denotes that fisheries impact was demonstrated.

(0+) and (>0+) above refer to fry and parr respectively both of which are juvenile salmonids less than one year old.

Appendix 12 Habscore results for sites electrofished in stage 2 of the survey showing HUI and HQS % for each site.

Site	Upstream HUI (-ve)		HQS%		Downstream HUI (-ve)		HQS%	
	0+	>0+	0+	>0+	0+	>0+	0+	>0+
1 Llwyd @ Abersychan	1.0	0.5	27	60	0.1	0.0	26	52
6 Sirhowy	**3.5**	0.1	46	14	0.4	0.5	16	1
7 Rhymney	**1.7**	0.5	13	12	0.4	0.2	7	8
11 Clydach Trib.	**3.7**	**2.3**	86	93	**3.9**	**2.5**	85	98
15 Llynfi Trib.	0.3	**1.7**	96	99	**2.8**	**2.9**	97	96
16 Nant Craig yr Aber	**3.9**	**3.2**	96	99	**4.4**	**4.3**	89	99
17 Afon Corrwg	**2.4**	**3.5**	93	99	**4.0**	**4.8**	95	99
18 Afon Corrwg Fechan	**6.0**	**5.5**	93	97	**6.4**	**5.9**	96	98
19 Nant Gwynfi	**3.4**	**5.5**	88	96	**3.5**	**3.9**	93	98
21 Afon Corrwg	**2.7**	0.4	88	50	**2.3**	**2.4**	92	79
23 Ffrwd Wyllt(Goytre)	**2.8**	**3.1**	86	95	**4.2**	**2.8**	88	96
26 Cwm Gwenffrwd	**5.7**	**6.8**	90	100	**5.9**	**5.8**	92	98
27 Nant Creagn Trib.	**4.9**	**4.6**	95	96	**4.7**	**2.8**	93	90
28 Nant y Fedw	**3.0**	**3.5**	90	94	**6.0**	**3.8**	93	98
29 Cwm Cathan	**4.2**	0.1	99	97	**4.5**	1.4	97	90
30 Afon Morlais	**4.0**	0.3	89	38	1.6	0.6	38	7
32 Nant Melyn	**2.9**	0.6	95	93	**4.4**	**1.8**	80	84

For full details of Habscore see Milner & Wyatt 1991.

HQS

This is the Habitat Quality Score (HQS). It is a measure of the habitat quality expressed as the expected density of fish in numbers per $100m^2$.

HQS %

'This is the habitat quality score (HQS) on a percentage scale, and is the approximate percentage of Welsh sites which have a worse habitat than that observed at this site. A value of 50 will therefore represent a median habitat quality for Welsh streams, and a value of 5, for example, will represent poor quality for which only 5 % of sites in Wales are worse.'

HUI

The Habitat Utilisation Index (HUI) is a measure of the extent to which habitat is used by salmonids. It is a calculation based upon the observed density (OBS) and that which is expected under pristine conditions (HQS) divided by the standard deviation of the HQS. Hence a HUI of 0 will be observed when the HQS and the OBS are exactly the same and negative values of the HUI will be noted when the observed densities of salmonids are less than expected. The HUI values above in **BOLD** are values which are significant at the 5 % level. Therefore, a negative value of HUI above in bold would suggest that there was a significant under utilisation of the habitat at the 5 % level.