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River Glen:
River Channel Assessment - Annex E

Instream Habitat Assessment of The River Glen, Lincolnshire

September 1992

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Kingfisher House, Goldhay Way,
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Prof. G Petts
I Maddock

Freshwater Environments Group

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ANNEX E

INSTREAM HABITAT ASSESSMENT OF THE RIVER GLEN, LINCOLNSHIRE

Undertaken for the National Rivers Authority, Anglian Region

By

FRESHWATER ENVIRONMENTS GROUP,
INTERNATIONAL CENTRE OF LANDSCAPE ECOLOGY,
LOUGHBOROUGH UNIVERSITY,
LEICESTERSHIRE, LE11 3TU

Supervised by Professor G.E. Petts

Researcher: Mr. I. Maddock

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SUMMARY

The following section attempts to assess the impact of the hydrology on the instream biota by examining the nature of the physical habitat within the main river and consequently developing a flow-habitat-biota relationship.

A physical survey of the West and East Glens from their source to the confluence was undertaken between 21/8/89 and 28/9/89. Measurements in the field were taken at every 50 m or at every riffle site, whichever was the closer. At each point, the location was assigned one or more of the following characteristics *i.e.* riffle, pool, run, dry, no visible flow and visible flow. Channel width and water width were also recorded to the nearest 10 cm.

In terms of channel size, both rivers show an overall increasing trend with the West Glen increasing quicker than the East Glen. The West Glen varies between 0.9 - 10.4 m whereas the East Glen varies between 0.7 - 8.3 m. A notable decline in channel width occurs below Greatford sluice reflecting the reduced peak flows downstream of the flood diversion channel. The West Glen below the River Tham is dominated by good quality habitat although some points had over half the channel bed exposed. whereas the East Glen is dominated by poorer habitat quality.

Data from the physical habitat survey was subsequently combined with two further surveys under different discharges to examine the response of the physical habitat along an approximately 10 km long reach of the West Glen from upstream of Essendine (TF050127) to the confluence with the East Glen confluence\including the effect of the Gwash-Glen transfer. Downstream of the transfer there is a clear increase in average water width from 3.72 m to 4.28 m with the corresponding increase in average wet width from 53.7% to 71.1%. However, the most prominent change is evident by comparing the average depths over riffles and runs. Upstream, average depths are 10 cm which are elevated to 20 cm downstream of the transfer, an increase of 100%.

This method has highlighted the importance of the instream geomorphology on the physical habitat under three different discharges. However, such techniques do not account for the specific habitat requirements of the instream ecology. Consequently, the following section examined the relationship between instream habitat quality and the biological characteristics of stream reaches and to develop an approach to facilitate a rapid assessment of how the ecology (expressed as BMWP scores) will be affected by a change in habitat using an empirical model.

Twenty eight sites throughout the Anglian region were visited that represent a wide range of average scores i.e. BMWP scores from 25 to 180 as shown in table in order to record 19 physical attributes. At each site, measurements were recorded at twenty transects, spaced approximately at every seven times channel width or at every riffle, whichever was closer. Two empirical models were constructed to correlate habitat variables with BMWP scores. The model using the raw data requires just four variables to attain a high degree of correlation with the BMWP score (r^2 = 0.880). Rating values for the six variables used in the second model increases predictive ability to r^2 = 0.913.In order to test the models on independent data, six sites within the Glen catchment were visited on the 22nd and 23rd of August 1991. Model predictions were all significant above the 98%ile level.

Five sites within the Glen catchment were also tested with the Physical Habitat Simulation System (PHABSIM). to determine the amount of usable habitat for three fish species (Brown trout, dace and chub) over all the flows experienced. Simuations highlighted the need for areas of deeper water within the main channel to provide habitat for selected species over the full range of flows experienced.

ANNEX E. INSTREAM HABITAT ASSESSMENT OF THE RIVER GLEN

E.1 Introduction

Annex C focussed on quantifying the nature and extent of low flows within the Glen catchment. The following section attempts to assess the impact of the hydrology on the instream biota by examining the nature of the physical habitat within the main river and consequently developing a flow-habitat-biota relationship.

With an increase in demand for surface water, coupled with a rise in environmental awareness, there is a growing need in this country for methods to predict the effect of proposed developments on the ecology of running waters. Four main components determine the productivity of any instream habitat, namely 1) the flow regime, 2) water quality, 3) the physical nature of the channel and 4) the energy budget (*e.g.* temperature, sediments, organic matter and nutrients) (Stalnaker, 1979). The magnitude of these components are altered significantly by human interference from reservoirs, abstractions for both industrial purposes (*e.g.* paper production) and agricultural purposes (*e.g.* spray irrigation) and by effluent discharges (*e.g.* from power stations or water treatment works). Instream habitat evaluation methods attempt to quantify the interaction and relative importance of these four components.

Up to date, methodologies have largely originated in the USA. Fish populations tend to provide a basis for human instream use and so early methods concentrated on their requirements (*e.g.* Wesche and Rechard 1980). Subsequent developments have realised that other instream users e.g. invertebrates (Gore and Judy 1981, Armitage *et al* 1987), birds (Robertson *et al* 1983) and plants (Mountford and Gomes 1990) have an intrinsic right to survive and so have gained some recognition.

From the array of methods now available, each relies on a different amount of knowledge required to analyse instream habitat needs and has different situations in which it can be best applied. The techniques themselves can be split into four basic approaches dependent on their rationale and data requirements:

1) discharge methods,
2) habitat methods,
3) biological response methods,
4) statistical models.

In accordance with this classification, the following section outlines each of these four approaches in more detail and gives examples of their application.

E.2 Established Methodologies

Methods for assessing instream habitat rely on differing techniques and levels of reconnaissance. However, they can be categorised into four basic groups according to the approaches they use.

E.2.1 Discharge Methods.

Initially, streamflow was the parameter examined in most detail, particularly with its relationship to fish habitat which gave rise to an approach called 'discharge' methods (Mosley, 1985). Tennant (1976) established the 'Montana' method, the most widely used of these which recommends flow needs based on percentages of the average annual flow. Depths and velocities were shown to be significantly reduced and substrate exposed as the instantaneous flow dropped below 10% of the average annual flow. Consequently, this was established as the absolute minimum needed to sustain short-term survival with 30% providing good survival and 60% sustaining excellent to outstanding habitat. The table below provides the full range of instream flow regimes outlined by Tennant (1976) on a two season basis.

Table E.1 - Instream flow regimes for fish, wildlife, recreation and related environmental resources (Tennant 1976).

Description of flows	Recommended base flow regimes	
	Oct. - Mar.	Apr. - Sept.
Flushing or maximum	200% of the average flow	
Optimum range	60-100% of the average flow	
Outstanding	40%	60%
Excellent	30%	50%
Good	20%	40%
Fair or degrading	10%	30%
Poor or minimum	10%	10%
Severe degradation	10% of average flow to zero flow	

Orth and Maughan (1981) suggested that in different environments flow recommendations may require modification. Rather than be based on two 6-month periods, seasonal and possibly monthly variation should be accounted for. The method also ignores the specific physical character of the stream and so is best utilised to obtain a preliminary estimate of flow requirements followed by more intensive field analysis if time and financial constraints permit.

E.2.2 Habitat Methods.

These examine the instream habitat in conjunction with discharge. However, unlike 'discharge' methods, they employ measurement of the actual hydraulic characteristics of the stream at one or more flows (*e.g.* Swank and Phillips 1976). Water surface elevations, flow velocities, tractive force and hydraulic radii can be simulated using computer programs (*e.g.* US Bureau of Reclamation Water Surface Profile (WSP) Program (Cochnauer 1976)). Loar and Sale (1981) suggested that minimum streamflows can then be designated by highlighting the inflection point where the chosen attribute *e.g.* wet width, starts to rapidly decline (as shown in figure E.1 below). However, these methods do not pay any consideration to the requirements of instream uses.

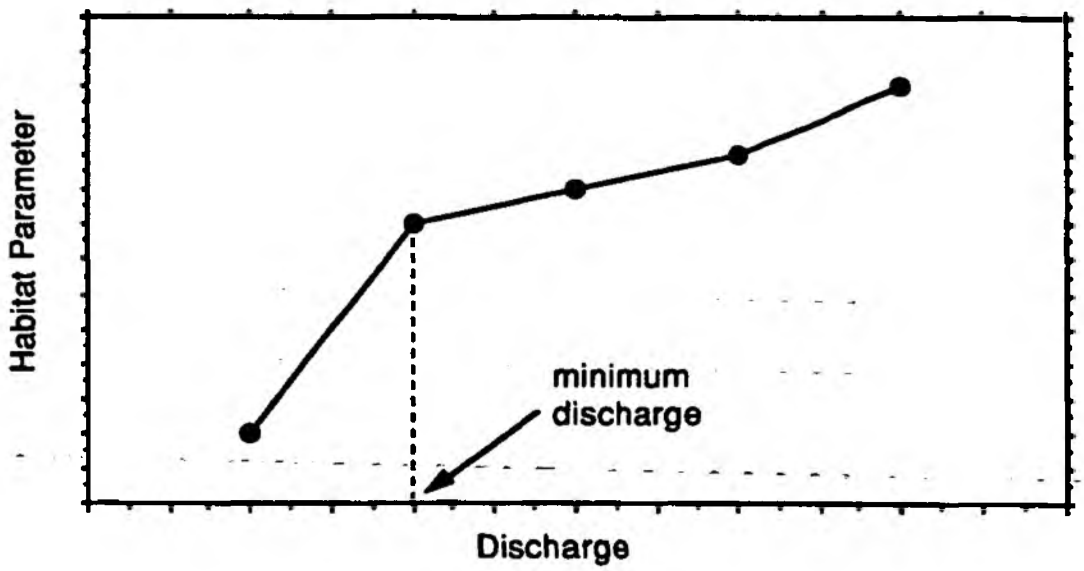


Figure E.1 - Example of a habitat discharge relationship and estimation of minimum flow using the inflection point method described by Loar and Sale (1981).

E.2.3 Biological Response Methods.

These employ habitat suitability criteria for target species to develop relationships between habitat variables and biota. Newcombe (1981) estimated the relative capacity of a stream to support fish by measuring water depth and velocity over a range of discharges. These are then weighted in accordance with frequency distributions of water depth and water velocity preferred by various life-history phases of target species. The need to incorporate the demands of particular instream uses was also recognised by the Instream Flow Service Group (US Fish and Wildlife Service) who developed the Instream Flow Incremental Methodology (IFIM) outlined by Bovee (1982). This is based on field measurements of water depth, velocity, substrate composition and cover at calibration flows to enable the suitability of habitat for a particular species to be described. Incremental changes in streamflow are then examined to predict the corresponding effect on availability of suitable microhabitat for a target species over the full range of flows by using the Physical Habitat Simulation Model (PHABSIM). This is a much more sophisticated approach than discharge or habitat methods. Nevertheless it has received criticisms due to the lack of evidence that predictions can be observed in the field and the intense field effort and large number of man hours required to obtain meaningful results (e.g. Orth and Maughan 1982, Mathur *et al* 1985). Consequently, studies have scrutinised the effectiveness of the model (Conder and Annear 1987, Osborne *et al* 1988, Gan and McMahon 1990) and tests are now being carried out on the suitability of PHABSIM for use on British rivers (Bullock *et al* 1991).

E.2.4 Empirical Model Methods.

Another approach has been to develop regression models to predict biological characteristics, such as trout standing crop based on existing habitat features (Binns and Eiserman 1979). Measurement of physical and chemical attributes has enabled the construction of simple empirical relationships that account for a high degree of variability in the size of the fish population likely to occur at a particular site (Scarnecchia and Bergersen, 1987). A problem lies in the choice of which habitat variables to measure and in what combination. Examples used in previous studies are shown in table E.2 below.

Table E.2 - Examples of habitat attributes used in previous studies.

Physical	Hydrological	Water Quality
Elevation	Average daily flow	pH
Catchment area	Average seasonal flow	Hardness
Stream order	Extreme flow variations	Nitrate - nitrogen
% cover	Flow regime stability	Conductivity
% riffles	Average annual baseflow as	Max. temperature
% pools	a % of average daily flow	Alkalinity
Average thalweg depth		Dissolved solids
Dominant substrate		Hydrogen ions
Width - depth ratio		

Nevertheless, published results appear encouraging with biomass and habitat measurements being highly correlated. Predictions of fish abundance using scoring systems for habitat features such as HABSCORE developed by the Environmental Appraisal Unit of the National Rivers Authority Welsh Region can then be used as a yardstick to assess habitat quality (Milner *et al* 1985).

The following sections describe how instream habitat assessment techniques have been used to describe the physical habitat availability within the Glen catchment. The first part outlines the geomorphological characteristics of the West and East Glen and the River Glen to Kates Bridge. The subsequent section outlines the develolpment of a habitat method to a selected reach of the West Glen in order to evaluate physical habitat changes with discharge. A third type of technique *i.e.* an empirical model method, has also been developed and tested within the context of this study and is discussed in detail in Section E.5. This is followed by a description of a biological response method *i.e.* the IFIM, and how PHABSIM has been applied to define the geomorphological requirements at a more detailed scale.

E.3 - Physical Habitat Survey of the West and East Glen

A physical survey of the West and East Glens from their source to the confluence was undertaken between 21/8/89 and 28/9/89. A full set of 1:2500 scale maps of the main river were obtained from the NRA Anglian region. Each A4 size map contained a coded reach approximately 500 m in length. Measurements in the field were taken at every tenth of the reach length or at every riffle site, whichever was the closer. At each point, the location was assigned one or more of the following characteristics:

1) riffle,
2) pool,
3) run,
4) dry,
5) no visible flow and
6) visible flow.

Channel width and water width was also recorded to the nearest 10 cm. A total number of 823 measuring points were recorded along 39.25 km of the West Glen and 762 points along 36.77 km of the East Glen.

E.3.1 Description of results

The complete set of results from the survey are shown in Appendix D. The moving average plots (based on each consecutive ten data points) of channel width against distance downstream for the West and East Glen are shown in figures E.2a and E.2b respectively. Both rivers show an overall increasing trend with the West Glen increasing quicker than the East Glen. The West Glen varies between 0.9 - 10.4 m whereas the East Glen varies between 0.7 - 8.3 m. The arrows indicate the location of major tributaries with the majority, especially for the West Glen, preceding an increase in width. A notable decline in channel width occurs below Greatford sluice reflecting the reduced peak flows downstream of the flood diversion channel.

Wet width is a measure of what proportion of the channel contained water, calculated by dividing the water width by channel width. Consequently, a value of 1.0 represents the entire bed taken up by water and a dry bed has a value of 0. By using each ten consecutive data points, the moving average of the wet width against distance downstream for both rivers is shown in figures E.3a and E.3b. In contrast to figures E.2a and E.2b, these highlight a very different picture for each river. The West Glen was largely dry from the source as far as Boothby Pagnell WTW. The next dry stretch occurred downstream of Burton Coggles potholes as far as Corby Glen WTW. Downstream, the water was lost to the river bed via seepage and remained dry until Creeton Springs. Minor inputs from this tributary maintained water for a short distance but losses meant a short dry section was evident upstream of the Tham confluence. Below the Tham confluence, wet width values remained around 0.7 - 0.8.

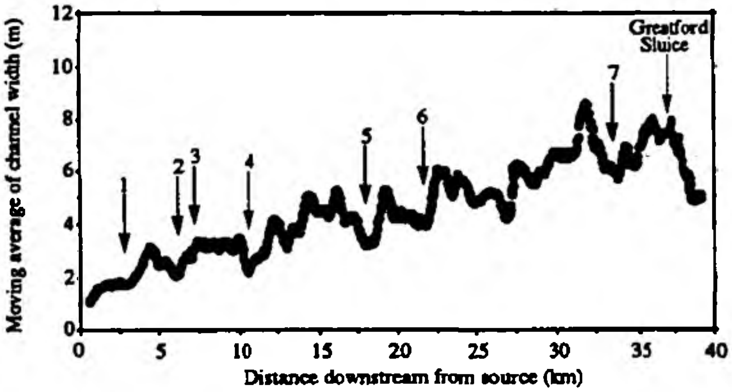


Figure E.2a - Moving average of channel width against distance downstream for the WEST GLEN. Arrows 1-7 represent the location of major tributaries.

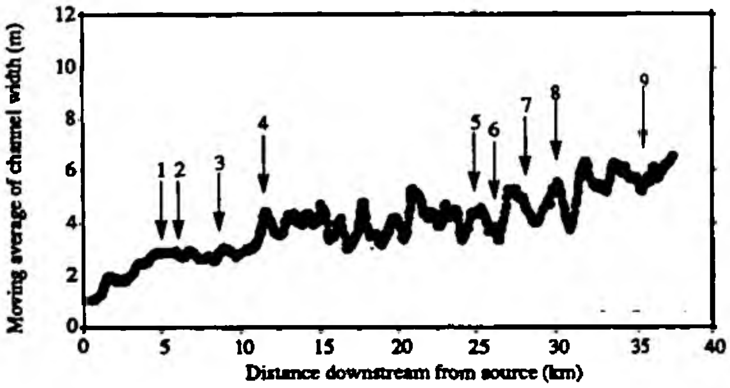


Figure E.2b. - Moving average of channel width against distance downstream for the EAST GLEN. Arrows 1-9 represent the location of major tributaries.

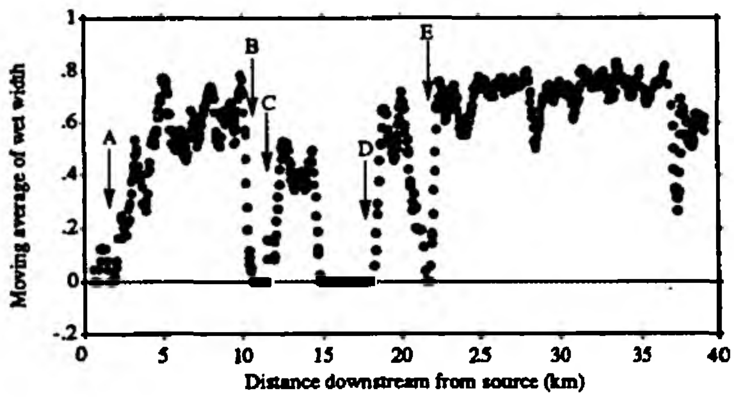


Figure E.3a. - Moving average of wet width against distance downstream for the WEST GLEN

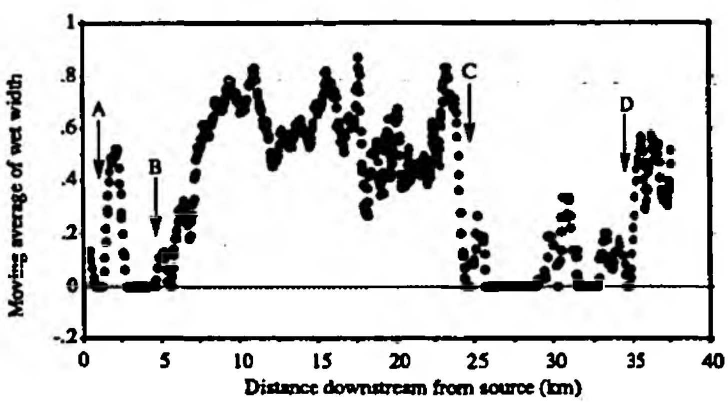


Figure E.3b. - Moving average of wet width against distance downstream for the EAST GLEN

On the East Glen the channel was largely dry to Ropsley WTW. Water was ponded in the channel downstream of here until it was lost via seepage about 1.5 km downstream. Lenton WTW marked the end of the dry section whereafter wet width values increased until below Edenham. The entire flow was lost to the bed through seepage here and the remaining stretch was largely dry to Braceborough where ponded sections were apparent to the West Glen confluence.

Both graphs highlight the importance of the WTW on the main channel during this period in maintaining water levels downstream. A comparison also indicates how the River Tham influences wet width values for the lower section of the West Glen whereas the East Glen has no comparable tributary and consequently its downstream section was largely dry.

Figure E.4 introduces a new vertical scale as a measure of habitat quality. This has been derived by firstly assigning each data point a value of +1, 0 or -1 depending on the habitat type. Those points of good habitat quality, *i.e.* riffles, runs and places of visible flow are assigned a value of +1. Poor habitat quality represented by pools and sites with no visible flow score -1 and dry sites receive a value of 0. These habitat values have subsequently been multiplied by the corresponding wet width value to add a further dimension to the graphs. For instance, points nearer the upper and lower extremes of the diagrams represents sites that have the majority of the channel width occupied by water. So, good quality reaches will have a large number of points in the top half of the diagram and will have values close to 1. Points on the centre of the line represent reaches that are dry. The diagram for the West Glen highlights how the lower reach below the River Tham is dominated by good quality habitat although some points are nearer the centre line indicating that over half the channel bed is exposed. A small number of data points in the lower half may be considered satisfactory here because these represent a degree of habitat variability. On the East Glen it is apparent that after the initial reaches that are dry, the next section is dominated by poorer habitat quality. This is followed by the mainly dry section interspersed by a some isolated pools.

It is important to recognise that both graphs display the nature of the physical habitat for the West and East Glens under low flow conditions at one point in time. The following section outlines the application of a habitat method to the Essendine to Kates Bridge reach to develop a preliminary assessment of the relationship between flow and physical habitat availability.

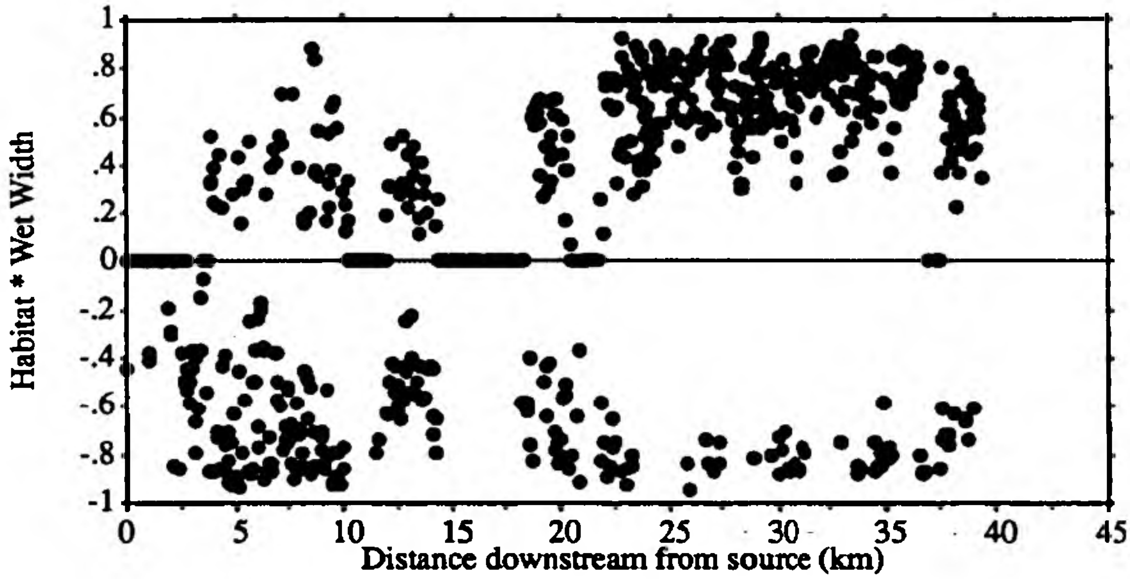


Figure E.4a - Habitat * Wet Width against distance downstream for the WEST GLEN. Points of good habitat quality, i.e. riffles, runs and places of visible flow have positive values. Points with poor habitat quality have negative values and points that are dry = 0.

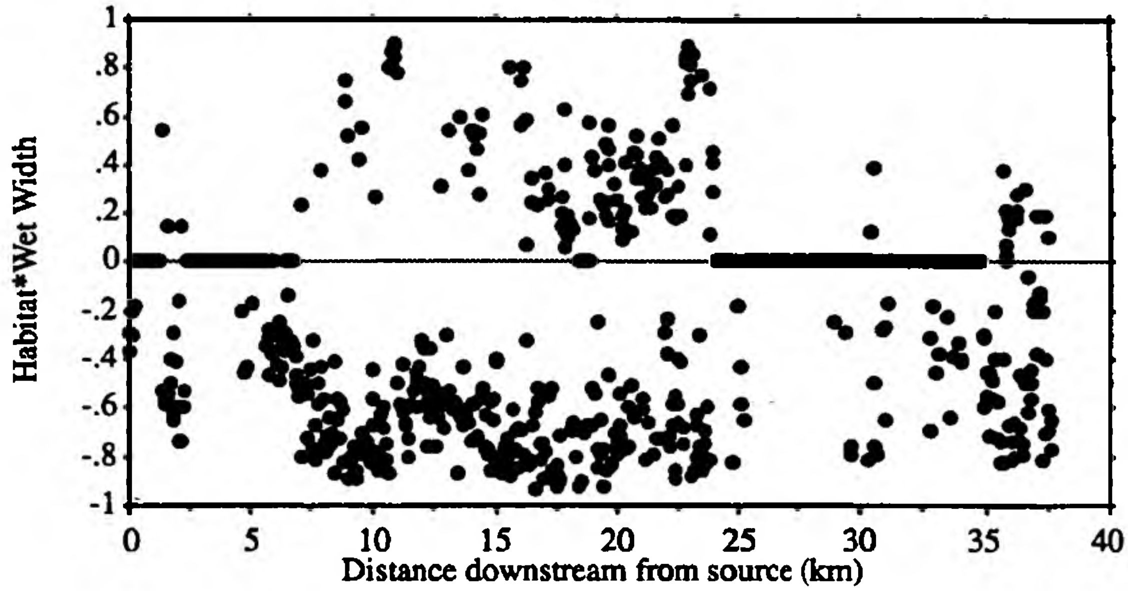


Figure E.4b. - Habitat * Wet Width against distance downstream for the EAST GLEN. Points of good habitat quality, i.e. riffles, runs and places of visible flow have positive values. Points with poor habitat quality have negative values and points that are dry = 0.

E.4 Habitat Method - Evaluating physical habitat changes with discharge

Section E.2.2 has already outlined how habitat methods employ the measurement of actual hydraulic characteristics along a reach at one or more flows. Data from the physical habitat survey discussed above was combined with two further surveys under different discharges to examine the response of the physical habitat along an approximately 10 km long reach of the West Glen. The reach, which stretches from upstream of Essendine (TF050127) to the confluence with the East Glen confluence was primarily selected because it is dissected by the Gwash - Glen transfer input point and so provides valuable information on the impact of the scheme. The reach has also been discussed in detail in Annex C with reference to the hydrological interactions between the surface and groundwater and to the intragravel temperature survey .

The first survey, as outlined above was part of the full survey of the West and East Glen. Average discharge along the reach were 0.04 cumecs during this period. The second survey was completed whilst average discharge was at an elevated level of 0.3 cumecs. Similar to the first survey, measurements were taken at the same places and recorded channel and water width in order that the wet width could be calculated.

The third survey was completed on 14/11/91 whilst the Gwash Glen transfer was in operation. The upstream section was characterised by the natural flows whereas the downstream section had augmented flows. Consequently, it has been possible to compare the 2.18 km reach upstream of the transfer with the 6.66 km reach downstream as far as the East Glen confluence. In addition to the measurements that were taken during the first two surveys, thalweg depth was also recorded to the nearest centimetre. Discharge upstream at Essendine was the lowest of all three surveys at 0.028 cumecs whereas downstream, the transfer augmented flows measured at Shillingthorpe G/S to 0.075 cumecs, a level between the previous two surveys. The effect on the wet width is shown in figure E.5. Clearly in the upstream section, values for the third survey are the lowest of all three but below the transfer point they are raised to an intermediate level.

Using the thalweg depth data, it has also been possible to determine an important influence of the transfer on physical habitat. The table set out below summarises some key parameters which highlight this influence.

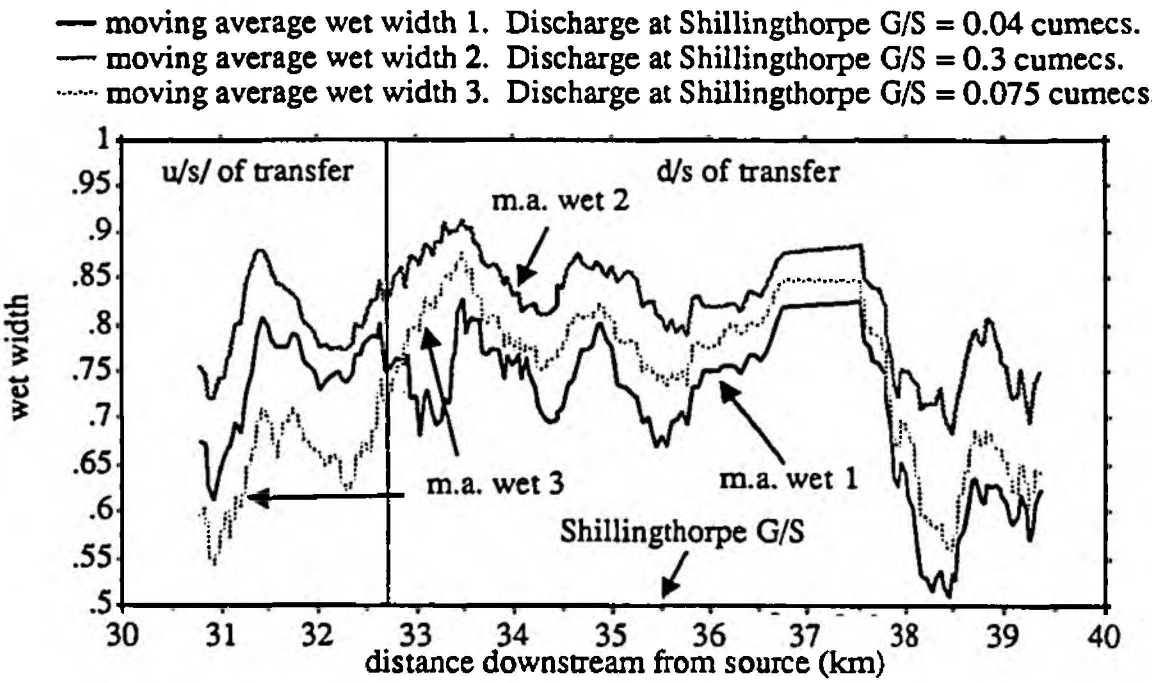


Figure E.5. - Moving average of wet width against distance downstream from source for the three surveys from Essendine to the East Glen confluence on the West Glen

Table E.3 - Some key statistics highlighting the influence of the transfer on physical habitat

Type of cross-sections included	no. measured	ave. water width (m)	ave. wet width (%)	ave. depth (cm)
All cross sections - upstream	46	4.80	65.3	22
All cross sections - downstream	131	4.77	74.6	26
Riffles + runs only - upstream	13	3.72	53.7	10
Riffles + runs only - downstream (all sections)	44	4.28	71.1	20
Riffles + runs only - downstream A	24	4.99	80.4	24
Riffles + runs only - downstream C	19	3.27	58.5	16

By comparing the data for all cross sections it would appear that there is little difference between the upstream and downstream section. Average water width is slightly lower in the downstream section but the channel width is also narrower and hence the average wet width increases from 65.3% upstream to 74.6% downstream. Similarly, a small increase in average thalweg depth is evident. However, when the data for the riffles and runs only are compared, a more striking difference is highlighted. Downstream of the transfer there is a clear increase in average water width from 3.72 m to 4.28 m with the corresponding increase in average wet width from 53.7% to 71.1%. However, the most prominent change is evident by comparing the average depths over riffles and runs. Upstream, average depths are 10 cm which are elevated to 20 cm downstream of the transfer, an increase of 100%. Figure E.6a illustrates the depth at all cross sections along the whole reach. To assess any significant difference between the upstream and downstream sections the student's t test was applied to all the cross sections with the resulting t value = 2.23 indicating a significant difference at the 95%ile level. Figure E.6b clearly shows the difference between the upstream and downstream sections when just examining riffles and runs. In this case, the t value = 6.27 and so the difference is significant at the 99.9%ile level. The downstream section has also been divided into three distinct reaches. Clearly downstream reach A has higher values of average water width, wet width and depth than reach C as shown in table E.3 above. Section B has no riffle/run type habitats due to the ponding effects of Shillingthorpe G/S and the mill sluice in Greatford.

Minimum habitat requirements in other studies have suggested a low flow depth of 10 cm is required to sustain invertebrate communities (O'Keefe and Davies 1991). Flows of 0.028 cumecs during the third survey at Essendine are just sufficient to maintain water levels over such areas at an average of 10 cm. However, during the previous summer, flows had fallen below this level by 25/9/90 and were consistently below this for the following three monthly surveys. An invertebrate sample taken upstream of the transfer in May 1991 gave an unusually low BMWP score of 65. This low score may reflect the impact of the low flows during the previous summer when this 10 cm threshold was crossed over a long period. A similar sample taken in October 1991 resulted in a score of 125. This may indicate the invertebrate community had recovered to some degree as discharge had been above the threshold throughout the year.

The application of a habitat method to a selected reach of the West Glen has highlighted the importance of the instream geomorphology on the physical habitat under three different discharges. It has also described the impact of the transfer scheme on the channel downstream. **However, such techniques do not account for the specific habitat requirements of the instream ecology.** To address this matter, two methods are discussed in the following sections. Firstly, an empirical model method was developed and secondly a biological response method *i.e.* PHABSIM was utilised. The following section describes the rationale and data requirements behind the development of the empirical model method, its application and its use within the Glen catchment.

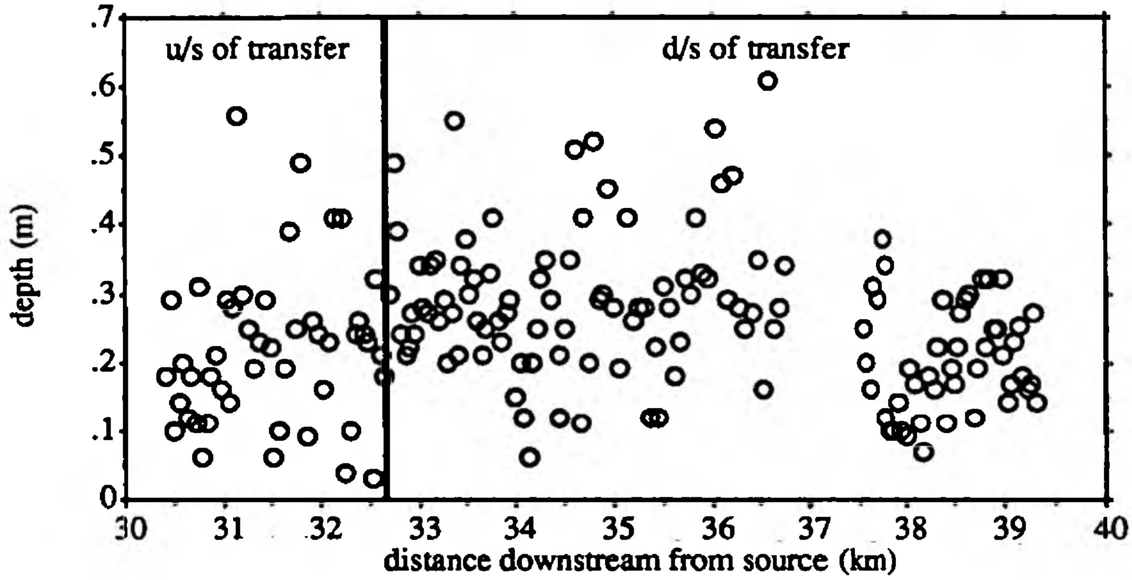


Figure E.6a. - Depth against distance downstream for all cross sections on the West Glen between Essendine and the East Glen confluence.

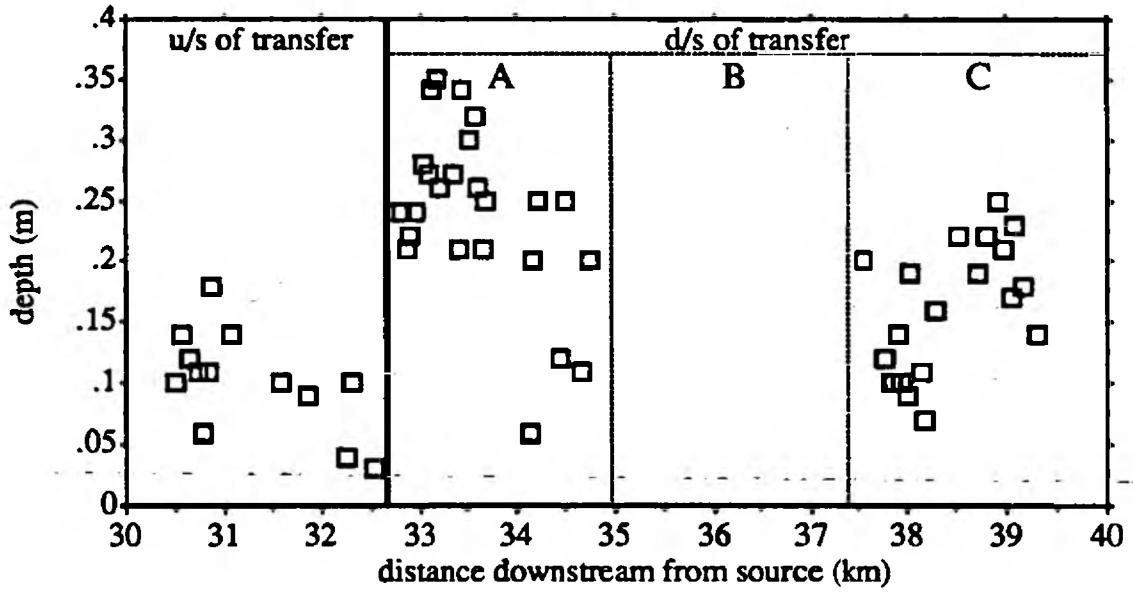


Figure E.6b - Depth against distance downstream for riffles and runs only on the West Glen between Essendine and the East Glen confluence.

E.5 Empirical Model Method - An evaluation of the potential use of BMWP scores to predict habitat quality

Instream habitat evaluation attempts to quantify the steam habitat resource and establish the sensitivity of rivers to changes of flow and variations of physical habitat. To accomplish this, a variety of methodologies have been developed, each of which relies on differing techniques and levels of reconnaissance. However, existing methods which provide quick estimates have received disapproval for ignoring the specific character of the stream whereas more sophisticated approaches have been criticised for the length of time required to obtain meaningful results. A simple but robust method will be needed to achieve a high enough degree of accuracy but remain quick and easy to calculate. Advances over the past fifteen or so years have gone some way to recognising this goal although none have been extensively adopted and applied within the water industry for use as a management tool. Consequently, it has been the aim of this project to examine the relationship between instream habitat quality and the biological characteristics of stream reaches and to develop an approach to facilitate a rapid assessment of how the ecology will be affected by a change in habitat.

Four major components determine the productivity of any habitat, namely 1) flow regime, 2) water quality, 3) physical structure of the channel and 4) energy (e.g. temperature, sediments, organic matter and nutrients) (Stalnaker, 1979). Instream habitat evaluation methods attempt to quantify the interaction and relative importance of these four components. Consequently, the ecological significance of a variation in any of these environmental parameters can be objectively evaluated and the result incorporated into the water resource planning process.

Up to date, methodologies have largely originated in the USA and concentrated on the influence of these parameters on fish populations (Wesche and Rechard 1980) although other instream users e.g. invertebrates (Gore and Judy 1981, Armitage *et al* 1987), birds (Robertson *et al* 1983) and plants (Mountford and Gomes 1990) have gained some recognition.

One approach has been to develop regression models to predict biological characteristics, such as trout standing crop based on existing habitat features (Binns and Eiserman 1979). Measurement of physical and chemical attributes has enabled the construction of simple empirical relationships that account for a high degree of variability in the size of the fish population likely to occur at a particular site (Scarnecchia and Bergersen, 1987). A problem lies in the choice of which habitat variables to measure and in what combination. Nevertheless, published results appear encouraging with biomass and habitat measurements being highly correlated. Predictions of fish abundance using scoring systems for habitat features e.g. HABSCORE can then be used as a yardstick to assess habitat quality (Milner *et al* 1985).

The following section describes the development of a habitat assessment technique which has been constructed along similar lines to those described above. However, invertebrate scores rather than fish abundance have been used to construct the empirical relationships with habitat features.

E.5.1 The BMWP score system

Invertebrate assemblages are routinely monitored across a wide network of sites throughout the U.K. to provide valuable information on water quality variations. Such monitoring exercises are based on the premise that different groups of aquatic animals show different resistance to pollution and each species thrives best under a narrow range of environmental conditions. Macroinvertebrates are used as they are 1) easily caught, 2) inhabit the whole spectrum of aquatic habitats under all conditions of water quality and 3) are relatively immobile when compared to other aquatic species such as fish. Consequently, they are considered to integrate the effects of both long term and intermittent pollution events. Monitoring is carried out to detect changes in communities and results from the lists of taxa are analysed to produce a score, class or index. Although this reduces the amount of information conveyed, it provides a useful tool for non-biologists to make decisions involving the management of running water ecosystems.

The Biological Monitoring Working Party (BMWP) was set up in 1976 to develop an invertebrate scoring system which could be used to assess the biological conditions of rivers in the U.K. The new score system was developed through questionnaires, surveys and discussion. Individual families were assigned a score of 1 - 10 which reflected their tolerance to pollution with low scores for pollution tolerant families and high scores for pollution intolerant ones (see table E.4). Summing the individual scores of all families present in a sample gives the site score. It has been clearly established that such scores are sensitive to organic pollution. However, score variation is also present without any evidence of changes in water quality and the BMWP system has been used as an indicator of biological or habitat quality in a broader sense. It was the aim of this study to establish the environmental parameters, that were determining the score, and to assess its potential for use as an indicator of habitat quality.

Table E.4 - The BMWP score system.

Siphlonuridae Heptageniidae Leptophlebiidae Ephemerellidae Potamanthidae Ephemeridae Taeniopterygidae Leuctridae Capniidae Perlodidae Perlidae Chloroperlidae Aphelocheiridae Phryganeidae Molannidae Beraeidae Odontoceridae Leptoceridae Goeridae Lepidostomatidae Brachycentridae Sericostomatidae	10
Astacidae Lestidae Agriidae Gomphidae Cordulegasteridae Aeshnidae Corduliidae Libellulidae Psychomyiidae Philopotamidae	8
Caenidae Nemouridae Rhyacophilidae Polycentropodidae Limnephilidae	7
Neritidae Viviparidae Ancylidae Hydroptilidae Unionidae Corophiidae Gammaridae Platycnemididae Coenagriidae	6
Mesoveliidae Hydrometridae Gerridae Nepidae Naucoridae Notonectidae Pleidae Corixidae Haliplidae Hygrobiidae Dytiscidae Gyrinidae Hydrophilidae Clambidae Helodidae Dryopidae Elminthidae Chrysomelidae Curculionidae Hydropsychidae Tipulidae Simuliidae Planariidae Dendrocoelidae	5
Baetidae Sialidae Piscicolidae	4
Valvatidae Hydrobiidae Lymnaeidae Physidae Planorbidae Sphaeriidae Glossiphoniidae Hirudidae Erpobdellidae Asellidae	3
Chironomidae	2
Oligochaeta (whole class)	1

E.5.2 Methods and study sites

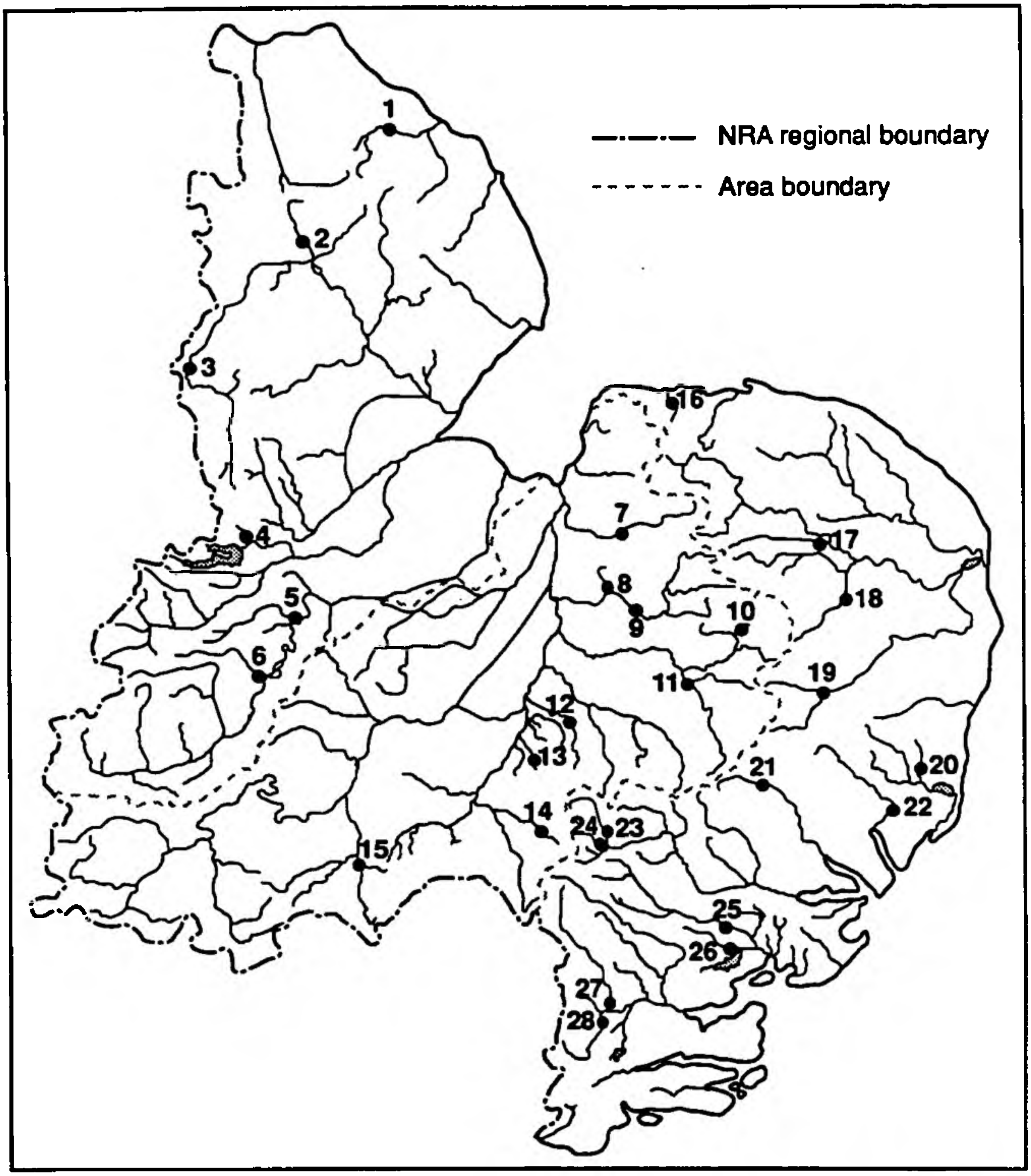
E.5.2.1 Site selection criteria and location

Twenty eight sites throughout the Anglian region were selected in order to record a number of physical attributes (see figure E.7). Initially, site choice was based on two factors. Firstly, each site had to be a NRA Anglian region biological monitoring site and secondly, a gauging station had to be present.

From the locations that met both these criteria, historical records were obtained of the invertebrates present over a maximum record of ten years (see Appendix C). Assemblages were expressed in terms of BMWP scores (Biological Monitoring Working Party, 1978). Furthermore, the locations were selected that represent a wide range of average scores i.e. BMWP scores from 25 to 180 as shown in table E.5.

Table E.5 - The 28 sites sampled and their associated BMWP score.

No.	River	Site Name	Grid ref.	BMWP	Area (km^2)
24.	Stour Brook	Sturmer	TL697440	25	34.5
21.	Gipping	Stowmarket	TM057579	35	128.9
28.	Wid	Writtle	TL686060	50	136.3
12.	Snail	Fordham	TL630703	55	60.6
23.	Stour	Kedington	TL708450	58	76.2
13.	Swaffham Lode	Swaffham Bulbeck	TL553628	66	36.4
16.	Burn	Burnham Overy	TF842427	67	80.0
27.	Chelmer	Springfield	TL713071	68	190.3
19.	Waveney	Billingford	TM168782	74	149.4
2.	Barlings Eau	Langworth Bridge	TF066766	74	210.1
26.	Roman River	Bounstead Bridge	TL985205	77	52.6
20.	Alde	Farnham	TM360601	77	63.9
3.	Witham	Claypole Mill	SK842480	88	297.9
15.	Hiz	Arlesey	TL190379	90	108.0
14.	Granta	A604 Linton bypass	TL570464	91	59.8
22.	Deben	Naunton Hall	TM321532	95	163.1
5.	Willow Brook	Fotheringhay	TL067933	97	89.6
6.	Harpers Brook	Old Mill Bridge	SP983799	98	74.3



Northern Area
1 Waithe Beck
2 Barlings Eau
3 Witham
4 North Brook
5 Willow Brook
6 Harpers Brook

Central Area
7 Nar
8 Stringside
9 Wissey
10 Thet
11 Little Ouse
12 Snail
13 Swaffham Lode
14 Granta
15 Hiz

Eastern Area
16 Burn
17 Tud
18 Tas
19 Waveney
20 Alde
21 Gipping
22 Deben
23 Stour
24 Stour Brook
25 Colne
26 Roman River
27 Chelmer
28 Wid

Figure E.7. - BMWP study site location

Table E.5 contd. - The 28 sites sampled and their associated BMWP score.

18.	Tas	Shotesham	TM226994	100	146.5
1.	Waithe Beck	Brigsley	TA253016	101	108.3
10.	Thet	Shropham Redbridge	TL996923	105	145.3
25.	Colne	Lexden	TL962261	114	238.2
17.	Tud	Costessey Park	TG169112	121	73.2
8.	Stringside	Stoke Ferry - White Bridge	TF716006	127	98.8
4.	North Brook	Empingham	SK957089	128	36.5
11.	Little Ouse	Euston A1088 Road Bridge	TL893802	139	128.7
7.	Nar	Marham	TF723119	169	153.3
9.	Wissey	Northwold	TL771965	180	274.5

The fieldwork was completed between 26th July and 15th August 1990. At each site, measurements were recorded at twenty transects, spaced approximately at every seven times channel width or at every riffle, whichever was closer. At each transect, the geomorphological character was recorded e.g. riffle, run, or pool and whether flow was visible or not. Channel width and water width were also measured. The raw data for each site is shown in Appendix A.

Habitat evaluation has been assessed by some workers (*e.g.* Binns and Eiserman 1979, Milner *et al* 1985, Bowlby and Roff 1986, Wesche *et al* 1987, Scarnecchia and Bergersen 1987) by measuring selected habitat attributes and deriving an empirical equation relating these to fish populations. Concurrent electrofishing in their studies enabled existing fish abundance to be used to calibrate the models. This was not done in this study, but the invertebrate data allowed the construction of a similar, empirically derived equation, based on the measured environmental parameters, to evaluate the instream habitat.

Milner *et al* (1985) has already recognised the difficulty of transforming the habitat measurements into a form that will correlate with the biological expression of the habitat quality. Another problem is that different studies have used many different habitat variables in alternative combinations of which examples are shown in table E.6. Consequently, a number of these have been used in this investigation and new ones developed.

Table E.6 - Examples of habitat attributes used in previous studies.

Physical	Hydrological	Water Quality
Elevation	Average daily flow	pH
Catchment area	Average seasonal flow	Hardness
Stream order	Extreme flow variations	Nitrate - nitrogen
% cover	Flow regime stability	Conductivity
% riffles	Average annual baseflow as	Max. temperature
% pools	a % of average daily flow	Alkalinity
Average thalweg depth		Dissolved solids
Dominant substrate		Hydrogen ions

E.5.2.2 Chemical and Physical Attributes Included

Stream classification based on geomorphic characteristics has become increasingly prominant since the 1940's as fisheries biologists and land managers have recognised their strong link to patterns of species distribution and abundance. Almost all classification schemes based on physical habitat features have been founded on the perception that stream units (*i.e.* segment, reach, channel, riffle/pool) are discrete, and can therefore be delineated (Naiman *et al* 1992). Within this study, measurements can be divided into catchment and reach scale attributes.

Six physical characteristics were measured at the catchment level. Catchment area (km^2) upstream of the gauging station was obtained from the Institute of Hydrology's (IH) Hydrometric Register 1981-1985 (IH 1988). Other catchment attributes were measured from Ordnance Survey (OS) 1:50000 scale maps including distance downstream from source, stream order in terms of the Shreve number (1967) and Strahler number (1952), altitude and gradient.

The chemical parameter used is that of the National Water Council (NWC) classification system. This examines the levels of a number of different chemical constituents along the entire river network and ranks separate reaches into one of five categories. Class 1A represents the best quality declining to 1B, 2, 3 or 4. Table E.7 below summarises some of the criteria used.

NWC classifications were obtained for the 28 sites from each of the 1981, 1983-4, 1984, 1985, 1986, 1987, 1988 and 1989 surveys. By assigning each NWC class a score between 1 and 4, an average was calculated for the whole period.

Width has long been established as a major determinand of the biota of instream habitats (Pennak 1971). When coupled with depth, it provides a simple measure of the quantity of habitat available. Consequently, average channel width and thalweg depth were recorded.

The flow regime that a habitat experiences has been recognised as one of the four main components that determine its productivity (Stalnaker 1979). Binns and Eiserman (1979) used

Table E.7 - NWC river quality classification.

River Class	Quality Criteria	Potential Uses
1A Good Quality	Dissolved oxygen (DO) saturation greater than 80%. Biochemical oxygen demand (BOD) not greater than 3mg/l. Ammonia not greater than 0.4mg/l.	Suitable for potable supply abstractions. High class fisheries. High amenity value.
1B Good Quality	DO > 60% saturation. BOD < 5mg/l. Ammonia < 0.9mg/l.	Less high quality than Class 1A but usable for similar purposes.
2 Fair Quality	DO > 40% saturation. BOD < 9mg/l.	Suitable for potable supply after advanced treatment.
3 Poor Quality	DO > 10% saturation. BOD < 17mg/l.	Usable for low grade industrial purposes.
4 Bad Quality	Anaerobic at times.	Grossly polluted.

late summer streamflow and annual stream flow variation and Wesche *et al* (1987) used average annual baseflow as a percent of average annual daily flow. To introduce a stochastic element, Milner *et al* (1985) suggested that the baseflow index (BFI) be incorporated into future analyses. Consequently this study used this index quoted by the IH in their Hydrometric Register and Statistics 1981-1985 (IH 1988). Basically, the index which is scored as values between 0 and 1, is calculated using gauged mean daily flows from the archived records and represents the degree of variability of river runoff over time. Catchments that derive a large proportion of their runoff from stored sources and have a steady flow regime such as chalk catchments are likely to score 0.9. Alternatively, rivers draining impervious clay catchments may well have a BFI of 0.3.

Tennant (1976) concluded that the aquatic habitats of 196 stream-miles at 58 cross-sections and 38 different flows were significantly reduced when the instantaneous flow fell below 10% of the average flow. Consequently, a critical time for the instream habitat in terms of stress is when low flows are being experienced. However, it is not just the intensity of the flow reduction, but also the nature of the channel at that site that must be accounted for. Therefore, the following measure has been utilised to attempt to combine these two measures. Q^{95}/channel width was used to represent the degree to which the wet width would respond to low flows. Q^{95} represents the flow that is equalled or exceeded for 95% of the time, i.e it is a measure of low flow experienced at any particular site. Q^{95} was chosen as an indicator of low flow rather than for instance Q^{99} for two reasons. Firstly, any lower value may not be accurate due to intrinsic problems of gauging structures accurately recording very small discharges. Secondly it is quoted in the IH Hydrometric Register and Statistics 1981-1985 (IH 1988).

Pennak (1971) suggested that the nature of the substrate is perhaps the single most important factor with respect to biological significance. Some studies (*e.g.* Hynes 1970, Ward 1976) have indicated that heterogenity of substratum particle size is critically important in providing varied microhabitats that can sustain a diverse and abundant fauna. However, others (*e.g.* Williams 1980, Scullion *et al* 1982) have reported the lack of a relationship between invertebrate abundance and substrate composition. Nevertheless, they do recognise that it is of ecological significance, by either providing a uniform habitat of diverse particle size or a range of microhabitats of different particle size groupings. As stated previously, substrate was identified on a presence or absence basis for each of the Wentworth size classification (Wentworth, 1922) categories. This was then converted into an index by dividing the percentage of the 20 transects that had gravel present by those that had silt or detritus present. Therefore, a high value would represent a reach with a majority of transects containing gravel, and few with silt or detritus. Alternatively, a very low score would be attained by the opposite scenario. A value of zero indicates no gravel present at any cross-sections.

Cover has also been shown to have important effect on the instream habitat and was recognised in this study under two headings i.e. instream and overhanging. Invertebrate biomass is usually three to ten times greater in a stream with a thick growth of submerged rooted aquatics than in a similar one without due to the additional spatial and food niches (Pennak 1971). Therefore, instream cover was visually estimated in terms of the total percentage of the wetted cross-sectional area across the transect that is taken up by objects protruding up into it. These could take the form of vegetation and/or cobbles or boulders. Streamside vegetation can provide important habitat for the breeding and oviposition phases of the terrestrial life stage of aquatic invertebrates. It can also provide important shading to reduce maximum water temperature and be an important source of allocthonous material. Overhanging cover was therefore estimated by assessing the percentage of the total wet width that was shaded from above the water surface.

The physical nature of the water present was also summarised in an index that was based on the measurement of two physical parameters. The percent of the channel bed that was taken up by water was calculated as well as the percent of cross sections with visible flow. These were then combined into one by adding the two values and dividing by two to give a percentage value. This was subsequently divided by one hundred to give an index of between 0 and 1.

E.5.2.3 Rating System

In the past, some authors have recognised the non-linearity that exists between some of the attributes measured and their influence on instream habitat quality. Consequently, rating systems have been introduced. Binns and Eiserman (1979) used a simple rating system scoring each measured attribute on a scale from 0-4 which resulted in significant correlations with trout standing crop. A similar method was therefore tried on this data for the six attributes that were the most significantly correlated with the BMWP score in their raw form. Each parameter was scored on a five point scale from 0 (worst) to 4 (best). For instance, a site that had 50% of the 20 transects with gravel present and 50% of them with silt or detritus present, then this would be rated 3. A site with the same amount of transects with gravel but all having silt or detritus present would achieve a rating of 2. Rating characteristics are shown in table E.8 below.

Table E.8 - Rating characteristics of the six chosen parameters.

Attribute	Score				
	0 (worst)	1	2	3	4 (best)
Average NWC score	1	1.01 - 2.75	2.76 - 3.13	3.14 - 3.99	4
Baseflow index	0	0.01 - 0.41	0.42 - 0.49	0.50 - 0.89	0.90 - 1.00
Q^{95}/channel width	0	0.001 - 0.010	0.011 - 0.046	0.047 - 0.054	>0.055
% gravel/% silt or det	0	0.01 - 0.100	0.101 - 0.588	0.589 - 1.059	>1.059
% instream cover	0	1 - 6	7 - 26	27 - 43	44 - 100
Wet width - % flow	0	0.01 - 0.69	0.70 - 0.75	0.76 - 0.91	0.92 - 1.00

E.5.3 Results

Relationships between the chosen parameters and BMWP scores were investigated using simple and stepwise regression techniques. The subsequent analysis is based on two groups; those that use actual measured data and those that use the rating table. Table E.9 indicates the correlation coefficients between BMWP score and the various habitat attributes using simple regression. As stated above, the six most significantly correlated attributes were rated and the correlation coefficients for the rated values are also shown in table E.9. Q95 was not rated separately as it is already incorporated with the channel width index. The rated values showed increased correlations for two out of the five parameters.

Simple regression between the actual values for each attribute and BMWP score indicate a wide variety of results. Regression values range from 0.001 for average overhanging cover to 0.441 for average NWC score. Noticeably, all parameters that were measured from the 1:50000 OS maps rather than in the field, i.e. catchment area, distance downstream, gradient, Strahler number and Shreve index were not correlated and gave r^2 values of less than 0.1. This demonstrates the importance of the reach rather than the cathcment characteristics.

Table E.9 - Correlation coefficients between measured habitat attributes and BMWP scores in order of significance.

Attribute	actual r^2
Average overhanging cover	.001
Distance downstream	.001
Catchment area (km^2)	.003
Average channel width	.015
Altitude	.023
Average thalweg depth	.025
Gradient	.030
% channel bed wet	.043
Strahler number	.050
% riffle transects	.055
Shreve number	.073
% transects with visible flow	.189
Baseflow index	.214
% gravel/% silt or detritus	.244
% wet width - % flow index	.245
Q95	.270
Q^{95}/channel width	.336
% instream cover	.348
Average NWC chemical score	.441

To construct model 1, stepwise regression was then used on the same parameters to extract the most influential one and weight them according to their importance to form an equation to predict BMWP score. Based on the actual measured values this extracted the NWC chemical score, Q^{95}/channel width % instream cover and the wet width - flow index into the following equation:

$$\begin{aligned} BMWP = & -39.387 \\ & + (\text{chemical score} \times 19.79) \\ & + (Q^{95}/\text{channel width} \times 466.703) \\ & + (\%\ \text{instream cover} \times 0.847) \\ & + (\text{wet width - flow index} \times 52.657). \end{aligned}$$

Using this equation, predictions for all 28 sites gives an $r^2 = 0.880$.

For model 2, the scores obtained from the rating table were added for each site. The total for each site was correlated with BMWP score and is described by the equation:

$$\text{BMWP score} = (10.029 \times \text{total of rating scores}) - 48.292.$$

This improved predictability as the r^2 value increases to 0.913. Predicted BMWP scores against actual average scores are shown for the two methods in figures E.8 and E.9. The two models were also analysed to test their sensitivity to variations of certain attributes included in their calculation. For instance, the predicted effect on changes in Q^{95} are explored which may result from flow augmentation or abstraction. Channel width variations are also examined as are water quality and instream cover changes. Prediction of the effect of an alteration in four of these is also determined. Results are shown for three sample sites in table E.10 below. The sites were selected to represent a range of initial BMWP scores.

The difference in the construction of each model has a clear influence on its predictive ability. Model 1 uses actual values and so an alteration automatically leads to a change in the predicted score. Alternatively, because model 2 uses ratings, unless the change is great enough to cause the site to move from one class to another for that attribute score the prediction remains the same. This is shown in figure E.10. Q^{95} variations are indicated across a range of possibilities with the associated BMWP predictions for the river Wissey. The smooth curve produced by model 1 can be contrasted with the stepped effect of model 2 as the Q^{95} value crosses the threshold from one score to another. The high predicted score even with very low Q^{95} values is noteworthy.

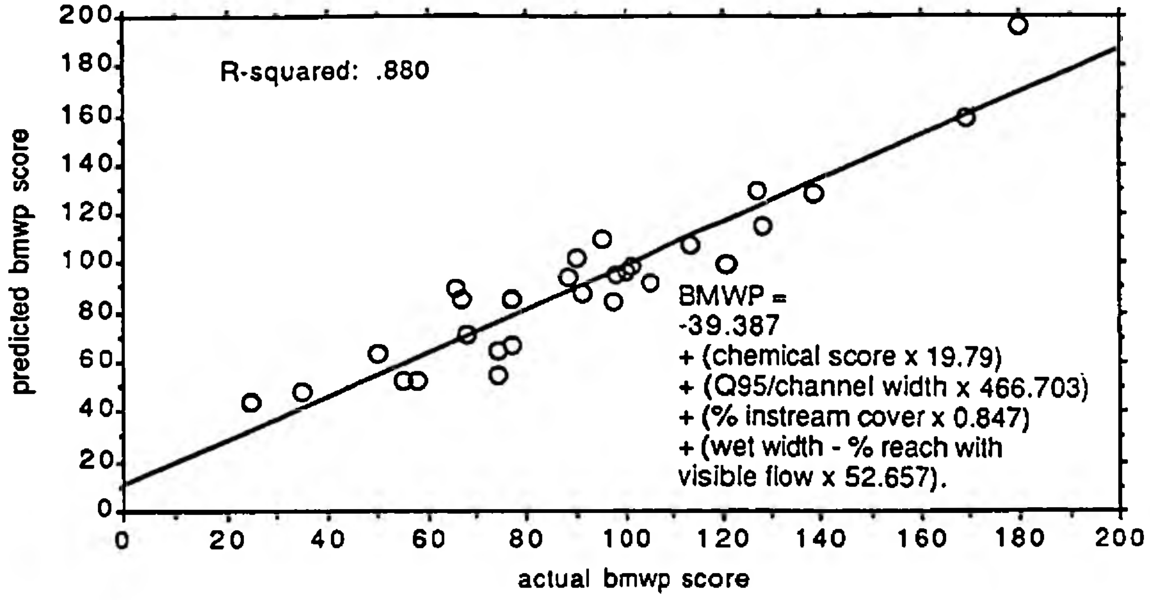


Figure E.8. - Predicted BMWP scores against actual values using model 1.

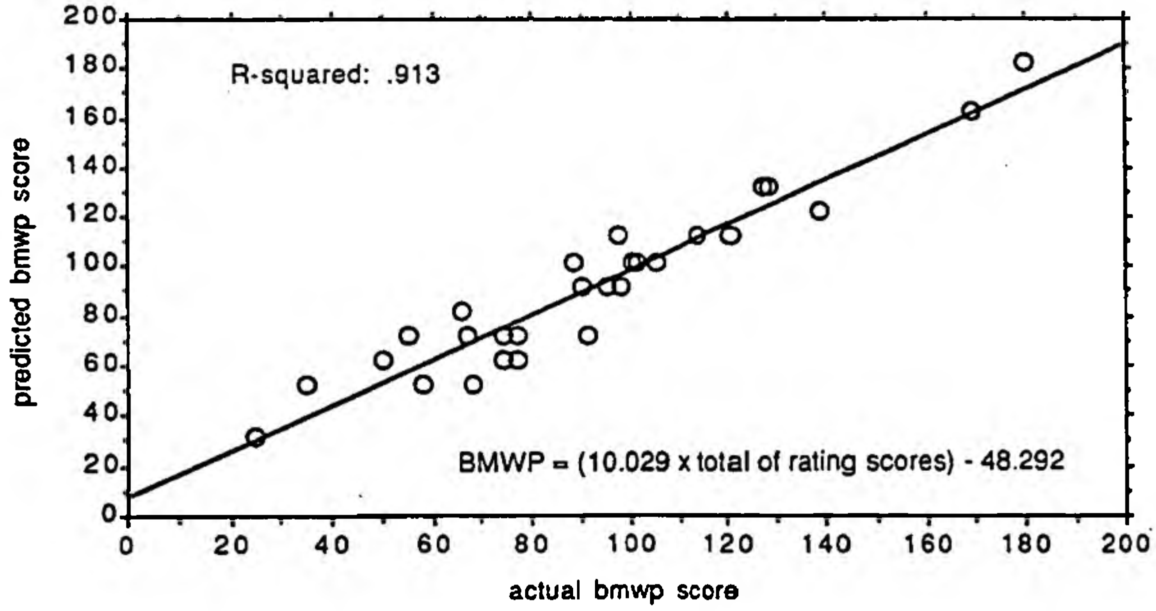


Figure E.9. - Predicted BMWP scores against actual values using model 2.

Table E.10 -Variations in predicted BMWP scores for the two models with changes in environmental variables at three sites.

	Nar		Tas		Stour	
Variable	model 1	model 2	model 1	model 2	model 1	model 2
Actual	169	169	100	100	53	53
Predicted	159	162	96	102	53	52
+1 NWC class	179	162	116	122	73	62
-1 NWC class	139	152	76	92	33	42
1.5 x Q^{95}	192	162	104	112	55	52
0.75 x Q^{95}	143	162	93	102	53	52
1.5 x channel width	137	162	91	102	53	52
0.75 x channel width	181	162	102	102	54	52
2 x Q^{95}/channel width	226	162	112	112	56	52
0.5 x Q^{95}/channel width	126	162	89	102	52	52
2 x instream cover	164	172	111	112	56	62
0.5 x instream cover	157	162	90	102	51	52
-1 NWC class + 0.75 x Q^{95} + 1.5 x channel width + 0.5 x instream cover	103	152	66	92	30	42

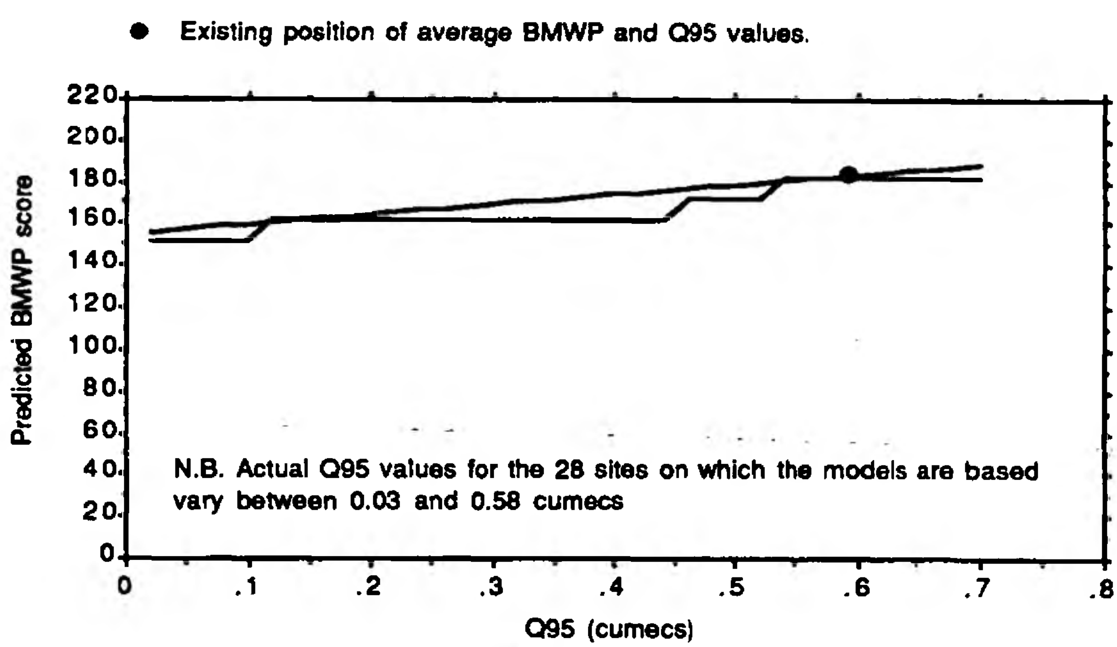


Figure E.10. - Variation of predicted BMWP with Q95 for the two models for the river Wissey.

E.5.4 Discussion

The two instream habitat models described here are foundered on the initial research undertaken for an EA (Petts *et al* 1990) and those developed by others (*e.g.* Binns and Eiserman 1979, Milner *et al* 1985, Scarnecchia and Bergersen 1987, Wesche *et al* 1987). Both use data collected in the field and from other published sources. Field data for the first relies on measurements in terms of channel bed width, % instream cover, measurements of wet width and the % of cross-sections with visible flow at twenty transects whereas the second also requires substrate estimates. Published data sources include the NWC chemical classification and the IH Baseflow index. NRA Anglian region supplied archived flow data and invertebrate scores. The model using the raw data requires just four variables to attain a high degree of correlation with the BMWP score ($r^2 = 0.880$). Rating values for the six variables used in the second model increases predictive ability to $r^2 = 0.913$. Consequently, neither require detailed or intense field efforts or subsequent visits. When correlating fish biomass and production with environmental variables, other studies have found the single most important parameter varies in type and for the degree to which it correlates e.g.annual streamflow variation $r = 0.80$ (Binns and Eiserman 1979), average annual baseflow as a percent of average annual daily flow $r^2 = 0.36$ (Wesche *et al* 1987), elevation $r^2 = 0.42$ (Scarnecchia and Bergersen 1987) and hardness $r^2 = 0.699$ (Milner *et al* 1985). Although this study has not used fish but invertebrate assemblages, the single most important parameter has a similar correlation i.e. average NWC classification score = 0.441 in model 1 and 0.418 in model 2. Furthermore, previously published models have accounted for between 52% and 97% of the variance in fish biomass and the two models have predictive abilities at the upper part of this range for the invertebrate score.

There are relatively small variations in altitude and gradient over the whole region and so as expected, these parameters have little impact on the invertebrate score. Furthermore, the insignificance of the other attributes measured from the 1:50000 OS maps reflects the importance of the local variations in physical habitat at the reach scale such as instream cover and flow related to channel width rather than those measured at the catchment scale.

The models developed within this report have attempted to utilise easily obtainable data in order to assess the instream habitat. To further improve any model that uses empirical equations based on measured physical and chemical attributes to predict invertebrate score requires a phase of testing. Milner *et al* (1985) has established that the calibration procedure is sometimes confused with independent testing. It is stressed that the compilation of new data sets is essential so further application and testing can proceed. This has been achieved by examining a number of sites within the Glen catchment, the results of which are described below.

E.5.5 Model Test Within the Glen Catchment

In order to test the models on independent data, six sites within the Glen catchment were visited on the 22nd and 23rd of August 1991. Three sites were selected on the West Glen, two on the East Glen and one on the River Glen downstream of the East and West Glen confluence. Physical habitat attributes were recorded in accordance with the first survey (see Appendix B). Flow and water quality data were obtained from Anglian NRA and a summary of site results are shown in table E.11. In each case, the actual values are shown in each column followed by the rating value in brackets. For instance, Burton Coggles has an average NWC score over 10 years of 1.88 which according to the rating table scores a value of 1. The baseflow index for Little Bytham was not available. By examining the last column, it is clear that all but two sites (*i.e.* Shillingthorpe and Kates Bridge) had unusually low wet width-% flow values. This can be attributed to the fact that the survey was completed under exceptionally low flow conditions. Consequently, the river was entirely dry over a large proportion of the reaches at Burton Coggles and Braceborough, and flows were close to zero at Edenham. The relatively high values at Shillingthorpe and Kates Bridge are due to the maintenance of flows from the Gwash-Glen transfer.

From these habitat parameters, predictions were made using both empirical equations and the results shown in table E.12. In each case, results have been compared with the BMWP score of the routine invertebrate sample taken by Anglian NRA closest to the survey date. For instance at Braceborough, the actual BMWP score on 3/10/91 was 49. Model 1 using the actual data predicted a score of 53 whereas model 2 using the rated values predicted a score of 52. Predictions for Little Bytham using model 2 require a baseflow index. As none was available, an estimated value of 0.92 was used due to the stable nature of the flow at this site. Long term flow records for Shillingthorpe and Kates Bridge to calculate Q95 do not take into account the interbasin transfer that was operational throughout the summer. Consequently, a value of 0.1 cumec was used for these simulations derived from the flow records of summer 1991. The fourth column represents the long term average BMWP score for these sites. However, as discussed above, the surveys were undertaken during extreme low flow conditions with low wet width-% flow index values. Under long term average conditions these would be expected to be much higher and so the predictions that the long term averages have been compared with have utilised wet width-% flow index values of 0.92.

Table E.11 - Selected habitat parameters for sites within the Glen catchment.

Site Name	Average NWC Score	Baseflow Index	Q95/ Channel Width	% Gravel/ % Silt or Detritus	% Instream Cover	Wet Width -% Flow Index
Burton Coggles	1.88 (1)	0.403 (1)	0.0003 (1)	0.600 (3)	15 (2)	0.129 (1)
Little Bytham	3.25 (3)	n/a	0.0050 (1)	0.666 (3)	35 (3)	0.588 (1)
Shillingthorpe	3.75 (3)	0.832 (3)	0.0040 (1)	2.000 (4)	29 (3)	0.941 (4)
Edenham	2.86 (2)	0.330 (1)	0.0007 (1)	0.579 (2)	22 (2)	0.419 (1)
Braceborough	3.00 (2)	0.352 (1)	0 (0)	0.750 (3)	28 (3)	0.167 (1)
Kates Bridge	3.88 (3)	0.600 (3)	0.0033 (1)	0.778 (3)	60 (4)	0.920 (4)

Table E.12 - Comparison of recorded BMWP scores against predicted values.

				With Wet Width - Flow at 0.92		
Site Name	Actual Score	Model 1 Prediction	Model 2 Prediction	Average Score	Model 1 Prediction	Model 2 Prediction
Burton Coggles	0	18	42	73	58	72
Little Bytham	95	88	102 *	119	106	132 *
Shillingthorpe	142	118 **	142 **	141	112	132
Edenham	80	58	42	77	85	72
Braceborough	49	53	52	93	93	82
Kates Bridge	162	143 **	142 **	135	137	132

* No baseflow index is available for Little Bytham therefore an assumed value of 0.92 has been used to calculate model 2 predictions.

** Predictions made using an increased Q95 value of 0.1 cumec due to the interbasin transfer.

To determine if the model predictions were significant, regressions were carried out against the associated BMWP scores at each site. The results are shown in figures E.11 to E.14. In each case, adjusted r^2 values are quoted as these take into account the number of data points being compared. Model 1 predictions compared with the actual values gives an adjusted $r^2 = 0.959$ ($p=0.0004$ therefore significant at the 99.9%ile) whereas model 2 predictions gives an adjusted r^2 value of 0.753 ($p=0.0158$, significant at 98%ile). Comparing the model 1 predictions with

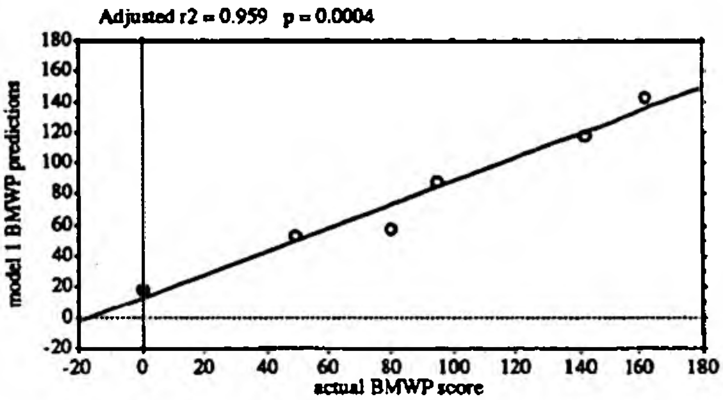


Figure E.11. - Comparison between actual BMWP scores against model 1 predictions.

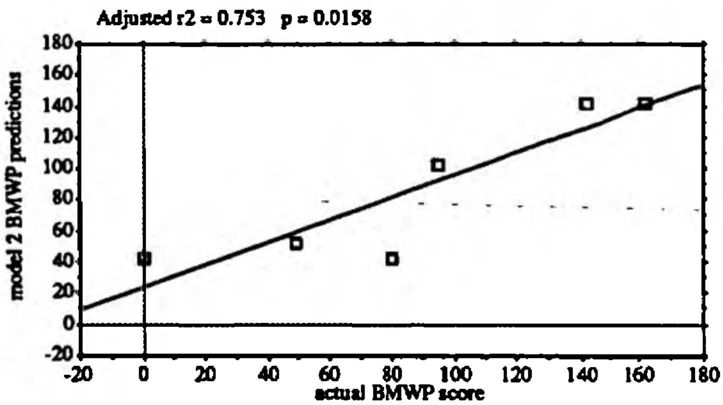


Figure E.12. - Comparison between actual BMWP scores against model 2 predictions.

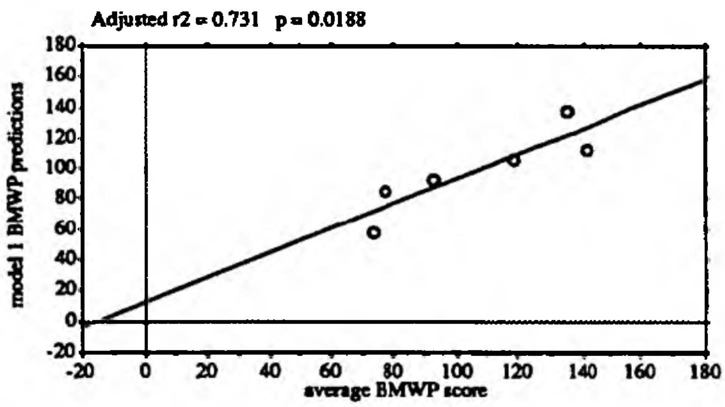


Figure E.13. - Comparison between average BMWP scores against model 1 predictions.

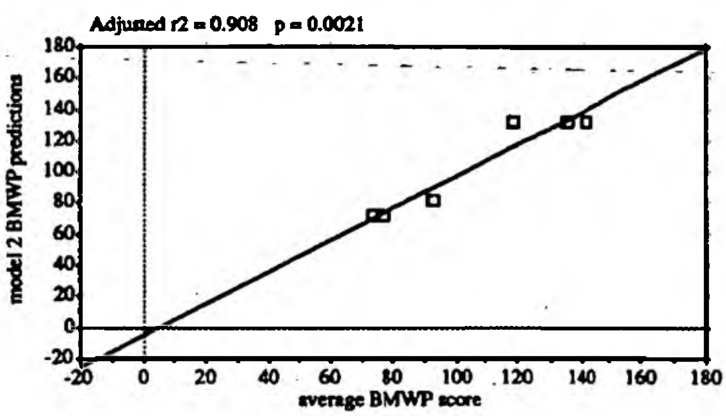


Figure E.14. - Comparison between average BMWP scores against model 2 predictions.

the long term average values results in an adjusted r^2 value of 0.731 ($p=0.0188$, significant at 98%ile) and model 2 gives an adjusted r^2 of 0.908 ($p=0.0021$, significant at 99%ile).

Clearly the models still perform well on this independent data set which lies within the same region as where the models were developed. Other workers (*e.g.* Bowlby and Roff 1986, Scarnecchia and Bergersen 1987) have discovered that similar models do not perform so well when applied to geographical areas different than those in which they were originally established. Only further evaluation outside the Anglian region would enable the models to be tested on streams that are geomorphologically different.

E.5.6 Summary

Results suggest that the models have potential application in two main areas. Firstly, they attempt to define which environmental parameters are important in influencing invertebrate assemblages expressed as BMWP scores. This has led to a method that seeks to assess the *in situ* habitat for its present ecological value. At this stage, success in producing empirical equations that account for a high degree of the variability in invertebrate scores within various streams indicates the inherent importance of the habitat features that were measured. Both models suggest that water chemistry primarily determines the overall quality of the river as described by the BMWP score but other environmental parameters are important. Secondly, possible manipulations of physical and chemical variables can be evaluated in terms of their impact on the aquatic environment. For instance, even with no alteration of water quality, the increase of low flows, indexed here by Q95 and the BFI, would improve BMWP. Reducing low-flow channel width, to increase Q95/channel width and increase the wet width-% flow index would have a positive effect and BMWP could also be improved by increasing instream cover. Consequently, by using the empirical relationships,the effect of abstracting or augmenting water could be determined or the enhancement of instream cover be assessed. River managers would then have the potential to examine the full range of management scenarios that are open to them and make an objective and quantifiable assessment of the likely impact of each.

E.6 Biological Response Method - Evaluating physical habitat and biota relationships

E.6.1 Introduction

The demand for habitat assessment methods that is now materialising in the U.K. has been evident in the U.S.A., particularly the western United States since the mid 1970's (see Section E.1). A similar situation of increasing demands for irrigation, domestic, and industrial water supply led to the development of a variety of methods to assess fish habitat tradeoffs against other uses of water. The Instream Flow Incremental Methodology (IFIM) developed by the U.S. Fish and Wildlife Service Cooperative Instream Service Group (IFG) has been considered by some to be "the most scientifically and legally defensible method available for most instream flow problems" (U.S. Department of the Interior 1979). It is also one of the most widely used methods in North America for estimating the effect of changes in flow on trout habitat (Conder and Annear 1987) and is described as "the current state of the art" (Orth 1987).

The Physical Habitat Simulation (PHABSIM) System is a set of computer models that are the cornerstone of the IFIM. Essentially, PHABSIM is used to relate changes in discharge or channel structure to changes in physical habitat availability for a chosen species. The underlying principles of PHABSIM are that:

1) the chosen species exhibits preferences within a range of habitat conditions that it can tolerate,
2) these ranges can be defined for each species, and
3) the area of stream providing these conditions can be quantified as a function of discharge and channel structure (Bovee 1982).

PHABSIM considers microhabitat as defined under this methodology to consist of two basic components *i.e.* rigid structural characteristics and variable hydraulic conditions.

Structural habitat characteristics reflect the hydrogeomorphology of the channel *e.g.* bed configuration, channel width or substrate composition and are assumed to be constant over a range of flows. The hydraulic variables which affect microhabitat utility are width, depth, and velocity. All three respond differently to changing discharge in conjunction with the structural nature of the channel and so the physical microhabitat is a complex array of combinations of these parameters. This array is redefined with a different set of depth, velocity, and structure combinations each time the discharge changes.

A natural stream contains a complex mosaic of physical features. One given species may find an area of deep, slow flowing water desirable whilst another may prefer an area of deep, fast flowing water. Alternatively, a third species may find neither conditions suitable. In order to quantify physical habitat, the area associated with each combination of features and an evaluation of that combination in terms of its suitability as a habitat for a particular species must be defined. When flow changes, the hydraulic variables will alter and so under the new flow, physical habitat has to be requantified.

PHABSIM consists of four basic components representing the process of;

1) data collection,
2) hydraulic simulation,
3) suitability index curve development, and
4) habitat simulation.

The following sections outline the requirements of each of these components in turn.

E.6.1.1 Data collection

Provided that the reach is suitable for hydraulic simulation (*i.e.* macrohabitat conditions such as temperature variations and water quality will be suitable) hydraulic conditions are characterised at usually three known (calibration) streamflows from measurements taken along transects within the reach. Reaches can either be representative, *i.e.* they are similar to any other reach within an area and contain most of the hydraulic variance found in the entire section, or they can be critical, *i.e.* they are particularly sensitive to changes in streamflow or contain rare habitat for a particular species or life stage. Data collection is based on field measurements at a number of transects along a chosen reach under three different flows, *i.e.* low flow, medium flow and high flow conditions. Transects are located at right angles to the flow so as to sample;

1) all the hydraulic controls, *i.e.* physical aspects of the streambed that determine the height of the water surface upstream, and
2) all habitat types that are represented along the reach.

Point measurements of flow velocity, depth, water surface level, substrate and cover need to be undertaken at exactly the same points at intervals across each transect during each visit and hence the reach has to be surveyed in detail prior to this. Essentially, these field measurements determine the amounts of different habitat conditions in the channel at particular discharges. In order to describe how these conditions change under discharges that have not been measured in the field, PHABSIM is used for hydraulic simulation purposes.

E.6.1.2 Hydraulic simulation

Hydraulic simulation models are then used to estimate depths, velocities and substrates at unmeasured flows (Bovee & Milhous 1978). The techniques used to simulate the hydraulic condition in a stream can have a significant impact on the habitat versus streamflow relationship determined in the habitat simulation portion of PHABSIM. The approaches available for calculation of water surface elevation at unknown discharges fall into one of three categories;

1) the stage-discharge relationship (the IFG4 program),
2) the use of Manning's equation (the MANSQ program), and
3) the standard step backwater method (the WSP program).

The following sections briefly outline each of the underlying concepts behind each application. A complete and detailed description of the theories underpinning each program has been discussed by Bovee and Milhous (1978).

IFG4

The most accurate method of obtaining a relationship between stage and discharge is to measure the discharge at various stages and to develop an empirical equation relating discharge to stage. This relationship is influenced by a number of factors, *e.g.* cross-sectional area, shape, slope and roughness and it is the interaction of these factors which control the relationship. Essentially, the IFG4 program uses an empirical equation between stage (*i.e.* water surface elevation) and discharge of the following form:

$$WSL = a\,Q^{b} \qquad \text{(Equation E.1)}$$

where:
WSL = stage or water surface elevation
Q = discharge
a, b = regression coefficients from measures values of discharge and stage.

Using a log transformation for this equation, results in a linear function of the form:

$$\text{Log (WSL - SZF)} = \text{Log (a)} + b * \text{Log (Q)} \qquad \text{(Equation E.2)}$$

where the water surface elevation has been adjusted by the stage of zero flow (SZF). Given two or more measurements of the stage - discharge relationship at a cross section, the above equation is then solved for the coefficients a and b which then serves as the basis upon which predicted stage is computed for any specified discharge. This is highlighted in figure E.15 below.

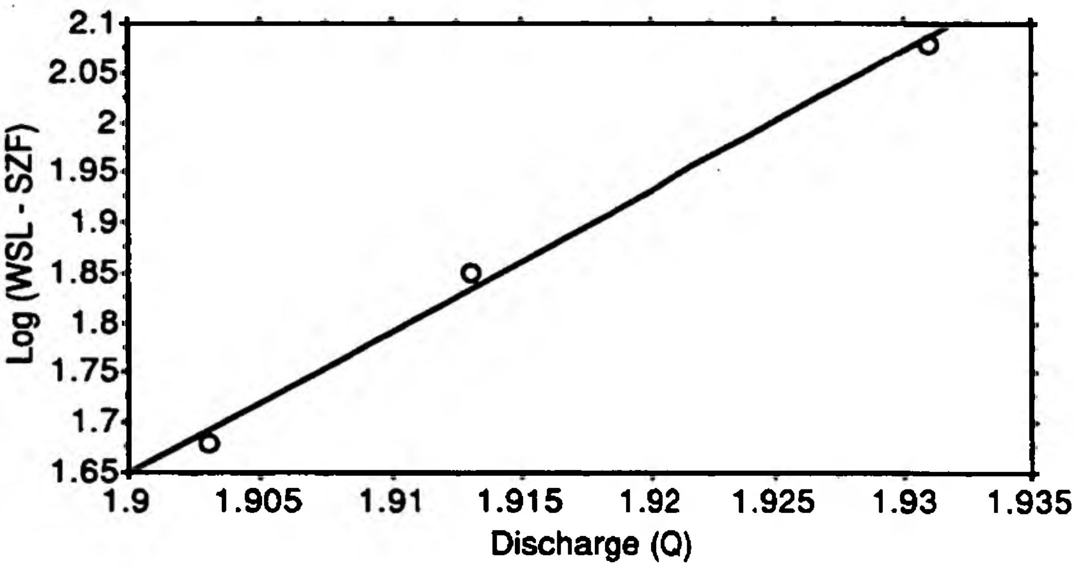


Figure E.15 - Example of a stage discharge relationship generated by IFG4

It is also important to note that the IFG4 treats each cross section independently of all others in the data set.

After satisfactory development of this relationship, velocities are predicted by solving Mannings equation. Velocity data is used from one of the measured flows to derive Mannings n from the following equation.

$$n_i = [\ 1.49 * S_e^{1/2} * d_i^{2/3}\ ] / v_i \qquad \text{(Equation E.3)}$$

where:
n_i = Estimated Mannings n value at vertical i
S_e = Energy slope for transect
d_i = Depth at vertical i
v_i = Velocity at vertical i

The apparent discharge for the transect is then determined from the predicted velocity values. This discharge may not necessarily be the same as the discharge requested in the simulation and so a Velocity Adjustment Factor (VAF) is obtained through the use of a mass balance to rectify this.

MANSQ

Similar to the IFG4 program, MANSQ treats each transect independently but will only simulate water surface elevations and not velocities. The Mannings equation can be written in the form:

$$Q = [\ (1.49 / n) * S^{1/2}\ ] * A * R^{2/3} \qquad \text{(Equation E.4)}$$

where:
Q = Discharge
n = Mannings n
S = Slope
A = Area of cross-section
R = Hydraulic radius

which can be simplified to :

$$Q = K\ A\ R^{2/3} \qquad \text{(Equation E.5)}$$

and the value of K is determined from one set of discharge-water surface elevation pairs. The MANSQ program calculates the average velocity in the channel and is not used to simulate individual cell velocities. Mannings equation is solved for n at one discharge for which the measurements of the water surface elevation and the discharge at the measured flow, the hydraulic slope and the dimensions of the cross section have been made. Mannings n is solved in accordance with the equations above and assumed constant in subsequent calculations where new stages are calculated for different discharges.

WSP

The Water Surface Profile (WSP) program differs from the previous two programs in that it treats cross-sections as dependent on the adjacent one downstream. The calculation of water surface elevations start from a known water surface elevation at the most downstream transect and uses the 'standard step backwater' method to calculate the water surface elevation at the next upstream cross section. This next cross section then becomes the downstream cross section and the water surface elevation for the next upstream is determined. The program provides very detailed depth and transverse velocity information. In this case, the model allows the computation of the change in roughness as a function of discharge by using roughness multipliers.

In many situations it may be necessary to use a mixture of models to simulate the hydraulic characteristics of the reach over the full range of flows. For instance, under low flows the IFG4 program may simulate water surface elevations and velocities most accurately whereas WSP may be more suitable over the higher flows. The correct choice of hydraulic model(s) as well as the proper calibration can be time consuming but may represent the most difficult step in the process of analysing streamflows.

E.6.1.3 Suitability index curve development

The third step utilises the information developed in suitability index curves. Different species of fish,macroinvertebrates and aquatic macrophytes occupy different habitat types in streams. Knowledge about the conditions that provide favourable habitat for a species, and those that do not, is defined as habitat suitability criteria: characteristic behavioural traits of a species which cause it to select specific habitat types in terms of preferred water velocities, depths and substrates. For example, the habitat suitability curves for adult brown trout are shown below. A separate graph is constructed for the depths, velocities and substrate types. These are based on the fact that a functional relationship exists between a response variable (*e.g.* depth, velocity or substrate) and the degree to which the variable is "usable" over a scale of 0.0 (no use) to 1.0 (maximum use).

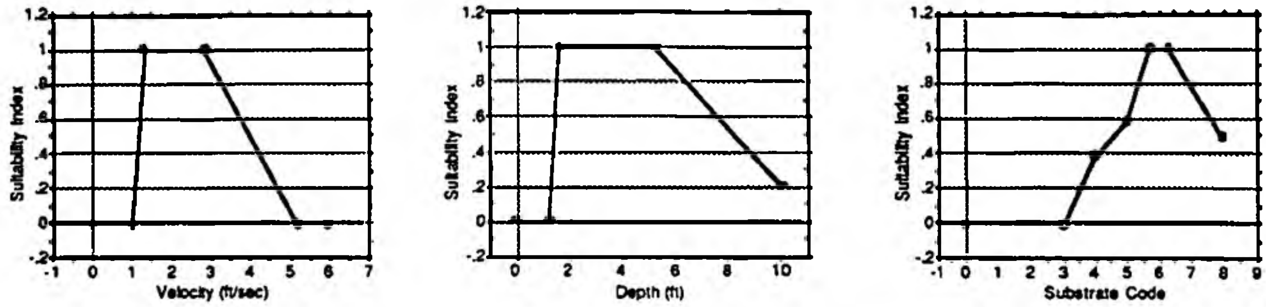


Figure E.16 - Examples of habitat suitability curves for adult brown trout.

Further information concerning the development and evaluation of habitat suitability criteria for use in the IFIM has been described by Bovee (1986).

E.6.1.4 Habitat simulation

The final step is that of habitat simulation. Hydraulic simulation has already been applied to determine the characteristics of the stream in terms of depth, velocity and substrate as a function of discharge. Physical habitat or weighted usable area (WUA) in the reach is then quantified based on the suitability of the variables simulated by the hydraulic models for a target organism. Similar to the hydraulic simulation, PHABSIM contains a number of different programs that can be used for this purpose, each of which has specific conditions in which it can be most suitably applied.

Individual suitabilities are extracted from the habitat preference curves and these are combined to give a single cell suitability in one of three ways. Multiplicative aggregation is given by:

$$C_i = V_i * D_i * S_i \qquad \text{(Equation E.6)}$$

where:
C_i = Composite suitability of cell i
V_i = Suitability associated with velocity in cell i
D_i = Suitability associated with depth in cell i
S_i = Suitability associated with substrate in cell i

Alternatively, the geometric mean can be used which implies a compensation effect. For example, if two of the three individual composite suitabilities are within the optimum range and the third is very low, the third individual composite suitability has a reduced effect on the computation of the composite suitability. It is calculated by:

$$C_i = (V_i * D_i * S_i)^{1/3} \qquad \text{(Equation E.7)}$$

Finally, the aggregate of the individual suitability factors using the concept of the limiting factor can be calculated by:

$$C_i = \mathrm{Min}\,(V_i, D_i, S_i) \qquad \text{(Equation E.8)}$$

Once the composite suitability has been determined, the amount of Weighted Usable Area (WUA) is computed according to the equation:

$$WUA = \sum A_i * C_i \qquad \text{(Equation E.9)}$$

where:
WUA = Total weighted usable area in stream at specified discharge
C_i = Composite suitability for cell i
A_i = Surface area of cell i

With the final step completed, the effects of changes in streamflow on the physical habitat of the target organism can be evaluated by changes in the amount of WUA. This enables PHABSIM to present biological information in a format suitable for entry into the water resource planning process.

At this juncture it must also be emphasised that predictions of PHABSIM are explicitly made in terms of changes to the **physical properties of the aquatic habitat *(i.e.* velocity, depth and substrate)** and do not predict changes in the biomass of organisms. Failure to recognise this fact has led to much criticism in the literature when PHABSIM results were applied and interpreted without consideration for other factors such as water quality, temperature, food availability and fishing mortality.

E.6.2 Use of PHABSIM within the Glen catchment

E.6.2.1 Site Selection

Selection of sites was based on a requirement to compare habitat availability between the West and East Glen and between upstream and downstream sites on each river. Three sites were selected on the West Glen (Creeton TF015196, Essendine TF050118 and Shillingthorpe TF056114) and two on the East Glen (Edenham TF063223 and Braceborough TF081136). Creeton and Shillingthorpe were selected to compare the upper and lower reaches of the West Glen and Edenham and Braceborough were chosen to compare similar sites on the East Glen. Essendine was also chosen as an extra site to provide a comparison with Shillingthorpe which are upstream and downstream of the Gwash-Glen transfer input point respectively. Each site consists of a riffle - pool - riffle - pool - riffle sequence. Figure E.17 shows the location of these sites.

E.6.2.2 Hydraulic Data

The guidelines established by Bovee and Milhous (1978) were followed to collect data for the hydraulic simulation models. Five transects were established along each reach in order to sample the microhabitat variability present at each site. In each case, the most downstream transect was placed at right angles to the flow across a hydraulic control, *i.e.* the crest of a riffle, and cross-sections upstream were located at sites where a clear change in habitat was evident. Survey markers were placed on either side of the stream at these transects and their exact position surveyed relative to each other. This enables the accurate mapping of the reach for hydraulic simulation. Stream widths were recorded at each cross-section and the transect profiles were also surveyed. Water depths and velocities were measured using a standard Ott current meter type C2"10.150" across each transect at approximately equidistant points. The number of measuring points across each transect is shown in table E.13 below. Each transect is represented by between 17 and 33 points.

Mean velocities were measured at 0.6 times the depth. Substrate type was also recorded for each point based on the presence of Wentworth (1922) grain size categories using the scheme proposed by Trihey and Wegner (1981) shown in table E.14 below. A mixture of two adjacent substrate types can also be described with this code. For example, a code of 5.5 indicates a substrate mixture of 50% gravel and 50% rubble. Similarly, a code of 4.2 indicates a mixture of 80% sand and 20% gravel.

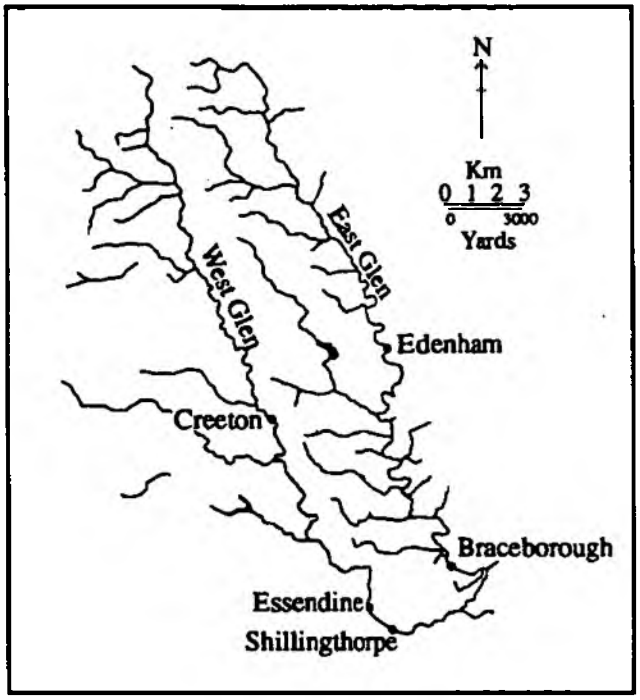


Figure E.17 - PHABSIM site location within the Glen catchment.

Table E.15. - Discharges and their associated percentile flows during data collection at each site.

Site	Low (cumecs)	%ile Flow	Medium (cumecs)	%ile Flow	High (cumecs)	%ile Flow
Creeton	0.0008	93	0.0725	37	0.2287	16
Essendine	0.0113	96	0.0786	80	0.1622	58
Shillingthorpe	0.0266	95	0.1833	55	2.4742	4
Edenham	0.0108	78	0.1581	22	1.0018	4
Braceborough	0.0071	71	0.0949	44	0.5866	16

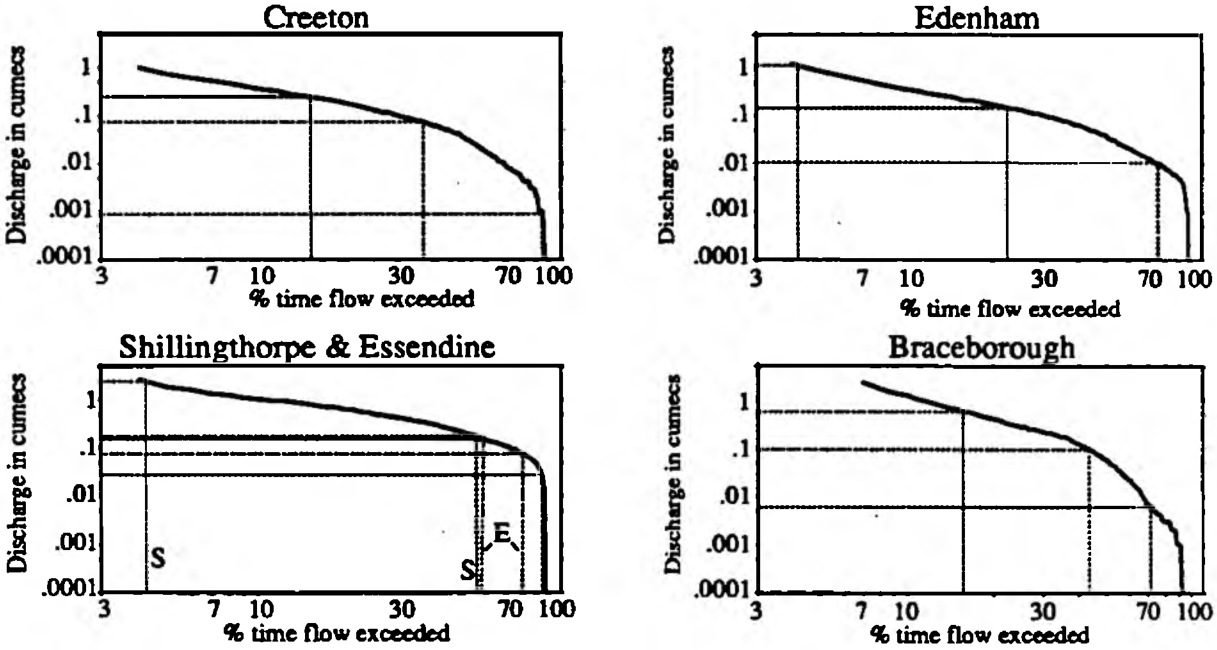


Figure E.18. - Flow duration curves for each site (dotted lines refer to measured flows).

Table E.13 - Number of observation points per transect

Site	Transect No. 1	2	3	4	5	Max. Water Width (m)
Creeton	25	27	25	19	25	4.1
Essendine	19	19	17	17	17	5.5
Shillingthorpe	30	32	33	32	29	6.6
Edenham	20	22	21	22	20	6.4
Braceborough	20	21	20	20	20	5.4

Table E.14 - Substrate classification scheme after Trihey and Wegner (1981).

Code No.	Substrate Type
1.	Plant Detritus
2.	Mud
3.	Silt (< 0.062 mm)
4.	Sand (0.062 - 2 mm)
5.	Gravel (2 - 64 mm)
6.	Rubble (64 - 250 mm)
7.	Boulder (250 - 4000 mm)
8.	Bedrock (solid rock)

Each site was visited under three different flows *i.e.* low, medium and high calibration flows. On each occasion, water surface elevations and velocities were recorded whereas substrate is assumed to be constant and was therefore only recorded on one of the visits. For each stage that was surveyed, the discharge estimates at all cross-sections were averaged to obtain the overall stream discharge. The discharges at each site during the surveys are shown with the associated %ile flow from the nearest gauging station in table E.15 and figure E.18. The three flows for which four of the sites were sampled successfully covered the majority of the normal flows experienced by those particular sites. However, due to the drought conditions experienced throughout the fieldwork phase, the high flow end of the spectrum is not extensively covered for the Essendine site.

E.6.2.3 Ecological Data

Microhabitat suitability curves utilised in this study were originally developed by Armitage and Ladle (1989). The curves themselves were developed based on experience and local knowledge of UK conditions. Curves have been used for three life stages (*i.e.* fry, juvenile and adult) for Brown trout, Dace and Chub and are expressed as suitability functions of depth, velocity and substrate.

E.6.3 PHABSIM simulation and results

For each site, data was processed through the standard paths described in sections E.6.1.1 to E.6.1.4 and shown diagramatically in figure E.19. The flows that are simulated at each site are constrained by certain bounds laid down by the PHABSIM system based on realistic extrapolations from observed data. For instance, it is not possible to simulate hydraulic conditions under extreme high flows based on the measured data set during extreme low flows. Consequently, simulated flows never fall below 0.4 times the lowest calibration flow or 2.5 times the highest calibration flow. Hydraulic conditions were simulated with a combination of the IFG4 and WSP hydraulic simulation programs. For all habitat simulations, the most widely used multiplicative composite suitability index function was adopted as described in section E.6.1.4 and Equation E.6.

Results are expressed in terms of the % of each reach that is usable habitat for the particular fish species over a range of flows. Full details of the actual values generated for each site are shown in Appendix E. These values have also been illustrated graphically by site in figures E.20 to E.24. Each figure contains three graphs, one each for the different species considered. The graphs for chub contain two lines rather than three as the adult and juvenile life stages are considered to have similar habitat suitability preferences. The vertical axis considers the amount of the reach that is usable habitat. The horizontal axis is an expression of discharge with low flows at the extreme left and high flows at the right extreme. Rather than display actual flow values, the graphs highlight the relative importance of the absolute flow with respect to the flow duration curve for the site in order to allow a direct comparison between sites. For instance, taking the Q95 as a measure of the low flow experienced at a site, the Shillingthorpe Q95 is approximately 0.02 cumecs whereas a comparable low flow at Edenham may be represented by 0.003 cumecs, *i.e.* an order of magnitude lower. Consequently, the scale of % of time lower than given flow is used to recognise the relative occurrence of each flow for each site.

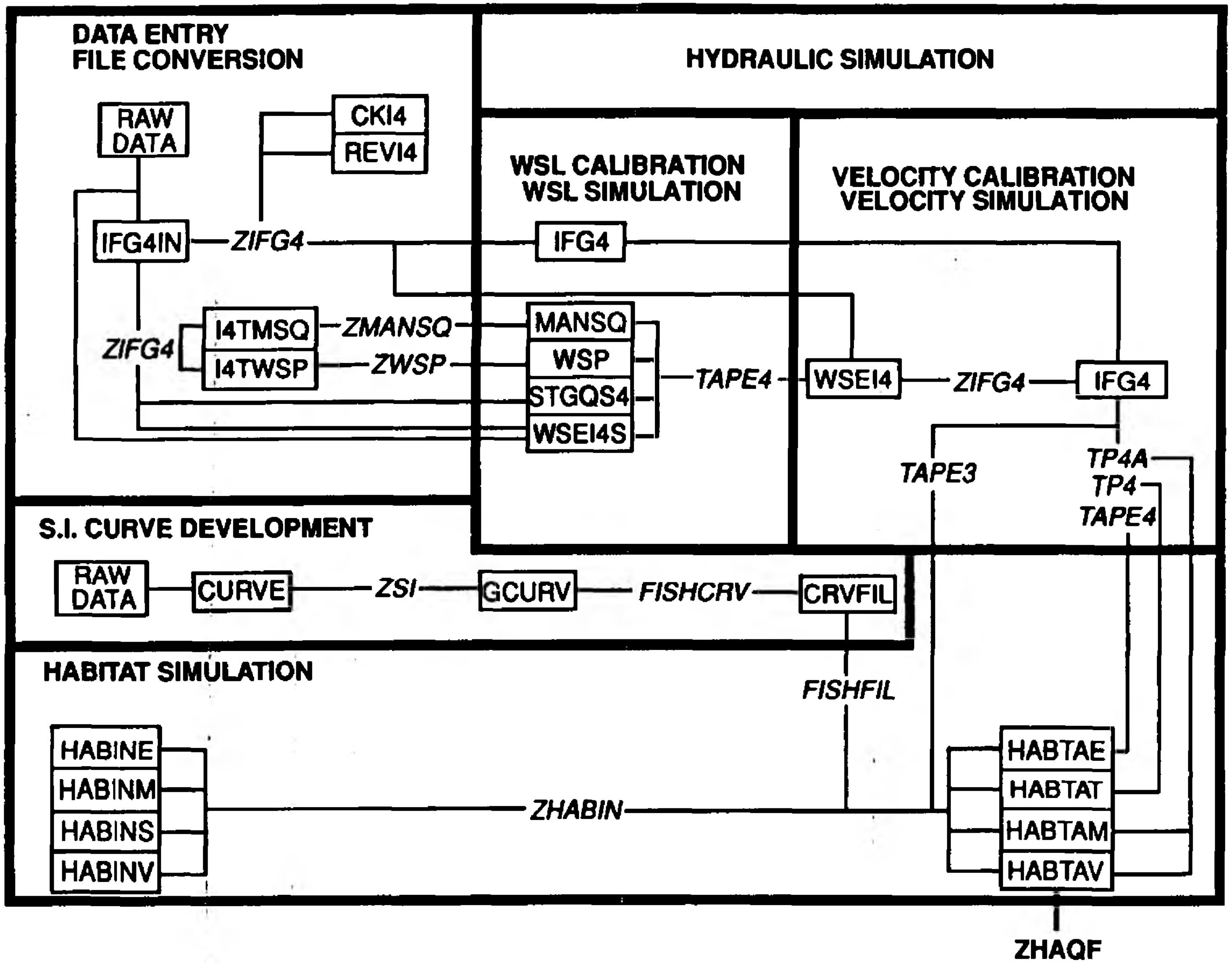


Figure E.19. - PHABSIM information flow. Programs are contained within boxes and default file names are italicized (Hardy 1991).

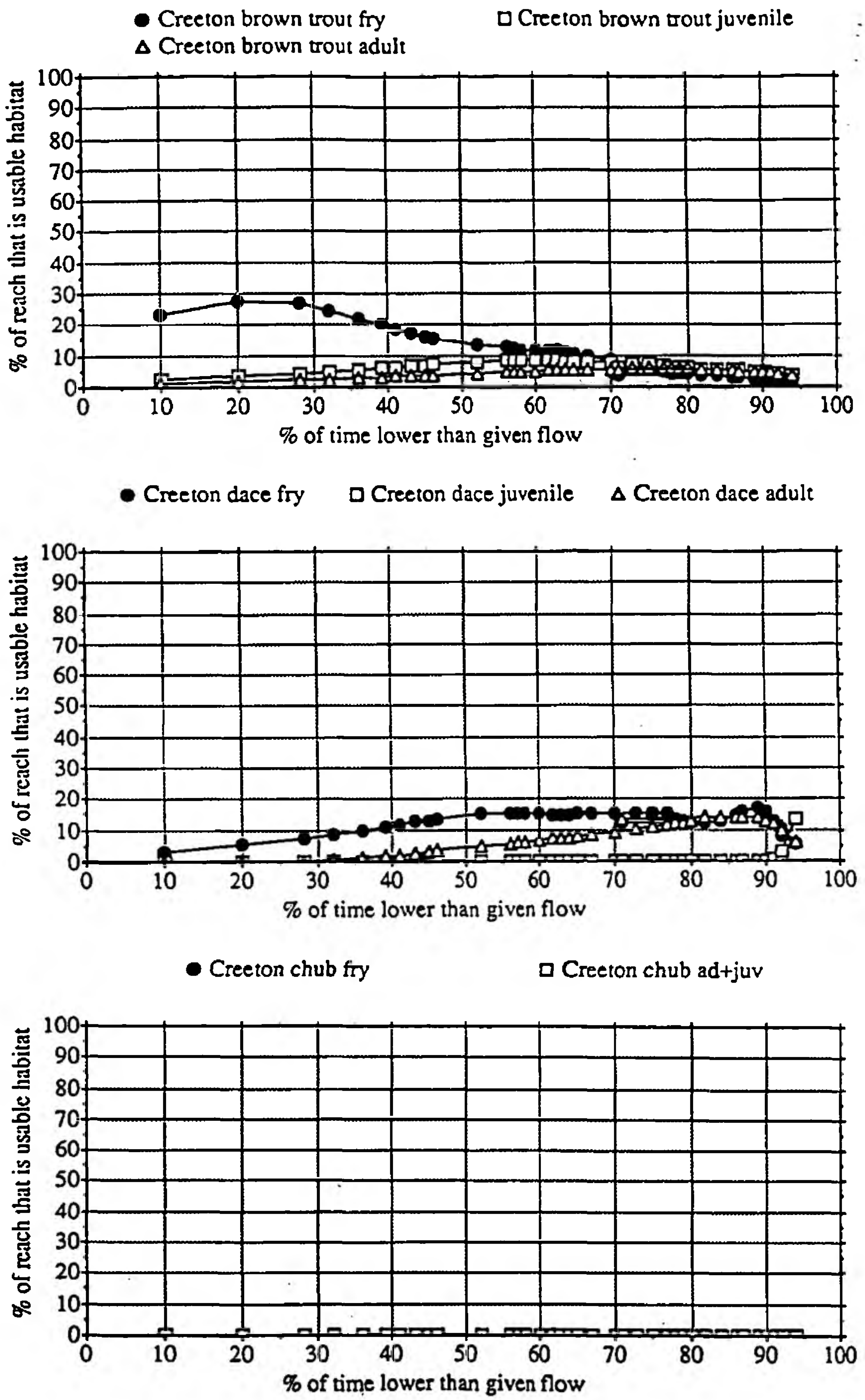


Figure E.20. - % usable habitat versus discharge relationship for Creeton.

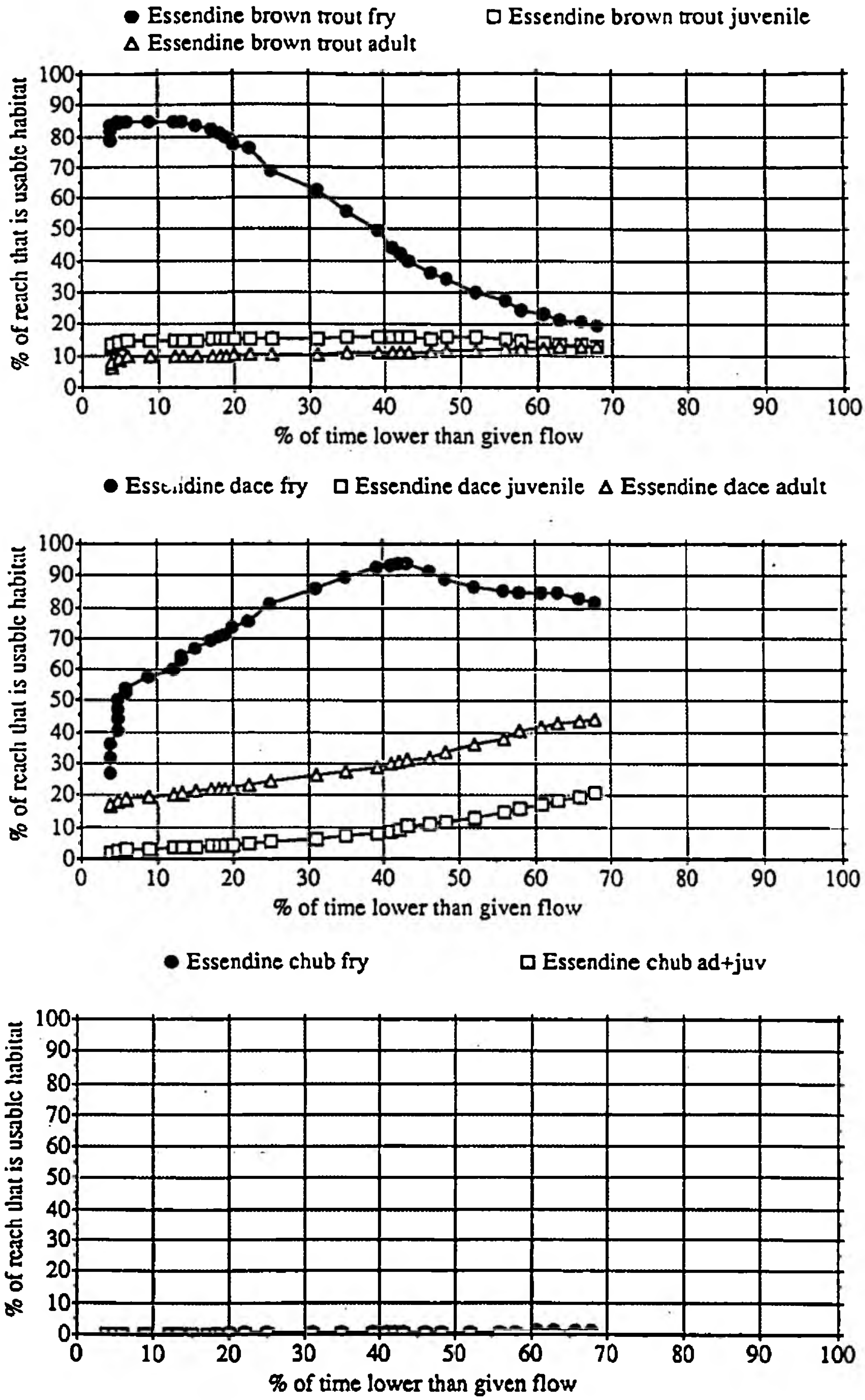


Figure E.21. - % usable habitat versus discharge relationship for Essendine.

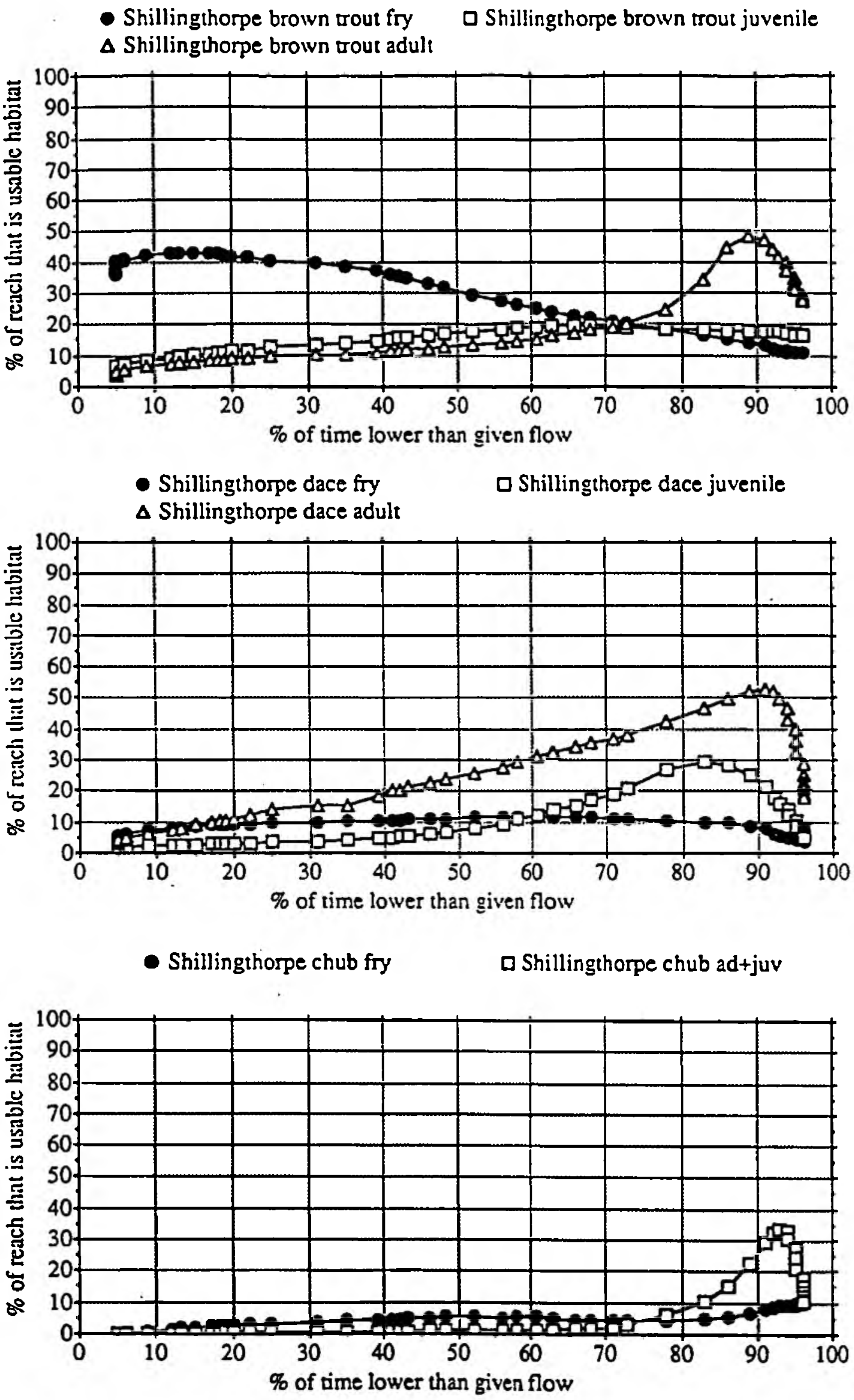


Figure E.22. - % usable habitat versus discharge relationship for Shillingthorpe.

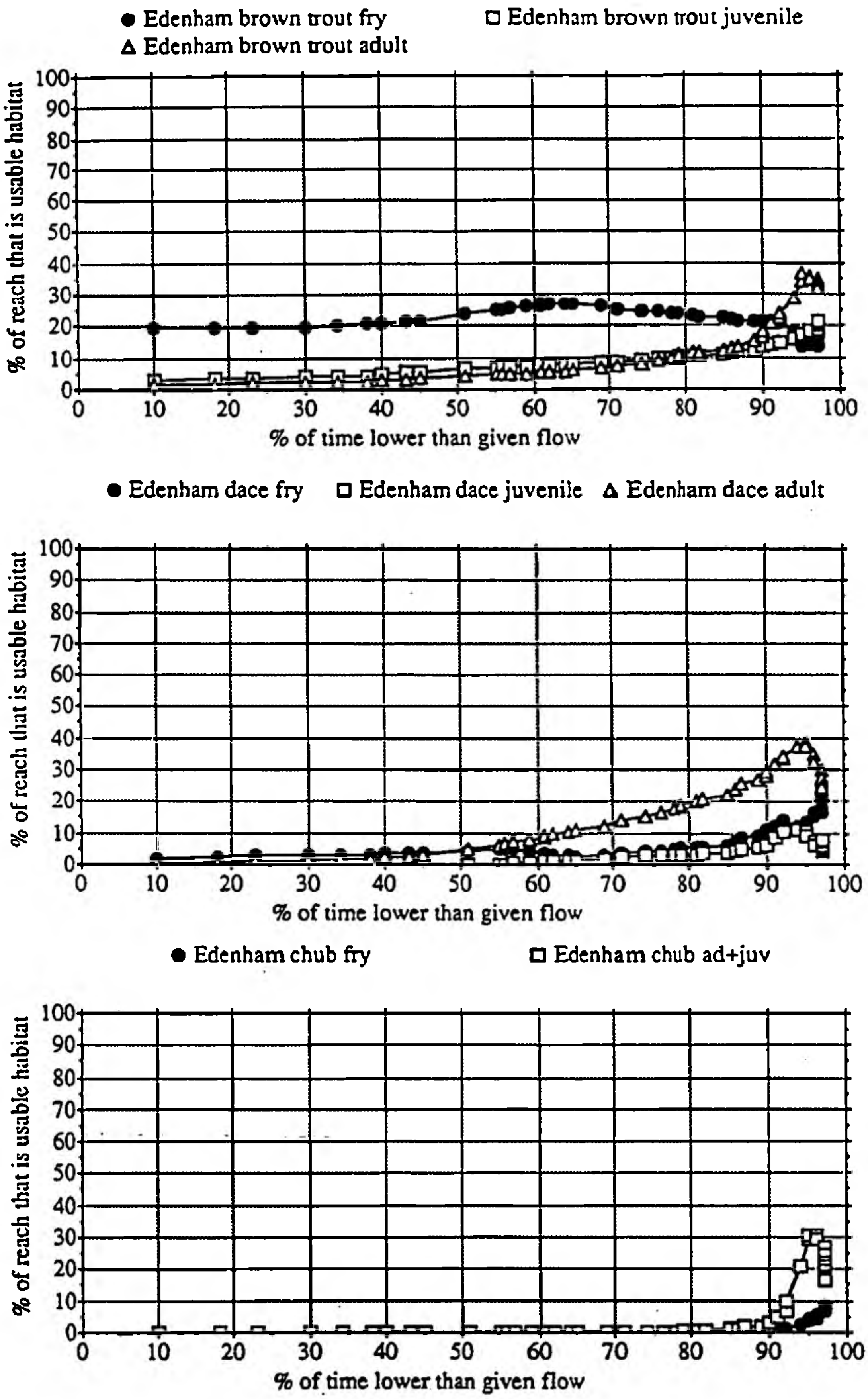


Figure E.23. - % usable habitat versus discharge relationship for Edenham.

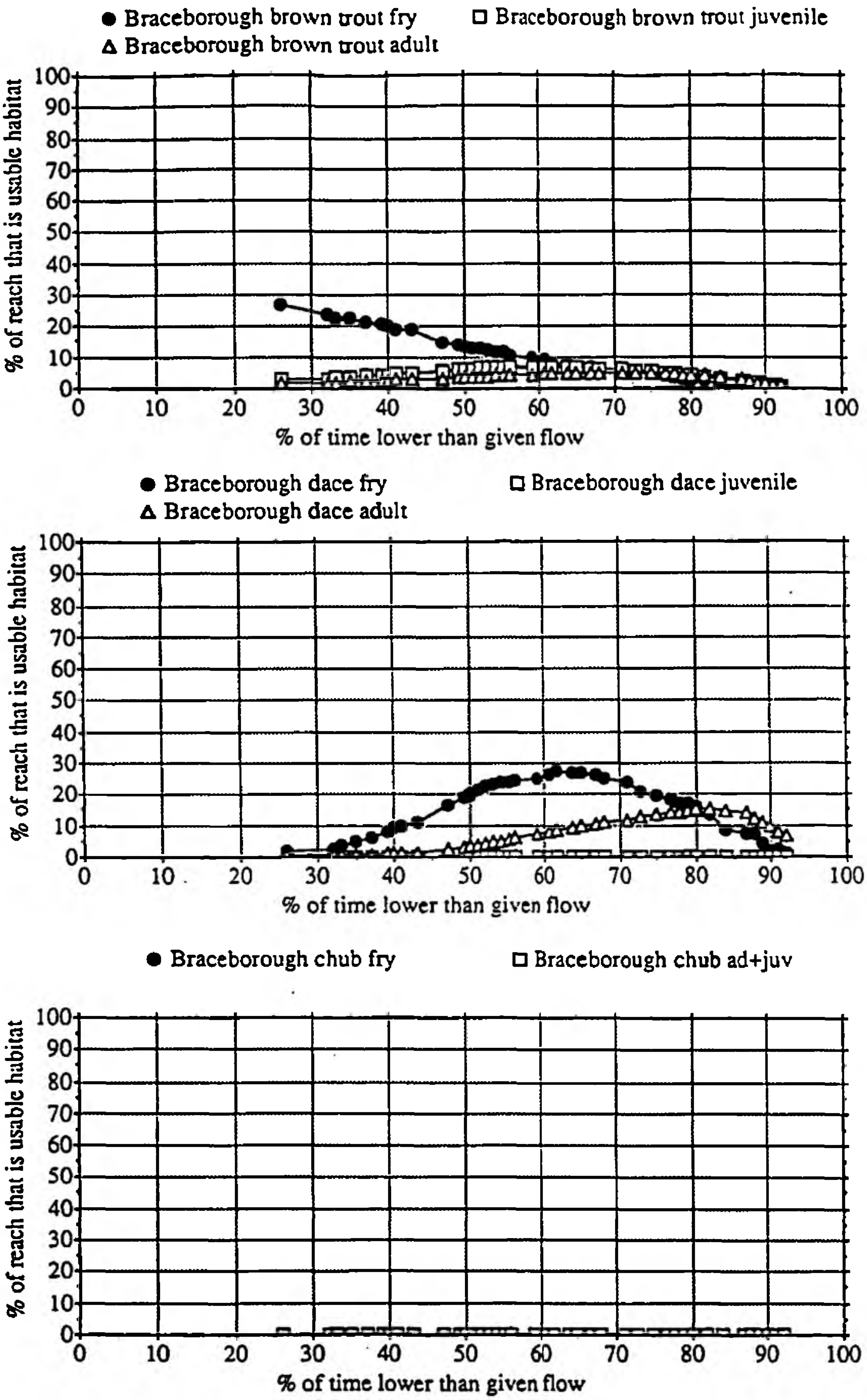


Figure E.24. - % usable habitat versus discharge relationship for Braceborough.

The following discussion examines each figure in turn moving through the sites in a downstream direction, firstly on the West Glen and followed by the East Glen.

Figure E.20 highlights the results for Creeton. More habitat is usable by brown trout fry under the lower flows than any other species for this particular reach. The curves for dace show an increasing habitat availability with increasing flow and no habitat is available under any of the flows normally experienced for chub. Similar to Creeton, figure E.21 shows how the Essendine reach is preferable to brown trout fry under low flows. However, the actual values are much higher peaking at 84.88%. Values for dace also increase with discharge and again actual values are much higher than at Creeton. No habitat is usable by chub. The curve shapes for brown trout and dace at Shillingthorpe (figure E.22) are similar to those at Creeton but the actual amounts of usable habitat are relatively higher. Conversely, habitat usable by chub is available over a large extent of the discharges albeit in small amounts. On the East Glen at Edenham, the curves show a similar picture with the low flows being more suitable to brown trout than any other of the selected species. Also chub habitat does become apparent in small amounts under the high flows. Finally, figure E.24 shows how there is no usable habitat in the selected reach at Braceborough for chub and dace juvenile. Although actual values are low, more habitat is usable to the fry life stages of brown trout and dace than any other.

With this description of figures E.20 to E.24 it is apparent that three main conclusions can be drawn from their results with respect to the amount of habitat available to each selected species and life stage:

1) most habitat tends to be usable by brown trout fry under the low flows experienced at each site,
2) habitat availability curves for brown trout tend to decrease under the higher discharges whereas habitat availability for dace tends to increase with flow, and
3) there is very little chub habitat at any of the sites with none at three and only small amounts under higher flows at Shillingthorpe and Edenham.

Furthermore, it is apparent that the sites fall into two distinct groups when their results are compared. The first group consists of Creeton, Essendine and Braceborough and all three are characterised by:

1) decreasing habitat available to all life stages of brown trout under higher flows and
2) no habitat available to chub.

The second group which contains the remaining sites of Shillingthorpe and Edenham have the opposite characteristics of:

1) maintaining brown trout habitat at levels of between 10-40% of the reach under the higher flows, and
2) containing chub habitat albeit in small amounts and only under the high flows at Edenham.

Clearly these latter sites provide more habitat overall for the given flows and life stages used in this study. When a site has little usable habitat it is due to the fact that the hydraulic variables are not suitable to that particular species at that site. In turn these hydraulic variables are determined by the nature of the hydrogeomorphology, *i.e.* the nature and shape of the bed. Consequently, the bed morphology of the sites within the Glen catchment were examined in order to determine any significant difference between them.

E.6.4 Comparison of bed morphology between sites

Based on the original field measurements, figure E.25 has been constructed to show the depth variations between each of the sites under the low, medium and high flow. The vertical axis for each chart highlights the number of measuring points in that reach that were counted with the particular value and the horizontal axis describes the depth in feet. From these charts it is clearly apparent that even under the higher flows there is a distinct lack of deeper water at those sites with the least habitat available *i.e.* Creeton, Essendine and Braceborough. Alternatively, under these flow conditions at Edenham and Shillingthorpe a much broader spectrum of water depths is apparent including water up to three feet deep at Shillingthorpe. Clearly, this highlights the need for deeper pools in providing habitat over the full range of flows. These provide areas of relatively deeper slack water under the low flows maintaining habitat for species which prefer these areas such as the juvenile and adult life stages of brown trout, dace adults and all the chub life stages. Under higher flows these areas can provide refugia to certain species and a full range of depths provides a mosaic of habitat in terms of depths and velocities and increases the likelihood of a suitable habitat being provided at some particular point. Where there is limited morphological variability, then under the higher flows the reach contains no variability in terms of depths or velocities with fast flowing and relatively shallow water prevailing. This provides habitat for only a limited number of life stages and species.

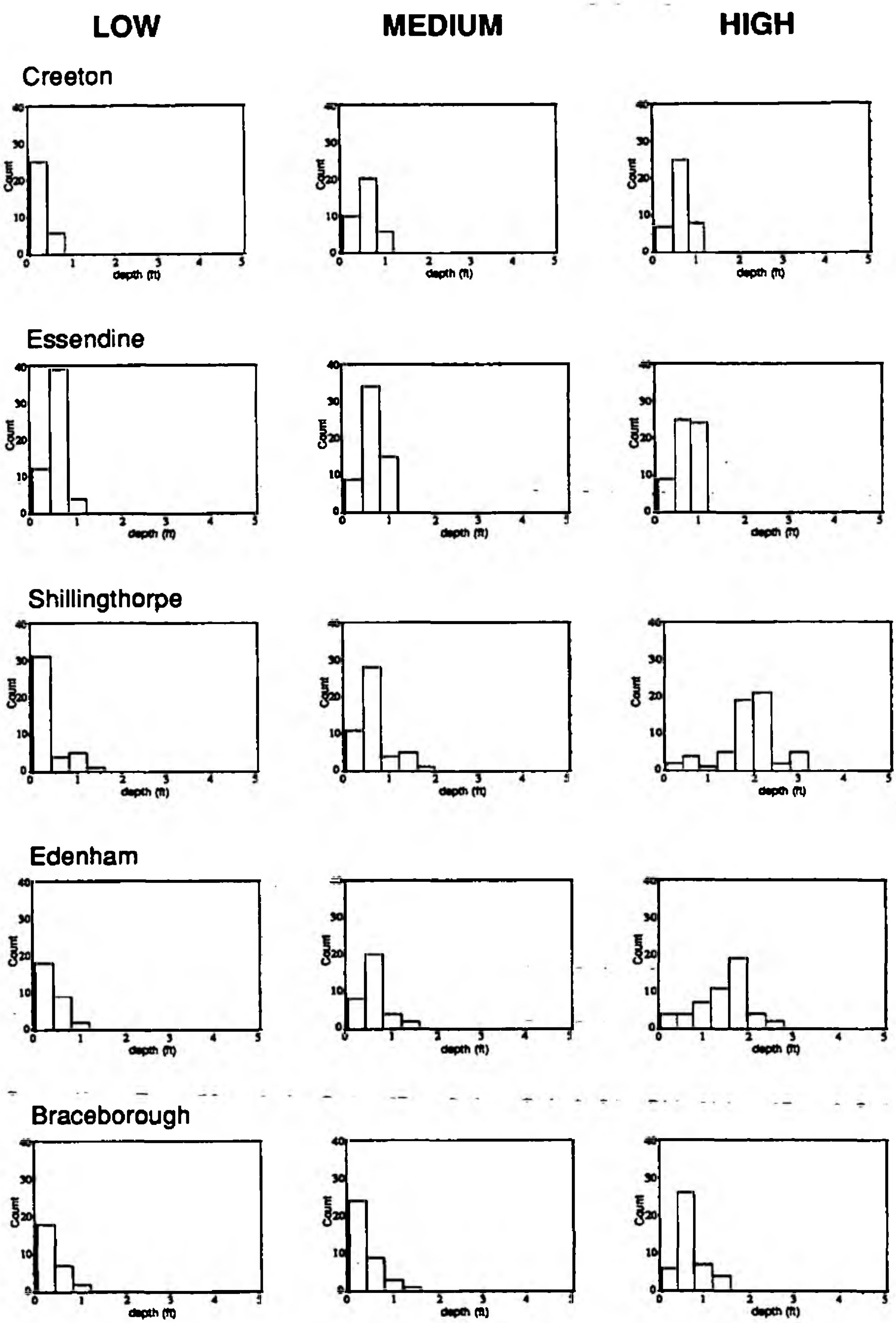


Figure E.25. - Frequency distributions of depth at each site under low, medium and high flows.

E.7 Conclusions

A physical habitat survey of the entire lengths of the West and East Glen allowed the detailed mapping and quantification of the nature and extent of instream habitat availability for each river. This in turn allowed the development of a habitat method in order to examine physical habitat changes with discharge for an approximately 10 km reach of the West Glen. The positive effect of the Gwash-Glen transfer on the physical habitat was clearly demonstrated by this technique. Finally, a biological response method, *i.e.* PHABSIM was utilised to determine fish habitat versus discharge tradeoffs at five sites within the catchment. Further analysis of the results generated by PHABSIM has undeniably highlighted the need for areas of deeper water within the main channel to provide habitat for selected species over the full range of flows experienced.

From these studies it has been possible to conclude that the key recommendations for instream habitat management are:-

1) in order for any instream habitat improvement to be effective it is necessary to provide adequate water quality,
2) the increase of low flows is beneficial for the instream biota and so the Gwash-Glen transfer should be operated at maximum levels permissible.
3) reducing low flow channel width would have a positive effect on the biota
4) maintaining and enhancing geomorphological varaibility along the stream bed will improve habitat quality.

Results suggest that for the upstream sectors of the West Glen and for the majority of the East Glen, while flows continue to reach zero for periods of the year as they have in the past then the opportunities for instream habitat improvement are severely limited. The existence of sluice gates within the reach with adequate flow *e.g.* at Greatford and Fletland Mill further limit the extent of the river to which habitat improvement could be effectively achieved. Therefore it is recommended that any instream enhancement be concentrated on the stretch of the West Glen between the interbasin transfer outflow point and Banthorpe Lodge as shown in figures E.26 and E.27.

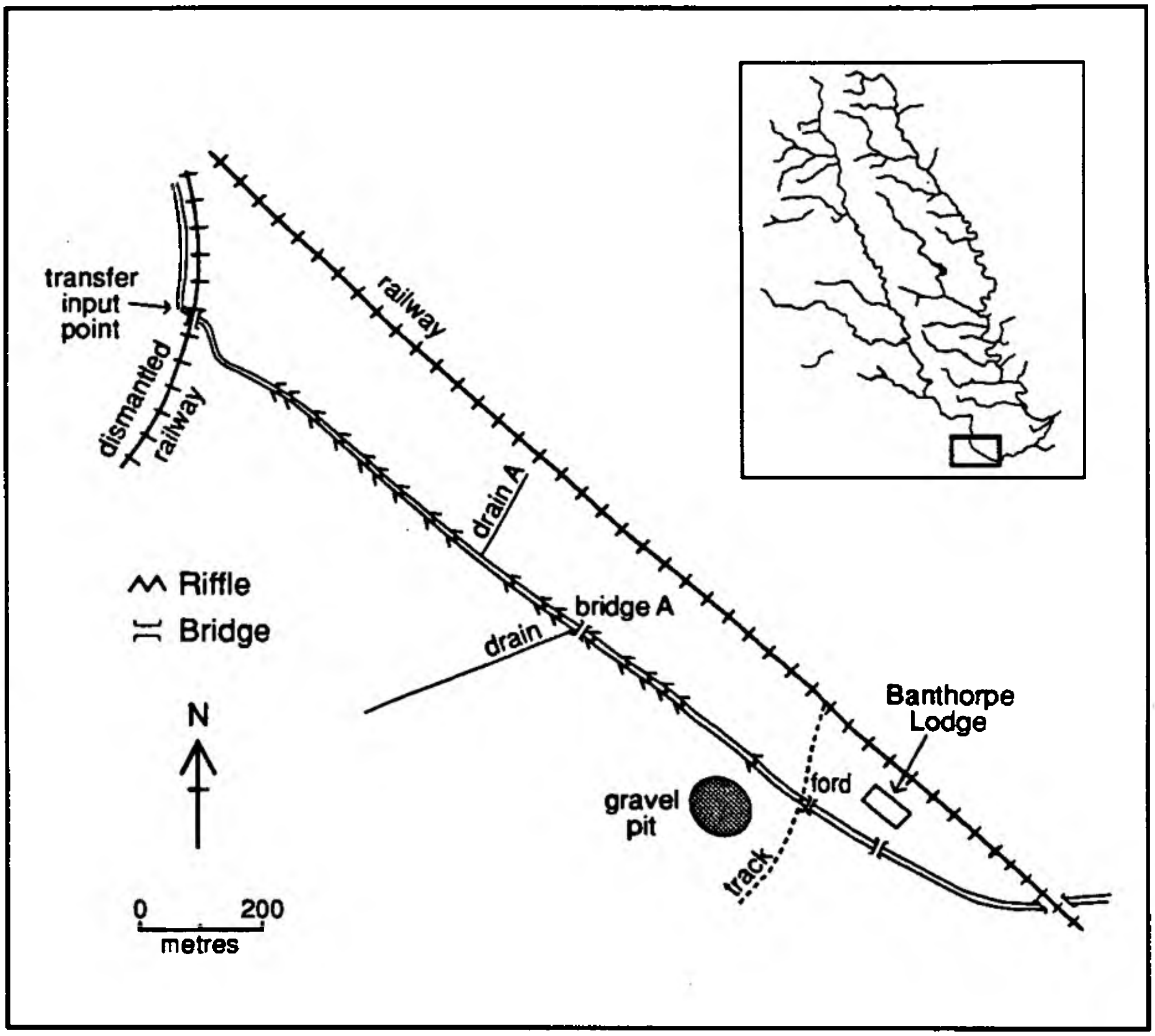


Figure E.26. - Selected reach for instream habitat improvement on the West Glen near Shillingthorpe.

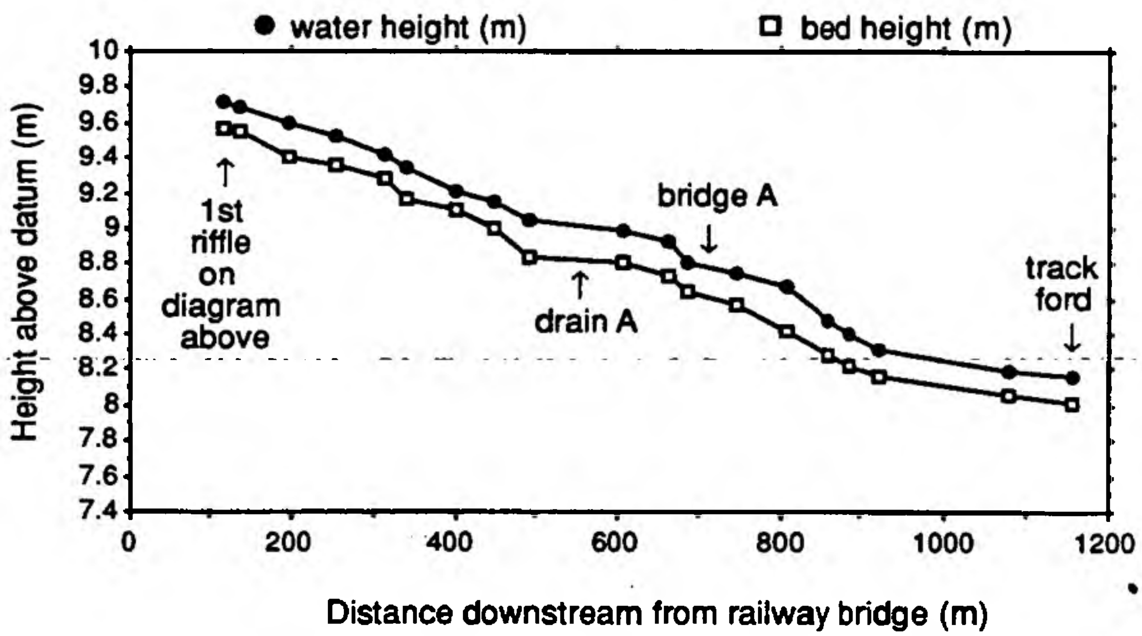


Figure E.27. - Long profile of reach shown in figure E.26 above. Points were surveyed at all riffles from downstream of railway bridge to the track ford.

E.8 References

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APPENDIX A

28 SITE HABITAT SURVEY RESULTS FOR BMWP TEST

Appendix A 28 site habitat survey results for BMWP test

tran- sect no.	dist. down. (m)	cum. dist. (m)	hab- itat type	flow type	channel width (m)	water width (m)	thalweg depth (m)	det- ritus	clay	silt	sand	gra- vel	cob- ble	bou- lder	bed- rock	% inst- ream cover	% over- hanging cover	% bank- side cover
Walthe	**Beck**																	
1	0	0	2	1	3.4	2.5	0.10	0	0	1	1	1	0	0	0	5	100	0
2	25	25	2	1	3.2	2.6	0.10	0	0	0	1	1	1	0	0	5	100	5
3	25	50	3	1	3.4	1.9	0.25	1	0	1	1	1	0	0	0	10	80	5
4	25	75	3	1	4.1	3.8	0.10	1	0	1	1	1	0	0	0	10	80	5
5	25	100	3	1	4.3	3.7	0.35	1	0	1	1	1	0	0	0	10	60	2
6	20	120	2	1	3.9	3.1	0.10	0	0	0	1	1	1	0	0	5	100	5
7	25	145	3	1	3.6	2.2	0.25	0	0	1	1	1	1	0	0	50	50	10
8	25	170	3	1	3.7	3.2	0.30	1	0	1	1	0	0	0	0	10	40	10
9	25	195	3	1	3.6	3.5	0.15	1	0	1	1	1	1	0	0	10	100	2
10	25	220	3	1	3.2	2.7	0.40	1	0	1	1	0	0	0	0	10	40	5
11	25	245	3	1	3.3	2.8	0.25	1	0	1	1	1	1	0	0	80	0	10
12	25	270	3	1	3.9	3.5	0.25	1	0	1	1	0	1	0	0	0	100	10
13	25	295	3	1	3.7	3.3	0.20	1	0	1	1	1	0	0	0	30	0	20
14	25	320	3	1	3.8	3.2	0.20	1	0	1	1	1	0	0	0	80	0	50
15	25	345	3	1	3.5	3.2	0.20	1	0	1	1	1	0	0	0	50	0	5
16	25	370	3	1	3.4	3.0	0.15	1	0	1	1	1	1	0	0	10	80	10
17	25	395	3	1	3.5	2.9	0.20	1	0	1	1	1	0	0	0	80	0	10
18	25	420	2	1	3.4	2.9	0.10	0	0	1	1	1	0	0	0	40	0	20
19	25	445	3	1	3.1	1.5	0.35	1	0	1	1	1	0	0	0	50	0	50
20	20	465	2	1	3.9	2.8	0.10	0	0	1	1	1	0	0	0	40	0	20
Barlings	**Eau**																	
1	0	0	1	1	7.2	5.3	0.05	0	0	1	1	1	1	0	0	40	0	15
2	30	30	3	1	6.7	5.8	0.25	1	0	1	0	0	0	0	0	10	0	5
3	30	60	3	1	7.8	6.7	0.20	1	0	1	1	1	0	0	0	10	0	10
4	30	90	3	1	7.9	6.5	0.20	1	0	1	0	0	0	0	0	5	0	5
5	30	120	3	1	6.4	5.4	0.15	1	0	1	0	0	0	0	0	2	40	2
6	30	150	1	1	6.2	3.9	0.50	1	0	1	1	1	0	0	0	20	0	0
7	30	180	2	1	6.1	3.9	0.15	1	0	1	1	1	0	0	0	2	0	20
8	30	210	3	1	6.5	4.2	0.10	1	0	1	1	1	0	0	0	5	0	5
9	30	240	1	1	6.1	2.9	0.50	0	0	0	1	1	0	0	0	2	0	5
10	30	270	2	1	6.3	2.9	0.10	1	0	1	1	1	0	0	0	5	0	5
11	25	295	1	1	5.9	3.7	0.50	1	0	1	1	1	0	0	0	2	0	2
12	30	325	3	1	5.7	4.3	0.15	1	0	1	1	1	0	0	0	30	0	5
13	30	355	3	1	5.3	4.4	0.25	1	0	1	1	1	0	0	0	5	0	10
14	30	385	3	1	5.6	4.1	0.15	1	0	1	1	1	0	0	0	5	0	5
15	15	400	1	1	4.8	2.9	0.50	1	0	1	1	1	0	0	0	5	0	10
16	30	430	3	1	5.7	4.2	0.30	1	1	1	1	1	0	0	0	0	0	10
17	30	460	3	1	6.3	4.8	0.15	1	1	1	1	1	0	0	0	0	0	2
18	30	490	3	1	6.3	5.0	0.20	1	1	1	0	0	0	0	0	5	20	0
19	30	520	3	1	6.6	5.4	0.20	1	1	1	1	1	0	0	0	20	0	20
20	30	550	3	2	6.1	4.7	0.25	1	1	1	1	1	0	0	0	0	0	20
Witham																		
1	0	0	1	1	10.3	8.4	0.20	0	0	1	1	1	1	0	0	20	0	2
2	30	30	3	1	10.2	9.3	0.40	0	0	1	1	0	1	0	0	20	0	2
3	30	60	2	1	10.8	9.7	0.35	0	0	1	1	1	1	0	1	10	0	5
4	20	80	1	1	11.9	9.4	0.20	0	0	0	1	1	1	0	1	50	0	0
5	30	110	2	1	10.0	6.4	0.35	1	0	0	1	1	1	0	0	10	0	2
6	30	140	1	1	10.5	8.8	0.30	1	0	1	1	1	1	0	0	60	0	0
7	30	170	1	1	11.4	10.8	0.25	0	0	0	1	1	1	0	0	50	0	2
8	30	200	3	1	10.4	9.6	0.40	1	0	1	1	1	0	0	0	30	0	0
9	30	230	3	1	11.3	10.1	0.40	1	0	1	1	1	0	0	0	20	0	0
10	30	260	3	1	10.5	10.2	0.50	1	1	1	1	1	0	0	0	50	0	5
11	30	290	3	1	11.4	10.8	0.55	1	0	1	1	1	0	0	0	30	0	2
12	30	320	3	1	11.1	10.6	0.60	1	0	1	1	1	0	0	0	20	0	5
13	30	350	3	1	11.0	10.5	0.75	1	0	1	1	1	0	0	0	30	0	2
14	30	380	3	2	10.5	9.4	0.50	1	0	1	1	1	0	0	0	10	0	5
15	30	410	3	2	9.5	8.8	0.75	1	0	1	1	1	0	0	0	10	0	2
16	30	440	3	2	9.7	9.3	1.00	1	0	1	1	1	0	0	0	30	0	2
17	30	470	3	2	10.1	9.4	0.80	1	0	1	1	0	0	0	0	20	0	2
18	30	500	3	2	10.5	9.8	0.40	1	0	1	1	1	0	0	0	5	0	5
19	30	530	2	1	10.9	10.1	0.20	1	0	1	1	1	0	0	0	10	0	10
20	30	560	2	1	12.1	11.3	0.15	0	0	0	1	1	0	0	0	30	0	5
North	**Brook**																	
1	0	0	2	1	5.2	3.5	0.15	0	0	1	1	1	1	0	0	20	50	0
2	30	30	3	1	4.3	3.2	0.25	1	0	1	1	0	1	0	0	10	80	0
3	30	60	2	1	4.4	3.0	0.15	0	0	0	1	1	1	0	0	30	100	0
4	30	90	3	1	4.7	3.6	0.35	1	0	1	1	1	0	0	0	5	0	0
5	30	120	3	1	3.6	3.1	0.45	1	0	1	1	0	0	0	0	0	0	10
6	30	150	3	1	3.4	2.9	0.35	1	0	1	1	0	0	0	0	20	30	5
7	30	180	2	1	3.6	3.1	0.05	0	0	0	1	1	1	0	0	30	0	2
8	30	210	3	1	3.8	3.5	0.30	1	0	1	1	1	0	0	0	5	0	2
9	30	240	3	1	3.4	3.2	0.55	1	0	1	1	1	0	0	0	10	0	5
10	30	270	1	1	4.9	4.2	0.10	1	0	1	1	1	1	0	0	10	100	2
11	30	300	3	1	6.5	6.0	0.30	1	0	1	1	1	1	1	0	70	100	0
12	30	330	1	1	4.7	3.8	0.10	0	0	0	1	1	1	1	0	50	100	2
13	30	360	3	1	3.1	2.9	0.45	1	0	1	1	0	1	0	0	10	100	0
14	30	390	3	1	3.5	3.1	0.35	1	0	1	1	1	1	0	0	80	80	2
15	30	420	3	1	3.3	2.9	0.40	1	0	1	1	0	1	0	0	0	100	5
16	30	450	2	1	4.7	4.2	0.25	1	0	1	1	1	1	0	0	60	100	0
17	30	480	2	1	4.3	3.1	0.20	1	0	1	1	1	1	0	0	0	100	0
18	30	510	3	1	4.4	3.2	0.30	1	0	1	1	1	1	0	0	20	80	2
19	30	540	3	1	4.7	4.1	0.50	1	0	1	1	1	1	0	0	35	100	0
20	30	570	1	1	3.9	3.2	0.10	0	0	0	0	1	1	1	0	10	100	2

Habitat type: 1-Riffle 2-Run 3-Pool Flow type: 1-Visible flow 2-No visible flow Substrate code: 0-Absent 1-Present

Appendix A 28 site habitat survey results for BMWP test

transect no.	dist. down. (m)	cum. dist. (m)	habitat type	flow type	channel width (m)	water width (m)	thalweg depth (m)	detritus	clay	silt	sand	gravel	cobble	boulder	bedrock	% instream cover	% overhanging cover	% bankside cover
Willow	**Brook**																	
1	0	0	2	1	7.1	6.6	0.20	0	0	0	1	1	0	0	0	10	40	5
2	30	30	2	1	7.3	6.5	0.25	0	0	0	1	1	0	0	0	10	0	20
3	30	60	3	1	5.9	4.7	0.30	1	0	0	1	1	0	0	0	20	75	10
4	30	90	2	1	5.8	5.2	0.25	0	0	0	1	1	0	0	0	30	0	5
5	30	120	3	1	5.3	4.8	0.45	0	0	1	1	1	0	0	0	30	0	10
6	30	150	2	1	5.9	5.2	0.25	0	0	0	1	1	0	0	0	5	30	5
7	30	180	2	1	6.5	6.0	0.20	0	0	0	1	1	0	0	0	10	0	10
8	30	210	2	1	7.1	6.6	0.20	0	0	0	1	1	0	0	0	20	80	5
9	30	240	2	1	7.5	7.1	0.20	0	0	0	1	1	0	0	0	5	50	5
10	30	270	2	1	7.1	5.6	0.15	0	0	0	1	1	0	0	0	0	20	5
11	30	300	2	1	6.6	6.1	0.10	0	0	0	1	1	0	0	0	0	50	2
12	30	330	3	1	4.9	4.6	0.45	0	0	1	1	1	0	0	0	20	0	10
13	30	360	2	1	5.7	5.3	0.20	0	0	0	1	1	0	0	0	50	0	5
14	30	390	2	1	6.9	5.3	0.15	0	0	0	1	1	0	0	0	0	0	5
15	30	420	3	1	4.9	4.6	0.40	0	0	1	1	1	0	0	0	10	25	10
16	30	450	2	1	4.7	4.3	0.25	0	0	0	1	1	0	0	0	5	0	10
17	30	480	2	1	5.3	4.9	0.20	0	0	0	1	1	0	0	0	5	0	5
18	30	510	3	1	4.7	4.2	0.30	0	0	0	1	1	0	0	0	10	10	10
19	30	540	2	1	6.2	5.9	0.15	0	0	0	1	1	0	0	0	0	0	2
20	30	570	2	1	5.9	3.7	0.25	0	0	0	1	1	0	0	0	0	0	5
Harpers	**Brook**																	
1	0	0	2	1	5.3	3.2	0.10	0	0	1	1	1	0	0	0	10	0	5
2	30	30	2	1	6.2	4.3	0.15	0	0	1	1	1	1	0	0	100	0	2
3	30	60	2	1	5.1	2.9	0.05	0	0	1	1	1	0	0	0	70	0	0
4	20	80	1	1	3.2	2.4	0.15	0	0	1	1	1	1	0	0	10	0	5
5	30	110	3	1	4.1	3.7	0.80	1	1	1	1	1	1	0	0	20	0	20
6	30	140	2	1	2.8	1.9	0.15	0	0	1	1	1	1	0	0	20	30	10
7	30	170	3	1	3.7	3.0	0.40	1	1	1	1	1	1	0	0	20	100	5
8	30	200	1	1	3.2	2.7	0.10	1	0	1	1	1	1	0	0	10	0	0
9	30	230	3	1	3.3	2.8	0.30	1	1	1	1	0	0	0	0	40	0	10
10	30	260	3	1	3.7	3.1	0.35	1	1	1	1	1	0	0	0	10	0	5
11	30	290	3	1	4.5	3.8	0.40	1	0	1	1	1	0	0	0	10	50	2
12	30	320	3	1	4.4	4.0	0.80	1	1	1	1	1	0	0	0	0	40	2
13	30	350	3	1	3.9	3.3	0.70	1	0	1	1	1	0	0	0	10	80	5
14	10	360	2	1	3.5	3.1	0.25	1	0	1	1	1	0	0	0	5	0	20
15	30	390	3	1	4.5	3.9	0.50	1	0	1	1	1	1	0	0	0	0	2
16	30	420	3	2	4.9	4.1	0.50	1	0	1	1	1	1	0	0	10	0	10
17	30	450	3	2	4.2	3.8	0.30	1	0	1	1	1	1	0	0	10	0	30
18	30	480	1	1	4.4	4.1	0.50	0	0	0	1	1	1	0	0	10	0	10
19	30	510	3	1	4.8	4.1	0.35	1	0	1	1	1	1	0	0	5	0	2
20	30	540	3	1	4.3	4.3	0.40	1	0	1	1	1	1	0	0	5	30	2
Nar																		
1	0	0	1	1	9.2	7.4	0.25	0	0	0	1	1	0	0	0	20	60	10
2	30	30	2	1	9.1	8.3	0.20	0	0	1	1	1	0	0	0	5	80	5
3	30	60	3	1	8.2	7.1	0.40	0	0	1	1	1	1	0	0	10	60	5
4	30	90	2	1	8.4	7.4	0.20	0	0	1	1	1	0	0	0	10	40	5
5	30	120	2	1	8.7	7.3	0.20	0	0	1	1	1	1	0	0	0	60	2
6	30	150	3	1	7.4	6.2	0.25	1	0	1	1	1	0	0	0	0	100	5
7	30	180	3	1	8.9	6.9	0.80	1	0	1	1	0	0	0	0	10	100	2
8	30	210	1	1	7.5	7.2	0.05	0	0	0	0	1	1	0	0	0	80	2
9	30	240	2	1	8.4	6.9	0.10	0	0	0	1	1	1	0	0	0	90	5
10	30	270	1	1	9.1	8.2	0.05	0	0	0	1	1	1	0	0	0	40	5
11	30	300	3	1	9.0	5.6	0.20	0	0	1	1	1	0	0	0	0	40	10
12	30	330	1	1	8.4	6.0	0.10	0	0	1	1	1	1	0	0	0	80	5
13	30	360	1	1	7.0	6.2	0.05	0	0	0	1	1	1	0	0	5	50	5
14	30	390	1	1	8.2	7.1	0.05	0	0	0	0	1	1	0	0	5	80	5
15	30	420	1	1	8.4	7.0	0.10	0	0	0	0	1	1	0	0	0	80	5
16	30	450	3	1	6.9	6.3	0.25	1	0	1	1	1	0	0	0	10	0	10
17	30	480	3	1	5.8	5.1	0.45	1	0	1	1	0	0	0	0	5	5	15
18	30	510	3	1	5.4	4.9	0.30	1	0	1	1	1	0	0	0	5	0	10
19	20	530	1	1	7.4	6.8	0.10	0	0	0	0	1	1	0	0	5	0	15
20	30	560	3	1	7.4	6.9	0.25	1	0	1	1	1	0	0	0	10	5	10
Stringsi	**de**																	
1	0	0	3	2	9.0	9.0	1.00	1	0	1	0	0	0	0	0	90	20	2
2	50	50	3	2	9.5	9.2	1.00	1	0	1	0	0	0	0	0	80	25	5
3	50	100	3	2	8.4	8.1	1.00	1	0	1	0	0	0	0	0	60	60	5
4	50	150	3	2	8.0	7.8	1.00	1	0	1	0	0	0	0	0	50	90	5
5	50	200	3	2	8.4	8.2	1.00	1	0	1	0	0	0	0	0	90	10	5
6	50	250	3	2	8.1	7.9	1.00	1	0	1	0	0	0	0	0	80	10	2
7	50	300	3	2	7.9	7.3	1.00	1	0	1	0	0	0	0	0	70	5	5
8	50	350	3	2	7.3	7.0	1.00	1	0	1	0	0	0	0	0	80	0	2
9	50	400	3	2	7.1	6.7	1.00	1	0	1	0	0	0	0	0	20	0	5
10	50	450	3	2	7.4	6.5	1.00	1	0	1	0	0	0	0	0	75	0	10
11	50	500	3	2	7.0	6.2	1.00	1	0	1	0	0	0	0	0	70	0	10
12	50	550	3	2	5.9	5.4	1.00	1	0	1	0	0	0	0	0	60	0	5
13	50	600	3	2	6.6	6.1	1.00	1	0	1	0	0	0	0	0	95	0	5
14	100	700	3	1	5.8	5.0	1.00	0	0	1	1	1	0	1	0	50	0	5
15	50	750	3	1	6.0	4.8	1.00	0	0	1	1	1	0	0	0	30	0	0
16	45	795	1	1	4.7	4.1	0.10	0	0	1	1	1	1	0	0	60	0	2
17	50	845	3	1	4.5	3.9	0.30	1	0	1	1	1	1	0	0	20	0	10
18	50	895	3	1	4.8	4.3	0.25	1	0	1	1	1	0	0	0	50	0	5
19	50	945	3	1	4.8	4.0	0.40	1	0	1	1	1	1	0	0	50	0	10
20	50	995	3	1	4.8	4.1	0.30	1	0	1	1	1	0	0	0	40	0	15

Habitat type: 1-Riffle 2-Run 3-Pool Flow type: 1-Visible flow 2-No visible flow Substrate code: 0-Absent 1-Present

Appendix A 28 site habitat survey results for BMWP test

tran-sect no.	dist. down. (m)	cum. dist. (m)	hab-itat type	flow type	channel width (m)	water width (m)	thalweg depth (m)	det-ritus	clay	silt	sand	gra-vel	cob-ble	bou-lder	bed-rock	% inst-ream cover	% over-hanging cover	% bank-side cover
Wissey																		
1	0	0	2	1	10.9	10.0	0.30	0	0	1	1	1	1	0	0	5	0	5
2	50	50	3	1	11.2	11.1	0.55	0	0	1	1	1	1	0	0	50	0	1
3	50	100	3	1	9.9	9.3	0.80	0	0	1	1	1	1	0	0	80	0	10
4	50	150	3	1	9.0	8.9	1.00	0	0	0	1	1	0	0	0	80	0	2
5	50	200	3	1	8.8	8.5	1.00	0	0	0	1	1	0	0	0	80	0	2
6	50	250	3	1	8.7	8.6	1.00	0	0	0	1	1	1	0	0	80	0	2
7	60	310	3	1	10.2	10.1	1.00	0	0	0	1	1	0	0	0	90	20	1
8	70	380	3	1	9.0	8.8	1.00	0	0	0	1	1	1	0	0	90	15	2
9	50	430	3	1	7.9	7.7	1.00	0	0	0	1	1	0	0	0	90	0	5
10	50	480	3	1	9.9	8.8	1.00	0	0	0	0	1	1	0	0	80	0	5
11	50	530	3	1	11.4	10.9	1.00	0	0	0	1	1	1	0	0	90	0	2
12	50	580	3	1	8.7	8.2	1.00	0	0	0	0	1	1	0	0	90	10	5
13	50	630	2	1	11.9	11.4	0.65	0	0	0	1	1	1	0	0	70	0	5
14	50	680	3	1	9.8	9.4	1.00	0	0	0	1	1	1	0	0	80	0	5
15	50	730	3	1	9.9	9.7	1.00	0	0	0	0	1	1	0	0	80	0	2
16	50	780	3	1	8.7	8.3	1.00	0	0	0	0	1	0	0	0	90	10	5
17	50	830	3	1	9.9	9.3	1.00	0	0	0	1	1	1	0	0	60	10	2
18	50	880	3	1	11.5	11.1	1.00	0	0	0	1	1	0	0	0	60	0	2
19	50	930	3	1	10.2	9.7	1.00	0	0	0	0	1	1	0	0	70	10	5
20	50	980	3	1	9.3	9.0	1.00	0	0	0	1	1	1	0	0	80	0	5
Thet																		
1	0	0	2	1	5.9	5.1	0.25	1	0	0	1	1	1	1	0	50	0	0
2	30	30	2	1	8.6	7.8	0.20	1	0	1	0	1	1	0	0	30	30	2
3	30	60	3	1	6.6	5.7	0.30	1	0	1	0	1	0	0	0	50	10	5
4	30	90	3	1	7.3	6.5	0.40	1	0	1	0	1	0	0	0	60	50	5
5	30	120	2	1	6.1	5.5	0.30	1	0	1	0	1	0	0	0	50	50	5
6	30	150	3	1	7.4	6.4	0.45	1	0	1	0	1	0	0	0	30	60	5
7	30	180	3	1	7.0	5.9	0.60	1	0	1	0	0	0	0	0	30	10	2
8	30	210	3	1	6.9	6.2	0.60	1	0	1	0	0	0	0	0	20	40	2
9	30	240	3	1	6.3	5.8	0.50	1	0	1	0	1	0	0	0	15	50	5
10	30	270	3	1	7.3	6.3	0.60	1	0	1	0	0	0	0	0	20	40	2
11	20	290	3	1	6.9	6.4	0.35	1	0	1	0	1	0	0	0	20	40	2
12	30	320	3	1	7.5	7.0	0.70	1	0	1	0	0	0	0	0	20	100	0
13	30	350	3	1	7.4	6.8	0.55	1	0	1	0	0	0	0	0	15	60	10
14	30	380	3	1	7.2	6.3	0.65	1	0	1	0	1	0	0	0	15	40	5
15	30	410	3	1	6.8	6.2	0.60	1	0	1	0	1	0	0	0	25	0	10
16	30	440	3	1	7.1	6.8	0.65	1	0	1	0	1	0	0	0	15	0	10
17	30	470	3	1	6.9	6.3	0.90	1	0	1	0	1	0	0	0	15	0	5
18	30	500	3	1	7.7	7.1	0.70	1	0	1	0	1	0	0	0	10	10	5
19	30	530	2	1	8.1	7.4	0.45	1	0	1	1	1	0	0	0	20	0	2
20	30	560	3	1	7.6	7.0	0.50	1	0	1	1	0	0	0	0	30	0	20
Little	**Ouse**																	
1	0	0	3	1	7.2	5.8	0.30	0	0	0	1	1	1	1	0	80	0	5
2	16	16	1	1	7.8	6.6	0.10	0	0	0	0	1	1	0	0	60	90	10
3	30	46	3	1	7.0	6.4	0.40	1	0	1	1	1	0	0	0	80	0	5
4	30	76	3	1	6.8	5.9	0.45	1	0	1	1	0	0	0	0	90	0	5
5	30	106	3	1	7.6	6.6	0.35	1	0	1	1	1	0	0	0	70	60	2
6	30	136	2	1	7.6	6.7	0.25	1	0	1	1	1	0	0	0	70	20	5
7	7	143	1	1	7.0	5.8	0.15	0	0	0	1	1	1	0	0	80	0	10
8	30	173	2	1	6.2	5.2	0.25	1	0	1	1	1	0	0	0	80	0	10
9	30	203	2	1	5.7	4.7	0.20	1	0	1	1	1	0	0	0	60	0	15
10	30	233	1	1	6.4	4.3	0.10	0	0	0	1	1	1	0	0	40	0	10
11	30	263	3	1	6.8	6.0	0.35	1	0	1	1	1	0	0	0	30	0	20
12	30	293	3	1	7.1	6.4	0.50	1	0	1	1	0	0	0	0	40	0	20
13	30	323	1	1	6.4	4.5	0.50	1	0	1	1	1	1	0	0	50	50	10
14	30	353	3	1	7.3	6.4	0.30	1	0	1	1	0	0	0	0	50	0	20
15	30	383	3	1	6.8	5.7	0.25	1	0	1	1	0	0	0	0	50	100	15
16	30	413	3	1	7.0	6.4	0.25	1	0	1	1	1	0	0	0	75	0	20
17	30	443	2	1	5.6	5.0	0.20	1	0	0	1	1	1	0	0	80	0	10
18	25	468	1	1	7.0	4.0	0.10	1	0	0	0	1	1	0	0	30	100	2
19	30	498	3	1	10.3	7.8	0.30	0	0	1	1	0	0	0	0	5	0	2
20	30	528	3	1	11.6	8.7	0.20	0	0	1	1	0	0	0	0	0	0	2
Snail																		
1	0	0	2	1	6.3	5.5	0.15	0	0	0	1	1	1	0	0	20	100	2
2	20	20	1	1	5.9	4.7	0.10	0	0	0	1	1	1	0	0	10	100	2
3	30	50	2	1	5.9	5.0	0.20	0	0	1	1	1	1	0	0	10	80	2
4	30	80	3	1	7.5	7.0	0.30	1	0	1	1	0	0	0	0	10	30	0
5	30	110	3	1	7.1	6.4	0.20	1	0	1	1	1	0	0	0	10	40	10
6	25	135	1	1	5.6	5.2	0.05	0	0	0	1	1	1	0	0	5	0	10
7	30	165	3	1	4.8	3.9	0.20	1	0	1	1	1	1	0	0	20	10	5
8	30	195	3	1	5.5	5.0	0.25	0	0	1	1	1	0	0	0	0	60	2
9	30	225	3	1	6.5	6.0	0.20	1	0	1	1	1	0	0	0	0	0	2
10	30	255	1	1	6.4	5.3	0.10	0	0	1	1	1	0	0	0	10	70	5
11	30	285	3	1	5.6	5.1	0.20	1	0	1	1	0	0	0	0	5	80	2
12	30	315	3	1	6.7	6.0	0.40	1	0	1	1	0	0	0	0	5	60	5
13	30	345	3	1	4.8	4.2	0.35	1	0	1	1	1	0	0	0	20	0	0
14	30	375	3	1	5.9	5.6	0.35	1	0	1	1	0	0	0	0	50	30	0
15	30	405	3	1	6.6	5.5	0.20	1	0	1	0	0	0	0	0	30	0	2
16	30	435	3	1	6.6	5.8	0.35	1	0	1	0	0	0	0	0	20	0	5
17	30	465	3	1	7.3	6.8	0.30	1	0	1	1	0	0	0	0	70	0	10
18	30	495	3	2	6.8	5.9	0.60	1	0	1	0	0	0	0	0	0	100	0
19	30	525	3	2	6.5	5.9	0.40	1	0	1	0	0	0	0	0	50	80	2
20	30	555	3	1	7.6	6.7	0.50	1	0	1	0	0	0	0	0	40	20	5

Habitat type: 1-Riffle 2-Run 3-Pool Flow type: 1-Visible flow 2-No visible flow Substrate code: 0-Absent 1-Present

Appendix A 28 site habitat survey results for BMWP test

tran-sect no.	dist. down. (m)	cum. dist. (m)	hab-itat type	flow type	channel width (m)	water width (m)	thalweg depth (m)	det-ritus	clay	silt	sand	gra-vel	cob-ble	bou-lder	bed-rock	% inst-ream cover	% over-hanging cover	% bank-side cover
Swaffha	**m**																	
1	0	0	2	1	6.3	5.0	0.20	1	0	1	1	0	0	0	0	30	0	0
2	30	30	2	1	6.9	5.8	0.10	1	0	1	1	0	0	0	0	40	0	0
3	30	60	2	1	7.9	6.5	0.10	1	0	1	0	0	0	0	0	30	0	0
4	30	90	2	1	7.3	6.0	0.10	1	0	1	0	0	0	0	0	20	0	0
5	30	120	2	1	6.2	5.2	0.10	1	0	1	0	0	0	0	0	20	0	0
6	30	150	2	1	5.8	5.0	0.10	1	0	1	0	0	0	0	0	10	0	0
7	30	180	2	1	6.5	5.0	0.15	1	0	1	0	0	0	0	0	15	0	0
8	30	210	2	1	6.1	5.1	0.10	1	0	1	0	0	0	0	0	10	0	0
9	30	240	2	1	5.9	5.0	0.10	1	0	1	0	0	0	0	0	15	0	0
10	30	270	2	1	6.5	5.4	0.15	1	0	1	0	0	0	0	0	10	0	0
11	30	300	2	1	7.1	6.0	0.10	1	0	1	0	0	0	0	0	50	0	0
12	30	330	2	1	6.5	5.2	0.15	1	0	1	0	0	0	0	0	30	0	0
13	30	360	2	1	6.9	5.9	0.15	1	0	1	0	0	0	0	0	20	0	0
14	30	390	2	1	6.3	5.6	0.15	1	0	1	0	0	0	0	0	20	0	0
15	30	420	2	1	5.8	4.9	0.10	1	0	1	0	0	0	0	0	5	0	2
16	30	450	2	1	6.4	5.5	0.15	1	0	1	0	0	0	0	0	20	0	0
17	30	480	2	1	6.1	4.9	0.15	1	0	1	0	0	0	0	0	5	0	2
18	30	510	2	1	6.0	5.3	0.15	1	0	1	0	0	0	0	0	5	0	0
19	30	540	2	1	6.9	5.2	0.15	1	0	1	0	0	0	0	0	2	0	2
20	30	570	2	1	5.9	4.5	0.10	1	0	1	0	0	0	0	0	10	0	0
Granta																		
1	0	0	3	2	5.5	4.9	0.30	1	0	1	1	1	1	0	0	10	0	0
2	30	30	3	2	3.6	3.1	0.30	1	0	1	1	1	1	0	0	30	0	10
3	30	60	3	2	4.2	3.5	0.35	1	0	1	1	1	1	0	0	10	0	10
4	30	90	3	2	4.8	3.8	0.45	1	0	1	1	1	1	0	0	20	0	5
5	10	100	1	1	3.9	2.8	0.05	1	0	0	1	1	1	0	0	30	40	20
6	30	130	3	2	3.3	2.4	0.50	1	0	1	1	1	1	0	0	40	0	2
7	30	160	3	2	3.7	3.3	0.45	1	0	1	1	0	0	0	0	20	0	5
8	30	190	3	2	3.3	3.0	0.50	1	0	1	1	0	0	0	0	30	0	10
9	30	220	3	2	4.4	4.0	0.70	1	0	1	1	1	1	0	0	20	0	10
10	20	240	2	1	3.4	3.0	0.15	1	0	0	1	1	1	0	0	0	0	20
11	30	270	3	2	3.6	2.7	0.50	1	0	1	1	1	0	0	0	10	0	5
12	25	295	1	1	3.5	1.8	0.10	1	0	0	1	1	1	0	0	80	0	50
13	30	325	3	2	5.5	4.9	0.20	1	0	1	1	1	0	0	0	0	100	5
14	30	355	3	1	3.6	2.6	0.15	1	0	1	1	1	0	0	0	5	100	2
15	15	370	1	1	3.7	2.8	0.05	1	0	0	1	1	1	0	0	20	0	20
16	20	390	2	1	4.1	2.2	0.10	0	0	0	1	1	0	0	0	0	100	0
17	20	410	1	1	3.8	3.1	0.05	0	0	0	1	1	0	0	0	0	100	20
18	30	440	3	1	2.6	1.9	0.20	1	0	1	1	1	0	0	0	50	0	50
19	20	460	1	1	3.4	2.6	0.05	1	0	0	1	1	1	0	0	20	0	10
20	30	490	2	1	2.9	2.1	0.15	1	0	1	1	1	1	0	0	0	0	10
Hiz																		
1	0	0	3	1	7.5	6.9	1.00	1	0	1	0	1	0	0	0	40	0	2
2	30	30	3	1	9.1	7.8	1.00	1	0	1	0	1	0	0	0	20	40	5
3	30	60	3	1	7.9	7.4	1.00	1	0	1	0	0	0	0	0	60	0	2
4	30	90	3	1	8.9	8.5	1.00	1	0	1	0	0	0	0	0	10	0	0
5	30	120	3	1	10.0	9.4	1.00	1	0	1	0	0	0	0	0	5	0	0
6	30	150	3	1	9.5	8.7	1.00	1	0	1	0	0	0	0	0	20	0	2
7	30	180	3	1	9.3	8.4	1.00	1	0	1	0	0	0	0	0	20	0	2
8	30	210	3	1	9.9	9.5	1.00	1	0	1	0	0	0	0	0	15	0	5
9	30	240	3	1	8.5	7.9	1.00	1	0	1	0	0	0	0	0	5	0	2
10	30	270	3	1	8.9	8.3	1.00	1	0	1	0	0	0	0	0	10	0	5
11	30	300	3	1	9.3	8.6	1.00	1	0	1	0	0	0	0	0	15	5	2
12	30	330	3	1	9.4	8.8	1.00	1	0	1	0	0	0	0	0	30	0	5
13	30	360	3	1	8.9	8.6	1.00	1	0	1	0	0	0	0	0	10	0	2
14	30	390	3	1	10.1	9.2	1.00	1	0	1	0	0	0	0	0	5	0	5
15	30	420	3	1	10.8	10.0	1.00	1	0	1	0	0	0	0	0	5	0	2
16	30	450	3	1	10.7	9.8	1.00	1	0	1	0	0	0	0	0	2	0	2
17	30	480	3	1	10.7	10.1	1.00	1	0	1	0	0	0	0	0	5	0	2
18	30	510	3	1	11.4	10.8	1.00	1	0	1	0	0	0	0	0	10	0	0
19	30	540	3	1	13.0	12.5	1.00	1	0	1	0	0	0	0	0	10	20	0
20	30	570	3	2	14.2	13.8	1.00	1	0	1	0	0	0	0	0	30	0	2
Burn																		
1	0	0	3	1	7.5	6.8	0.25	1	0	1	1	0	0	0	0	10	0	5
2	30	30	3	1	7.6	6.7	0.30	1	0	1	0	0	0	0	0	0	0	5
3	30	60	3	1	7.4	7.0	0.30	1	0	1	0	0	0	0	0	0	5	5
4	30	90	3	1	8.0	7.4	0.25	1	0	1	0	0	0	0	0	0	0	5
5	30	120	3	2	7.2	6.4	0.25	1	0	1	0	0	0	0	0	5	0	10
6	30	150	3	2	7.5	6.3	0.30	1	0	1	0	0	0	0	0	0	0	5
7	30	180	3	2	7.8	7.0	0.30	1	0	1	0	0	0	0	0	0	30	10
8	30	210	3	2	6.7	5.7	0.30	1	0	1	0	0	0	0	0	0	10	20
9	30	240	3	2	6.1	5.5	0.35	1	0	1	0	0	0	0	0	0	30	10
10	30	270	3	1	6.8	6.1	0.30	1	0	1	0	0	0	0	0	0	50	10
11	30	300	3	1	7.7	6.6	0.35	1	0	1	0	0	0	0	0	0	5	30
12	30	330	3	1	7.8	6.9	0.30	1	0	1	0	0	0	0	0	0	5	40
13	30	360	3	1	6.2	5.7	0.35	1	0	1	0	0	0	0	0	10	0	40
14	30	390	3	1	6.8	6.1	0.35	1	0	1	0	0	0	0	0	0	10	10
15	30	420	3	1	7.4	7.0	0.35	1	0	1	0	0	0	0	0	0	30	2
16	30	450	3	1	7.4	6.8	0.30	1	0	1	0	0	0	0	0	0	80	5
17	30	480	3	1	6.6	5.9	0.35	1	0	1	0	0	0	0	0	5	0	30
18	30	510	3	2	6.6	6.1	0.35	1	0	1	0	0	0	0	0	10	50	40
19	30	540	3	2	7.7	6.7	0.30	1	0	1	0	0	0	0	0	0	0	20
20	30	570	3	2	9.0	8.0	0.50	1	0	1	0	0	0	0	0	0	0	10

Habitat type: 1-Riffle 2-Run 3-Pool Flow type: 1-Visible flow 2-No visible flow Substrate code: 0-Absent 1-Present

Appendix A 28 site habitat survey results for BMWP test

transect no.	dist. down. (m)	cum. dist (m)	habitat type	flow type	channel width (m)	water width (m)	thalweg depth (m)	detritus	clay	silt	sand	gravel	cobble	boulder	bedrock	% instream cover	% overhanging cover	% bankside cover
Tud																		
1	0	0	1	1	6.4	4.6	0.10	0	0	0	0	1	1	0	0	10	10	10
2	30	30	2	1	5.7	4.1	0.05	1	0	0	0	1	1	0	0	10	0	2
3	30	60	3	1	5.0	4.4	0.20	1	0	1	1	0	0	0	0	10	40	10
4	30	90	3	1	4.5	3.5	0.15	1	0	1	1	0	0	0	0	40	20	5
5	30	120	1	1	4.8	2.8	0.05	0	0	0	0	1	1	0	0	20	80	40
6	30	150	1	1	4.8	3.8	0.05	1	0	1	1	1	1	0	0	5	100	0
7	30	180	2	1	4.9	4.0	0.10	1	0	0	1	1	1	0	0	40	0	20
8	30	210	1	1	5.3	4.3	0.10	0	0	0	0	1	1	0	0	10	50	10
9	30	240	1	1	4.3	3.5	0.05	0	0	0	0	1	1	0	0	15	0	5
10	30	270	2	1	5.0	2.7	0.05	0	0	0	1	1	1	0	0	60	0	30
11	30	300	3	1	5.8	3.4	0.20	1	0	1	1	1	0	0	0	5	50	5
12	30	330	2	1	4.4	3.6	0.10	0	0	0	1	1	1	0	0	50	20	5
13	30	360	2	1	4.0	3.2	0.10	1	0	1	1	1	1	0	0	5	40	5
14	30	390	3	2	4.5	3.5	0.40	1	0	1	1	1	0	0	0	10	60	2
15	30	420	3	1	4.8	4.2	0.30	1	0	1	1	1	0	0	0	90	0	2
16	30	450	3	1	4.4	3.7	0.30	1	0	1	1	1	0	0	0	90	0	2
17	30	480	3	1	4.4	3.3	0.25	1	0	1	1	1	0	0	0	80	0	5
18	30	510	3	1	4.7	4.2	0.20	1	0	1	1	1	1	0	0	70	40	20
19	30	540	3	1	4.4	3.7	0.20	1	0	1	1	1	1	0	0	80	30	20
20	30	570	3	2	5.2	4.6	0.40	1	0	1	1	1	1	0	0	30	100	2
Tas																		
1	0	0	3	1	8.9	7.0	0.35	1	0	1	1	1	1	0	0	0	20	5
2	30	30	3	1	9.0	7.5	0.30	1	0	1	1	1	0	0	0	0	60	2
3	30	60	3	1	6.8	5.9	0.25	1	0	1	1	1	0	0	0	20	30	5
4	30	90	3	1	7.5	6.7	0.20	1	0	1	1	1	0	0	0	20	0	2
5	30	120	1	1	8.3	7.3	0.15	1	0	0	1	1	1	0	0	40	70	5
6	30	150	3	1	8.0	7.6	0.20	1	0	1	1	1	0	0	0	20	20	20
7	30	180	1	1	7.4	6.4	0.15	1	0	0	1	1	1	0	0	60	0	5
8	30	210	3	1	7.8	7.1	0.25	1	0	1	1	1	0	0	0	0	100	2
9	30	240	3	1	7.6	6.8	0.20	1	0	1	1	1	0	0	0	10	50	5
10	30	270	2	1	8.9	8.0	0.10	0	0	0	1	1	0	0	0	20	50	2
11	30	300	1	1	9.2	8.7	0.05	0	0	0	1	1	0	0	0	60	60	2
12	30	330	3	1	8.6	6.4	0.15	1	0	1	1	1	0	0	0	5	100	0
13	30	360	3	1	8.1	6.9	0.15	1	0	1	1	1	0	0	0	5	80	2
14	30	390	3	1	9.2	8.0	0.15	1	0	1	1	1	0	0	0	5	60	5
15	30	420	3	1	8.9	7.7	0.30	1	0	1	1	1	0	0	0	15	80	2
16	30	450	3	1	7.8	6.2	0.35	1	0	1	1	0	0	0	0	0	100	5
17	30	480	3	1	8.4	7.3	0.40	1	0	1	1	0	1	0	0	5	100	2
18	30	510	3	1	6.8	5.8	0.35	1	0	1	1	0	0	0	0	5	0	2
19	30	540	3	2	6.7	5.9	0.40	1	0	1	1	0	0	0	0	50	60	10
20	30	570	3	2	6.5	5.6	0.50	1	0	1	1	0	0	0	0	5	30	10
Waveney																		
1	0	0	3	1	7.5	7.1	0.20	1	0	1	1	1	1	0	0	40	20	10
2	30	30	3	2	10.1	10.0	0.80	1	0	1	1	1	0	0	0	40	60	2
3	30	60	3	2	10.8	9.8	0.90	1	0	1	1	1	0	0	0	40	40	2
4	30	90	3	2	12.2	11.1	1.00	1	0	1	1	1	0	0	0	20	0	5
5	30	120	3	2	12.0	11.4	1.00	1	0	1	1	1	0	0	0	20	0	2
6	30	150	3	2	11.3	10.8	1.00	1	0	1	1	1	1	0	0	20	0	2
7	30	180	3	2	11.2	10.3	1.00	1	0	1	1	1	0	0	0	30	0	5
8	30	210	3	2	10.7	8.8	1.00	1	0	1	1	1	0	0	0	50	0	5
9	30	240	3	2	9.4	9.1	1.00	1	0	1	1	1	0	0	0	20	60	2
10	50	290	3	2	11.2	10.8	1.00	1	0	1	1	1	0	0	0	50	10	2
11	30	320	3	2	10.9	10.7	1.00	1	0	1	1	1	0	0	0	10	0	0
12	30	350	3	2	10.7	10.4	1.00	1	0	1	1	1	0	0	0	10	0	0
13	30	380	3	2	12.2	11.9	1.00	1	0	1	1	1	0	0	0	10	0	0
14	30	410	3	2	11.4	11.7	1.00	1	0	1	1	1	0	0	0	10	0	2
15	30	440	3	2	10.5	9.7	1.00	1	0	1	1	1	0	0	0	10	0	2
16	30	470	3	2	11.5	10.9	1.00	1	0	1	1	1	0	0	0	10	0	1
17	30	500	3	2	11.3	10.8	1.00	1	0	1	1	1	0	0	0	15	0	1
18	30	530	3	2	11.2	10.2	1.00	1	0	1	1	1	0	0	0	5	0	2
19	30	560	3	2	11.0	10.4	1.00	1	0	1	1	1	0	0	0	5	0	1
20	30	590	3	2	11.8	11.4	1.00	1	0	1	1	1	0	0	0	15	0	2
Alde																		
1	0	0	3	1	4.1	3.4	0.20	1	0	1	1	0	0	0	0	0	100	10
2	30	30	3	1	5.0	4.8	0.30	1	0	1	1	0	0	0	0	5	20	0
3	20	50	2	1	3.3	2.1	0.05	0	0	0	1	1	0	0	0	40	0	50
4	30	80	3	2	4.0	3.6	0.25	1	0	1	1	0	0	0	0	20	0	5
5	30	110	2	1	5.4	2.3	0.15	1	0	1	1	0	0	0	0	0	100	10
6	30	140	1	1	3.6	2.8	0.10	1	0	1	1	1	0	0	0	0	0	20
7	30	170	3	2	3.8	3.5	0.40	1	0	1	0	0	0	0	0	10	0	10
8	14	184	2	1	2.8	2.4	0.25	1	0	1	1	1	0	0	0	40	0	5
9	30	214	2	1	3.4	2.3	0.20	1	0	1	1	1	0	0	0	70	50	2
10	25	239	1	1	3.4	3.0	0.20	1	0	1	1	1	0	0	0	70	0	10
11	30	269	3	1	3.7	2.7	0.40	1	0	1	1	0	0	0	0	90	10	20
12	30	299	1	1	3.5	2.4	0.10	1	0	1	1	1	1	0	0	10	0	40
13	30	329	1	1	4.4	3.7	0.05	1	0	0	1	1	1	0	0	0	100	40
14	17	346	1	1	4.6	2.7	0.05	0	0	0	1	1	1	0	0	0	100	0
15	30	376	3	2	5.2	4.8	0.50	1	0	1	1	0	0	0	0	40	0	5
16	15	391	1	1	2.2	1.7	0.10	0	0	0	1	1	0	0	0	10	0	20
17	30	421	1	1	2.4	1.9	0.10	1	0	0	1	1	0	0	0	5	0	5
18	30	451	3	2	5.1	4.8	0.30	1	0	1	1	0	0	0	0	30	100	2
19	25	476	1	1	2.1	1.6	0.10	1	0	0	1	1	0	0	0	10	60	2
20	30	506	3	2	4.8	4.4	0.40	1	0	1	1	0	0	0	0	50	100	5

Habitat type: 1-Riffle 2-Run 3-Pool Flow type: 1-Visible flow 2-No visible flow Substrate code: 0-Absent 1-Present

transect no.	dist. down. (m)	cum. dist. (m)	habitat type	flow type	channel width (m)	water width (m)	thalweg depth (m)	detritus	clay	silt	sand	gravel	cobble	boulder	bedrock	% instream cover	% overhanging cover	% bankside cover
Gipping																		
1	0	0	2	1	6.8	5.8	0.10	1	0	1	1	1	1	0	0	5	10	2
2	14	14	1	1	4.2	3.0	0.10	1	0	1	1	1	1	0	0	5	0	5
3	25	39	2	1	4.8	4.1	0.10	1	0	1	1	1	1	0	0	5	0	10
4	25	64	1	1	4.2	3.6	0.05	1	0	1	1	1	1	0	0	10	0	2
5	30	94	3	1	5.3	4.0	0.10	1	0	1	1	1	1	0	0	2	0	2
6	30	124	3	2	5.8	4.3	0.15	1	0	1	1	1	1	0	0	2	0	0
7	30	154	3	2	5.5	4.1	0.15	1	0	1	1	1	1	0	0	2	0	2
8	30	184	3	2	5.8	4.4	0.20	1	0	1	1	1	1	0	0	5	10	2
9	30	214	3	2	5.6	4.0	0.20	1	0	1	1	1	1	0	0	0	50	0
10	30	244	3	2	4.9	3.9	0.20	1	0	1	1	1	1	0	0	5	40	2
11	20	264	1	1	5.7	4.8	0.10	1	0	1	1	1	1	0	0	10	0	5
12	30	294	3	2	6.7	5.8	0.20	1	0	1	1	1	1	0	0	20	0	2
13	30	324	3	2	7.2	5.1	0.25	1	0	1	1	1	0	0	0	20	0	2
14	30	354	1	1	5.7	4.6	0.10	1	0	1	1	1	0	0	0	20	0	20
15	30	384	3	2	6.6	6.1	0.20	1	0	1	1	1	1	0	0	10	50	2
16	30	414	3	2	5.9	5.6	0.25	1	0	1	1	1	1	0	0	5	0	5
17	30	444	3	2	6.1	5.8	0.20	1	0	1	1	1	1	0	0	10	50	0
18	30	474	3	2	6.8	6.0	0.20	1	0	1	1	1	1	0	0	5	0	2
19	30	504	3	2	6.6	6.1	0.25	1	0	1	1	1	1	0	0	20	0	5
20	30	534	3	2	7.1	6.3	0.30	1	0	1	1	1	1	0	0	5	70	5
Deben																		
1	0	0	1	1	8.1	5.4	0.05	1	0	0	1	1	1	0	0	30	0	0
2	30	30	2	1	7.5	6.8	0.10	1	0	1	1	1	0	0	0	40	0	5
3	30	60	1	1	7.7	5.7	0.05	1	0	1	1	1	0	0	0	10	0	2
4	30	90	3	1	8.9	7.8	0.15	1	0	1	1	1	0	0	0	50	20	0
5	30	120	2	1	6.9	5.6	0.10	1	0	1	1	1	0	0	0	20	20	0
6	30	150	2	1	11.7	10.9	0.20	1	0	1	1	1	1	0	0	50	30	0
7	25	175	1	1	9.3	8.5	0.10	1	0	0	1	1	1	0	0	60	20	0
8	30	205	3	1	8.4	7.8	0.50	1	0	1	1	1	0	0	0	60	0	5
9	30	235	2	1	9.0	8.0	0.15	1	0	1	1	1	0	0	0	50	0	2
10	30	265	3	2	7.7	6.8	0.70	1	0	1	1	1	0	0	0	100	0	2
11	30	295	1	1	9.3	7.8	0.10	1	0	0	1	1	1	0	0	50	0	2
12	30	325	1	1	8.3	7.6	0.10	1	0	0	1	1	1	0	0	50	0	2
13	30	355	2	1	7.7	6.5	0.10	1	0	1	1	1	1	0	0	20	0	5
14	30	385	3	2	7.6	6.4	0.60	1	0	1	1	1	1	0	0	90	0	10
15	30	415	2	1	7.2	6.0	0.15	1	0	0	1	1	1	0	0	10	0	30
16	15	430	1	1	7.4	5.7	0.05	1	0	0	1	1	1	0	0	50	50	5
17	30	460	3	2	9.9	8.8	0.80	1	0	1	1	1	1	0	0	60	0	2
18	30	490	2	1	9.7	9.0	0.30	1	0	1	1	1	1	0	0	60	0	2
19	30	520	2	1	8.6	8.1	0.15	1	0	0	1	1	1	0	0	30	0	10
20	30	550	3	1	8.5	7.7	0.20	1	0	1	1	1	1	0	0	30	0	2
Stour																		
1	0	0	1	1	6.2	5.7	0.10	0	0	1	1	1	1	0	0	5	100	0
2	30	30	3	1	4.9	3.3	0.30	0	0	1	1	1	0	0	0	10	100	0
3	30	60	3	1	4.7	3.3	0.25	0	0	1	1	1	0	0	0	5	100	0
4	30	90	3	1	5.1	4.4	0.40	0	0	1	1	1	0	0	0	5	50	0
5	30	120	2	1	4.8	3.1	0.20	0	0	1	1	1	1	0	0	0	50	0
6	30	150	3	1	4.4	3.2	0.25	0	0	1	1	1	0	0	0	25	100	2
7	30	180	3	1	5.2	4.1	0.40	0	0	1	1	1	0	0	0	0	100	0
8	30	210	3	1	5.0	3.5	0.20	0	0	1	1	1	0	0	0	5	100	2
9	30	240	3	1	5.3	4.5	0.20	0	0	1	1	1	0	0	0	5	20	58
10	30	270	3	1	4.8	3.7	0.25	0	0	1	1	1	0	0	0	10	60	5
11	30	300	3	1	7.4	7.1	0.30	0	0	1	1	1	1	0	0	0	0	2
12	30	330	3	1	7.4	7.0	0.40	0	0	1	1	0	0	0	0	0	0	5
13	30	360	3	1	7.2	5.1	0.65	0	0	1	1	0	0	0	0	2	30	0
14	30	390	3	1	7.1	6.6	0.70	0	0	1	1	0	0	0	0	0	50	2
15	30	420	3	1	7.5	6.9	0.65	0	0	1	1	0	0	0	0	0	20	0
16	30	450	3	1	6.9	6.2	0.65	0	0	1	1	0	0	0	0	0	50	0
17	30	480	3	1	7.4	7.1	0.75	0	0	1	1	0	0	0	0	0	100	0
18	30	510	3	1	7.8	7.2	0.70	0	0	1	1	0	0	0	0	5	60	2
19	30	540	3	1	7.9	7.4	0.65	0	0	1	1	0	0	0	0	2	20	0
20	30	570	3	1	7.8	7.0	0.65	0	0	1	1	0	0	0	0	0	80	0
Stour	**Brook**																	
1	0	0	1	1	5.2	2.3	0.10	0	0	0	1	1	1	0	0	5	100	2
2	20	20	1	1	3.9	3.4	0.10	1	0	1	1	1	1	0	0	20	100	5
3	25	45	1	1	4.1	3.2	0.05	1	0	1	1	1	1	0	0	20	80	2
4	20	65	1	1	4.1	3.1	0.10	1	0	1	1	1	1	0	0	20	20	2
5	25	90	3	2	4.7	4.0	0.25	1	0	1	1	1	0	0	0	10	80	0
6	25	115	3	1	5.5	4.3	0.25	1	0	1	1	1	0	0	0	25	80	0
7	20	135	1	1	4.1	3.6	0.10	1	0	1	1	1	1	0	0	10	50	2
8	25	160	3	2	5.7	4.9	0.35	1	0	1	1	1	1	0	0	50	50	0
9	25	185	3	1	4.9	3.8	0.25	1	0	1	1	1	0	0	0	20	60	0
10	15	200	1	1	4.8	4.1	0.05	1	0	1	1	1	0	0	0	35	10	2
11	25	225	3	1	4.2	2.0	0.10	1	0	1	1	1	0	0	0	40	60	0
12	20	245	1	1	4.8	3.1	0.10	1	0	1	1	1	1	0	0	25	100	0
13	20	265	3	2	4.2	3.1	0.25	1	0	1	1	1	1	0	0	5	80	0
14	25	290	1	1	5.9	2.3	0.05	0	0	1	1	1	1	0	0	5	100	0
15	25	315	1	1	4.6	2.9	0.10	0	0	1	1	1	1	0	0	30	50	2
16	25	340	3	1	3.8	2.3	0.20	1	1	1	1	1	0	0	0	10	100	0
17	25	365	3	2	4.3	3.8	0.45	1	1	1	1	0	1	0	0	20	80	2
18	20	385	1	1	5.2	2.7	0.15	1	1	0	0	0	0	0	0	60	10	0
19	25	410	3	2	6.1	5.0	0.20	1	1	1	1	1	0	0	0	60	70	0
20	25	435	3	2	7.3	3.2	0.25	1	1	1	1	0	0	0	0	40	5	0

Habitat type: 1-Riffle 2-Run 3-Pool Flow type: 1-Visible flow 2-No visible flow Substrate code: 0-Absent 1-Present

Appendix A 28 site habitat survey results for BMWP test

tran-sect no.	dist. down. (m)	cum. dist. (m)	hab-itat type	flow type	channel width (m)	water width (m)	thalweg depth (m)	det-ritus	clay	silt	sand	gra-vel	cob-ble	bou-lder	bed-rock	% inst-ream cover	% over-hanging cover	% bank-side cover
Colne																		
1	0	0	2	1	8.4	7.2	0.30	0	0	1	1	1	0	0	0	5	0	0
2	30	30	2	1	9.1	8.5	0.25	1	0	1	1	1	1	0	0	50	0	10
3	15	45	1	1	7.3	6.9	0.15	0	0	0	0	1	0	0	0	50	5	5
4	30	75	3	1	7.7	7.3	0.30	1	0	1	1	1	1	0	0	60	0	5
5	30	105	3	1	9.3	8.7	0.35	1	0	1	1	1	0	0	0	60	0	10
6	30	135	3	1	6.3	4.9	0.40	1	0	1	1	1	0	0	0	20	0	10
7	30	165	3	2	6.1	5.2	0.80	1	0	1	1	1	0	0	0	60	0	5
8	30	195	2	1	7.8	6.9	0.25	1	0	1	1	1	0	0	0	30	0	2
9	30	225	3	1	5.8	5.0	0.75	1	0	1	1	1	1	0	0	60	0	5
10	30	255	3	1	7.1	6.6	0.80	1	0	1	1	1	0	0	0	60	0	2
11	30	285	3	1	7.4	6.2	1.00	1	0	1	1	1	1	0	0	80	0	15
12	30	315	3	1	8.2	7.1	1.00	1	0	1	1	1	1	0	0	50	80	5
13	30	345	2	1	7.1	4.2	0.20	1	0	0	1	1	1	0	0	40	0	2
14	30	375	3	1	6.7	5.9	0.40	1	0	1	1	1	0	0	0	20	0	2
15	30	405	2	1	8.1	7.1	0.20	1	1	1	1	1	0	0	0	80	0	0
16	30	435	3	2	8.4	8.0	1.00	1	0	1	1	0	0	0	0	75	30	2
17	30	465	3	2	7.2	6.8	1.00	1	1	1	1	0	0	0	0	85	0	0
18	30	495	3	1	7.5	6.9	1.00	1	0	1	1	1	0	0	0	60	0	2
19	30	525	3	2	6.2	4.8	1.00	1	0	1	1	1	0	0	0	90	0	5
20	30	555	3	2	7.2	6.9	1.00	1	0	1	1	1	0	0	0	100	0	0
Roman	**River**																	
1	0	0	3	1	6.9	6.5	0.40	1	0	1	1	1	0	0	0	5	5	5
2	20	20	3	1	4.5	2.3	0.40	1	0	1	1	0	0	0	0	20	0	2
3	20	40	3	1	2.8	2.4	0.45	1	0	1	0	0	0	0	0	20	0	2
4	20	60	3	1	3.0	2.5	0.50	1	0	1	0	0	0	0	0	10	100	0
5	20	80	3	2	3.2	2.8	0.55	1	0	1	0	0	0	0	0	10	100	0
6	20	100	3	2	7.8	6.6	0.60	1	0	1	0	0	0	0	0	5	100	0
7	20	120	3	2	5.0	4.5	0.45	1	0	1	0	0	0	0	0	5	100	2
8	20	140	3	2	4.9	4.2	0.60	1	0	1	1	0	0	0	0	10	10	0
9	20	160	3	2	3.6	3.2	1.20	1	0	1	1	0	0	0	0	5	100	2
10	20	180	3	2	3.7	3.4	0.80	1	0	1	1	0	0	0	0	10	100	10
11	20	200	3	2	4.1	3.8	1.00	1	0	1	1	0	0	0	0	0	100	0
12	20	220	3	2	3.9	3.3	1.00	1	0	1	1	0	0	0	0	2	100	0
13	20	240	3	2	4.8	4.3	0.70	1	0	1	0	0	0	0	0	5	75	2
14	20	260	3	2	3.6	3.4	1.10	1	0	1	0	0	0	0	0	5	20	2
15	20	280	2	1	4.8	4.3	0.80	1	0	1	0	0	0	0	0	80	40	2
16	20	300	3	2	3.7	3.1	0.80	1	0	1	0	0	0	0	0	5	60	2
17	20	320	2	1	3.8	3.3	0.50	1	0	1	0	0	0	0	0	50	20	0
18	20	340	3	2	4.5	4.1	0.65	1	0	1	0	0	0	0	0	0	0	2
19	20	360	3	2	5.0	4.7	0.40	1	0	1	0	0	0	0	0	0	5	0
20	20	380	3	2	4.0	3.6	0.50	1	0	1	0	0	0	0	0	5	80	2
Chelmer																		
1	0	0	3	2	12.6	12.2	1.00	1	0	1	1	0	0	0	0	20	0	0
2	30	30	3	2	12.8	12.4	1.00	1	0	1	1	0	0	0	0	20	0	5
3	30	60	3	2	12.5	11.3	1.00	1	0	1	1	0	0	0	0	10	0	5
4	30	90	3	2	11.2	10.8	1.00	1	0	1	1	0	0	0	0	10	10	10
5	30	120	3	2	12.7	12.4	1.00	1	0	1	1	0	0	0	0	5	20	2
6	30	150	3	2	10.7	10.5	1.00	1	0	1	1	0	0	0	0	5	10	0
7	30	180	3	2	11.6	11.3	1.00	1	0	1	1	0	0	0	0	5	0	2
8	30	210	3	2	10.7	10.3	1.00	1	0	1	1	0	0	0	0	5	10	5
9	30	240	3	2	12.4	11.7	1.00	1	0	1	1	0	0	0	0	20	0	5
10	30	270	3	2	11.3	10.7	1.00	1	0	1	1	0	0	0	0	5	0	0
11	30	300	3	2	11.4	11.0	1.00	1	0	1	1	0	0	0	0	20	0	5
12	30	330	3	2	11.0	10.1	1.00	1	0	1	1	0	0	0	0	5	0	5
13	30	360	3	2	12.6	11.8	1.00	1	0	1	1	0	0	0	0	30	0	2
14	30	390	3	2	12.1	11.6	1.00	1	0	1	1	0	0	0	0	25	0	5
15	30	420	3	2	12.3	11.9	1.00	1	0	1	1	0	0	0	0	20	40	2
16	30	450	3	2	12.6	12.0	1.00	1	0	1	1	0	0	0	0	10	0	2
17	30	480	3	2	11.9	11.5	1.00	1	0	1	1	0	0	0	0	10	20	0
18	30	510	3	2	12.1	11.8	1.00	1	0	1	1	0	0	0	0	5	0	0
19	30	540	3	2	10.6	10.0	1.00	1	0	1	1	0	0	0	0	10	0	5
20	30	570	3	2	11.4	10.8	1.00	1	0	1	1	0	0	0	0	5	0	2
Wid																		
1	0	0	3	1	8.3	7.5	0.30	1	0	1	1	1	1	0	0	10	10	30
2	30	30	3	1	6.4	5.9	0.45	1	0	1	1	1	1	0	0	0	20	2
3	30	60	3	1	6.6	5.9	0.30	1	0	1	1	1	1	0	0	0	0	2
4	30	90	3	1	6.1	5.5	0.40	1	0	1	1	1	1	0	0	0	0	0
5	30	120	3	1	9.7	8.6	0.45	1	0	1	1	1	1	0	0	5	0	0
6	30	150	1	1	8.7	3.9	0.15	1	0	1	1	1	1	0	0	0	0	5
7	30	180	2	1	8.0	6.9	0.20	1	0	1	1	1	1	0	0	5	20	0
8	30	210	3	1	7.3	6.9	0.70	1	0	1	1	1	1	0	0	5	50	2
9	30	240	3	1	7.4	6.8	0.35	1	0	1	1	1	1	0	0	20	0	10
10	30	270	3	1	7.8	7.0	0.40	1	0	1	1	1	1	0	0	5	0	10
11	30	300	2	1	7.0	6.5	0.15	1	0	1	1	1	1	0	0	0	20	58
12	30	330	2	1	7.9	7.0	0.20	1	0	1	1	1	1	0	0	5	0	5
13	30	360	1	1	6.9	6.2	0.05	1	0	1	1	1	1	0	0	0	0	2
14	30	390	3	1	7.1	6.5	0.30	1	0	1	1	1	1	0	0	0	0	20
15	30	420	3	1	6.8	6.2	0.40	1	0	1	1	1	1	0	0	20	5	2
16	30	450	3	1	7.6	7.1	0.60	1	0	1	1	1	1	0	0	10	0	0
17	30	480	3	1	8.1	7.8	0.80	1	0	1	1	1	1	0	0	10	0	10
18	30	510	3	2	8.6	8.1	1.00	1	0	1	1	1	1	0	0	10	0	10
19	30	540	3	2	7.8	7.1	1.00	1	0	1	1	1	1	0	0	10	0	2
20	30	570	3	2	7.8	7.2	1.00	1	0	1	1	1	1	0	0	5	10	5

Habitat type: 1-Riffle 2-Run 3-Pool Flow type: 1-Visible flow 2-No visible flow Substrate code: 0-Absent 1-Present

APPENDIX B

GLEN HABITAT SURVEY RESULTS FOR BMWP TEST

tran-sect no.	dist. down. (m)	cum. dist. (m)	hab-itat type	flow type	channel width (m)	water width (m)	thalweg depth (m)	det-ritus	clay	silt	sand	gra-vel	cob-ble	bou-lder	bed-rock	% inst-ream cover	% over-hanging cover	% bank-side cover
Burton	**Cogg.**																	
1	20	20	5	2	3.2	0.0	0.00	1	1	1	1	1	1	0	0	10	0	5
2	20	40	5	2	2.2	0.0	0.00	1	1	1	1	1	1	0	0	20	0	5
3	20	60	5	2	2.5	0.0	0.00	1	1	1	1	1	1	0	0	0	0	5
4	20	80	3	2	2.7	0.3	0.02	1	1	1	1	1	1	0	0	0	0	2
5	20	100	3	2	3.4	2.7	0.15	1	1	1	1	1	1	0	0	0	0	10
6	20	120	3	2	3.1	2.4	0.26	1	1	1	1	1	1	0	0	0	0	2
7	20	140	5	2	3.5	0.0	0.00	1	1	1	1	1	1	0	0	60	0	0
8	20	160	5	2	2.3	0.0	0.00	1	1	1	1	1	1	0	0	20	0	2
9	20	180	1	2	3.5	0.0	0.00	1	1	1	1	1	1	0	0	20	10	5
10	20	200	3	2	3.4	1.7	0.18	1	1	1	1	1	1	0	0	10	0	5
11	20	220	5	2	2.8	0.0	0.00	1	1	1	1	1	1	0	0	0	0	2
12	20	240	1	2	3.9	0.0	0.00	1	1	1	1	1	1	0	0	0	0	2
13	20	260	5	2	3.1	0.0	0.00	1	1	1	0	0	0	0	0	0	0	0
14	20	280	5	2	3.3	1.0	1.20	1	1	1	0	0	0	0	0	10	0	0
15	20	300	5	2	2.8	0.7	0.80	1	1	1	0	0	0	0	0	20	0	0
16	20	320	5	2	3.2	1.0	0.12	1	1	1	0	0	0	0	0	20	0	0
17	20	340	5	2	3.3	2.2	0.26	1	1	1	0	0	0	0	0	30	0	0
18	20	360	5	2	3.1	1.5	0.21	1	1	1	0	0	0	0	0	40	0	0
19	20	380	3	2	4.2	3.1	0.10	1	1	1	0	0	0	0	0	40	0	0
20	20	400	3	2	4.8	0.0	0.00	1	1	1	0	0	1	0	0	0	0	0
Little	**Byth.**																	
1	0	0	1	1	5.2	3.9	0.13	1	1	1	1	1	1	0	0	40	40	10
2	13	13	1	1	5.1	3.3	0.08	1	0	1	1	1	1	0	0	20	0	5
3	25	38	3	2	5.3	4.0	0.13	1	1	1	1	1	1	0	0	5	40	5
4	25	63	1	1	4.7	3.6	0.10	1	1	1	1	1	1	0	0	15	0	5
5	20	83	1	1	5.2	3.2	0.18	1	1	1	1	1	1	0	0	50	0	5
6	25	108	3	2	4.7	4.2	0.24	1	1	1	1	1	1	0	0	10	10	2
7	25	133	3	2	5.9	4.5	0.29	1	1	1	0	0	1	0	0	0	20	0
8	25	158	3	2	4.7	3.9	0.29	1	1	1	0	0	1	0	0	20	80	2
9	25	183	3	2	4.2	2.6	0.25	1	1	1	0	0	1	0	0	80	0	2
10	25	208	3	2	3.9	2.7	0.11	1	1	1	1	0	1	0	0	50	0	0
11	25	233	3	2	5.1	4.1	0.18	1	1	1	1	0	1	0	0	30	0	0
12	10	243	1	1	4.1	2.1	0.10	1	1	1	1	1	1	0	0	90	0	2
13	25	268	1	1	5.2	3.7	0.14	1	1	1	1	1	1	0	0	40	80	0
14	25	293	3	2	5.4	4.8	0.29	1	1	1	0	0	1	0	0	0	20	2
15	25	318	3	2	5.4	4.9	0.20	1	1	1	0	0	1	0	0	5	20	2
16	25	343	3	2	5.3	4.9	0.19	1	1	1	0	0	1	0	0	0	20	2
17	20	363	1	1	5.6	4.5	0.12	0	0	0	1	1	1	0	0	60	0	5
18	25	388	3	2	5.4	4.6	0.14	1	1	1	1	1	1	0	0	40	50	0
19	25	413	1	1	5.0	4.5	0.08	0	0	0	1	1	1	0	0	70	10	0
20	25	438	3	1	4.8	3.5	0.20	1	1	1	1	1	0	0	0	60	0	0
Shillingt	**horpe**																	
1	0	0	1	1	5.6	5.0	0.20	0	0	0	1	1	1	0	0	70	30	0
2	20	20	3	1	6.4	5.0	0.28	0	0	1	1	1	1	0	0	30	30	2
3	20	40	3	1	6.2	6.0	0.26	0	0	1	1	1	1	0	0	5	5	0
4	20	60	1	1	6.0	5.2	0.15	0	0	0	1	1	1	0	0	50	30	5
5	20	80	3	1	5.7	4.7	0.24	0	0	0	1	1	1	0	0	50	30	5
6	15	95	1	1	5.4	5.1	0.19	0	0	0	1	1	1	0	0	50	20	5
7	20	115	3	1	4.4	3.6	0.42	0	0	1	1	1	0	0	0	40	0	2
8	20	135	3	1	4.8	4.5	0.29	0	0	1	1	1	0	0	0	10	0	0
9	20	155	1	1	5.4	4.7	0.20	0	0	1	1	1	1	0	0	30	0	2
10	15	170	1	1	5.8	5.2	0.12	0	0	0	1	1	1	0	0	20	50	2
11	20	190	3	1	6.3	5.6	0.19	0	0	1	1	1	0	0	0	30	10	2
12	15	205	1	1	6.4	5.9	0.16	0	0	0	1	1	1	0	0	30	0	2
13	20	225	3	1	5.4	4.9	0.20	0	0	1	1	1	0	0	0	10	5	2
14	20	245	3	1	6.1	5.3	0.22	0	0	0	1	1	0	0	0	20	5	0
15	20	265	3	1	6.2	5.5	0.26	1	1	1	1	1	0	0	0	20	0	2
16	20	285	1	1	6.0	5.4	0.17	0	0	0	1	1	1	0	0	20	5	0
17	20	305	3	1	6.1	5.7	0.20	0	0	1	1	1	0	0	0	10	0	2
18	20	325	3	1	6.6	5.3	0.26	0	0	1	1	1	0	0	0	30	5	2
19	20	345	1	1	5.9	5.1	0.16	0	0	0	1	1	0	0	0	30	0	5
20	20	365	1	1	6.0	5.0	0.15	0	0	0	1	1	1	0	0	20	5	0
Edenha	**m**																	
1	0	0	1	1	6.7	3.4	0.02	1	1	1	1	1	1	0	0	10	10	10
2	20	20	3	2	5.2	3.4	0.07	1	1	1	1	1	1	0	0	10	0	0
3	20	40	3	2	6.3	3.3	0.03	1	1	1	0	0	0	0	0	5	0	2
4	20	60	3	2	5.5	4.5	0.09	1	1	1	0	0	0	0	0	10	0	0
5	20	80	3	2	5.4	4.2	0.12	1	1	1	0	0	0	0	0	2	10	0
6	20	100	1	1	4.5	3.2	0.02	1	1	1	1	1	0	0	0	20	0	5
7	20	120	3	2	5.2	4.0	0.03	1	1	1	1	1	0	0	0	10	10	0
8	20	140	3	2	3.7	2.8	0.23	1	1	1	1	1	0	0	0	10	0	2
9	20	160	3	2	4.8	3.9	0.16	1	1	1	0	0	0	0	0	10	0	0
10	20	180	3	2	4.5	3.4	0.18	1	1	1	0	0	0	0	0	0	0	0
11	20	200	3	2	4.7	2.2	0.05	1	1	1	1	1	0	0	0	20	5	0
12	20	220	1	1	5.2	0.8	0.01	0	0	0	1	1	0	0	0	0	0	5
13	20	240	3	2	3.4	3.1	0.22	1	1	1	1	0	0	0	0	2	0	0
14	20	260	3	2	3.2	2.3	0.16	1	1	1	1	0	0	0	0	2	0	2
15	20	280	1	1	2.4	0.8	0.01	1	1	1	1	1	0	0	0	90	0	2
16	20	300	3	2	3.2	1.1	0.02	1	1	1	1	0	0	0	0	80	0	2
17	20	320	3	2	3.7	0.6	0.03	1	1	1	1	1	0	0	0	90	40	2
18	20	340	3	2	4.0	1.8	0.08	1	1	1	1	1	0	0	0	30	0	2
19	20	360	3	2	3.0	2.1	0.14	1	1	1	1	1	0	0	0	20	0	0
20	20	380	1	1	2.5	0.6	0.01	0	0	1	1	0	0	0	0	0	0	10

Habitat type: 1-Riffle 2-Run 3-Pool Flow type: 1-Visible flow 2-No visible flow Substrate code: 0-Absent 1-Present

Appendix B Glen habitat survey results for BMWP test

tran-sect no.	dist. down. (m)	cum. dist. (m)	hab-itat type	flow type	channel width (m)	water width (m)	thalweg depth (m)	det-ritus	clay	silt	sand	gra-vel	cob-ble	bou-lder	bed-rock	% inst-ream cover	% over-hanging cover	% bank-side cover
Bracebo	**ro.**																	
1	0	0	3	2	6.3	1.3	0.02	1	1	1	1	1	0	0	0	30	0	0
2	20	20	3	2	5.0	4.3	0.20	1	1	1	1	1	0	0	0	40	0	2
3	20	40	3	2	5.1	4.0	0.08	1	1	1	1	1	0	0	0	20	0	2
4	20	60	5	2	6.5	0.0	0.00	1	1	1	1	1	0	0	0	0	100	2
5	20	80	5	2	4.8	0.0	0.00	1	1	1	1	1	0	0	0	30	0	0
6	20	100	5	2	5.1	0.0	0.00	1	1	1	1	1	0	0	0	2	0	0
7	20	120	5	2	5.1	0.0	0.00	1	1	1	1	1	0	0	0	20	0	0
8	20	140	5	2	5.3	0.0	0.00	1	1	1	1	1	0	0	0	10	0	0
9	20	160	5	2	4.6	0.0	0.00	1	1	1	0	1	0	0	0	5	0	0
10	20	180	5	2	4.7	0.0	0.00	1	1	1	0	1	0	0	0	10	30	0
11	20	200	3	2	4.9	2.0	0.06	1	1	1	0	0	0	0	0	10	30	0
12	20	220	1	2	6.0	1.3	0.02	1	1	1	0	1	0	0	0	40	40	2
13	20	240	1	2	5.8	4.3	0.34	1	1	1	0	0	0	0	0	20	80	0
14	20	260	1	2	5.1	3.4	0.15	1	1	1	0	1	0	0	0	10	20	0
15	20	280	1	2	5.2	3.8	0.14	1	1	1	0	1	0	0	0	20	40	2
16	20	300	1	2	4.9	3.0	0.16	1	1	1	0	0	0	0	0	20	60	0
17	20	320	1	2	5.0	1.9	0.04	1	1	1	0	0	0	0	0	60	50	0
18	20	340	1	2	5.7	2.3	0.04	1	1	1	0	0	0	0	0	80	10	0
19	20	360	3	2	5.5	2.8	0.09	1	1	1	0	1	0	0	0	30	50	0
20	20	380	3	2	6.3	1.3	0.02	1	1	1	0	1	0	0	0	100	0	0
Kates B	**ridge**																	
1	0	0	1	1	9.2	7.6	0.08	0	0	1	1	1	1	0	0	20	0	5
2	20	20	3	1	10.2	9.2	0.38	0	0	1	1	0	1	0	0	70	0	2
3	20	40	3	1	8.9	8.2	0.48	0	0	1	1	1	1	0	0	20	0	2
4	20	60	3	1	9.1	8.6	0.51	1	1	1	1	1	0	0	0	90	0	5
5	20	80	3	1	9.2	8.4	0.56	1	1	1	1	1	0	0	0	80	0	2
6	20	100	3	1	7.1	6.1	1.00	1	1	1	1	0	0	0	0	70	0	0
7	20	120	3	1	9.1	8.5	1.00	1	1	1	1	0	0	0	0	70	0	0
8	20	140	3	1	8.1	6.3	1.00	1	1	1	1	0	0	0	0	80	0	0
9	20	160	3	1	8.6	6.4	0.56	1	1	1	1	0	0	0	0	70	0	0
10	20	180	3	1	7.4	5.8	0.51	1	1	1	1	1	0	0	0	75	0	0
11	20	200	3	1	7.8	6.2	0.40	1	1	1	1	1	0	0	0	80	0	0
12	20	220	3	1	8.1	7.0	0.35	1	1	1	1	1	0	0	0	70	0	0
13	20	240	3	1	7.2	5.1	0.32	1	1	1	1	1	0	0	0	80	0	0
14	20	260	3	1	6.2	5.4	0.40	1	1	1	1	1	0	0	0	50	0	0
15	20	280	3	1	6.8	5.8	0.37	1	1	1	1	1	0	0	0	50	0	0
16	20	300	3	1	6.6	6.1	0.44	1	1	1	1	1	0	0	0	40	0	0
17	20	320	3	1	8.1	7.6	0.44	1	1	1	1	0	0	0	0	20	0	2
18	20	340	3	1	6.6	5.7	0.45	0	0	0	1	1	1	0	0	40	0	2
19	20	360	3	1	6.2	4.7	0.49	0	0	0	1	1	1	0	0	100	0	0
20	20	380	3	1	8.9	6.9	1.00	0	1	1	1	1	1	0	0	40	5	0

Habitat type: 1-Riffle 2-Run 3-Pool Flow type: 1-Visible flow 2-No visible flow Substrate code: 0-Absent 1-Present

APPENDIX C

BMWP SCORES BY SITE 1980-1990

Appendix C BMWP scores by site 1980-1990

Site	1980	1980	1981	1981	1982	1982	1983	1983	1984	1984	1985	1985	1986	1986
Waithe Beck		•	•	•	96	•	111	92	106	101	91	111	73	117
Barlings Eau		•	•	•	62	•	72	72	55	72	62	81	64	93
Witham		•	•	•	84	•	95	89	65	85	61	93	88	127
North Brook	135	•	122	•	122	•	122	•	•	•	•	•	•	•
Willow Brook	83	73	77	98	94	109	78	•	110	•	93	•	90	•
Harpers Brook		•	80	•	103	•	89	•	122	•	116	•	107	•
Nar	166	•	167	•	195	•	160	•	184	•	142	•	175	•
Stringside	149	•	137	•	117	•	134	•	160	•	•	•	154	•
Wissey	160	•	194	•	200	•	214	•	198	•	223	•	168	•
Thet	158	•	183	•	154	•	66	105	124	•	•	•	95	•
Little Ouse	143	•	137	130	•	•	147	132	187	•	135	•	119	•
Snail	64	•	57	•	67	•	60	•	76	•	43	•	61	•
Swaffham Lode	57	72	70	•	77	•	74	•	72	•	•	•	89	68
Granta	96	138	123	•	116	•	96	•	•	•	109	•	96	•
Hiz	72	•	57	•	110	•	137	•	101	•	101	136	88	•
Burn	42	•	63	•	64	•	68	•	78	•	57	•	67	•
Tud	144	•	104	•	108	•	125	•	126	•	135	•	126	•
Tas	101	•	117	•	83	•	110	•	105	•	112	•	109	•
Waveney	60	•	71	•	83	•	54	•	87	•	67	•	74	•
Alde	78	•	60	•	78	•	85	•	89	•	84	•	76	•
Gipping	30	•	33	•	37	•	40	•	•	•	46	•	30	•
Deben	90	•	99	•	136	•	107	•	79	•	111	•	93	•
Stour	73	•	83	•	71	44	37	62	72	76	20	30	42	41
Stour Brook	8	•	17	21	•	•	28	•	•	•	•	•	35	•
Colne	78	•	82	103	127	•	100	124	120	•	129	•	135	•
Roman River	77	•	70	105	116	•	106	•	87	•	77	•	71	•
Chelmer		•	•	•	•	•	•	•	•	•	•	•	•	•
Wid	44	•	35	55	58	55	61	•	72	•	67	•	32	•

Site	1986	1987	1987	1987	1988	1988	1988	1989	1989	1989	1989	1990	1990	Ave.
Waithe Beck	•	117	106	92	101	105	108	101	101	•	•	92	•	101
Barlings Eau	•	70	71	68	86	86	82	78	90	•	•	66	•	74
Witham	104	82	79	92	94	91	82	99	80	•	•	75	•	88
North Brook	•	110	112	106	114	94	154	180	140	•	•	156	•	128
Willow Brook	•	104	•	•	102	•	•	146	•	•	•	•	•	97
Harpers Brook	•	95	•	•	77	•	•	100	99	•	•	93	•	98
Nar	•	180	•	•	173	•	•	149	•	•	•	•	•	169
Stringside	•	120	•	•	141	•	•	104	•	•	•	56	•	127
Wissey	•	212	•	•	186	•	•	128	•	•	•	101	•	180
Thet	•	64	•	•	62	•	•	53	•	•	•	72	•	105
Little Ouse	•	141	•	•	176	•	•	109	135	135	•	126	•	139
Snail	•	64	•	•	60	•	•	50	38	•	•	47	29	55
Swaffham Lode	•	73	60	•	62	•	•	52	38	•	•	54	77	66
Granta	•	75	•	•	85	•	•	85	82	42	•	57	70	91
Hiz	•	70	•	•	78	•	•	73	70	89	•	83	•	90
Burn	•	73	•	•	87	•	•	73	65	67	•	67	•	67
Tud	•	119	•	•	110	•	•	108	105	122	119	99	•	118
Tas	•	•	•	•	•	•	•	83	95	101	•	99	•	101
Waveney	•	71	•	•	86	•	•	75	71	•	•	93	•	74
Alde	•	•	•	•	68	•	•	72	74	•	•	77	•	77
Gipping	•	74	•	•	41	32	•	28	10	•	•	24	•	35
Deben	•	•	•	•	102	•	•	71	106	78	•	108	•	98
Stour	•	31	56	•	46	50	•	72	63	86	•	98	•	58
Stour Brook	•	26	•	•	21	•	•	31	33	•	•	27	•	25
Colne	•	130	•	•	117	•	•	129	127	107	•	102	•	114
Roman River	•	90	•	•	66	•	•	50	55	40	•	65	•	77
Chelmer	•	•	•	•	•	•	•	74	69	68	•	61	•	68
Wid	•	56	•	•	48	•	•	52	46	31	•	44	•	50

APPENDIX D

RIVER GLEN PHYSICAL HABITAT SURVEY RESULTS

		WEST	GLEN					EAST	GLEN		
Reach Number	Distance Down. (m)	Cumulative Distance (m)	Channel Width (m)	Water Width (m)	Channel Type	Reach Number	Distance Down. (m)	Cumulative Distance (m)	Channel Width (m)	Water Width (m)	Channel Type
UWGL 001	0	0	1.8	0.7	5	UEGL 001	0	0	0.7	0.2	5
	60	60	0.9	0.0	4		50	50	1.1	0.4	5
	60	120	1.0	0.0	4		50	100	1.0	0.3	5
	60	180	1.0	0.0	4		50	150	1.0	0.2	5
	60	240	0.9	0.0	4		50	200	1.1	0.2	5
	60	300	1.1	0.0	4		50	250	1.2	0.0	4
	60	360	1.0	0.0	4		50	300	0.9	0.0	4
	60	420	1.2	0.0	4		50	350	0.9	0.0	4
	60	480	1.1	0.0	4		50	400	1.0	0.0	4
	60	540	1.3	0.0	4		50	450	1.3	0.0	4
UWGL 002	60	600	1.3	0.0	4	UEGL 002	50	500	1.1	0.0	4
	50	650	1.6	0.0	4		50	550	1.0	0.0	4
	50	700	1.8	0.0	4		125	675	1.3	0.0	4
	50	750	1.4	0.0	4		50	725	0.9	0.0	4
	50	800	1.7	0.0	4		50	775	1.3	0.0	4
	50	850	1.4	0.0	4		50	825	1.2	0.0	4
	50	900	1.5	0.0	4		50	875	1.5	0.0	4
	50	950	1.7	0.7	5		50	925	1.3	0.0	4
	50	1000	1.6	0.8	5		50	975	1.3	0.0	4
	50	1050	1.7	0.7	5	UEGL 003	50	1025	1.4	0.0	4
UWGL 003	50	1100	1.5	0.0	4		52	1077	1.5	0.0	4
	47	1147	1.8	0.0	4		53	1130	2.1	0.0	4
	48	1195	1.8	0.0	4		52	1182	1.8	0.0	4
	47	1242	1.4	0.0	4		53	1235	2.0	0.0	4
	48	1290	1.6	0.0	4		52	1287	1.6	0.0	4
	47	1337	1.8	0.0	4		53	1340	2.2	1.2	6
	48	1385	2.0	0.0	4		52	1392	1.9	1.0	5
	47	1432	1.7	0.0	4		53	1445	1.7	1.0	5
	48	1480	1.7	0.0	4		52	1497	2.5	1.4	5
	47	1527	1.7	0.0	4	UEGL 004	53	1550	2.8	1.4	5
UWGL 004	48	1575	1.6	0.0	4		40	1590	1.4	0.2	1
	52	1627	1.8	0.0	4		10	1600	2.1	1.2	5
	53	1680	2.0	0.0	4		50	1650	1.8	0.9	5
	52	1732	1.5	0.0	4		50	1700	1.5	0.6	5
	53	1785	1.6	0.0	4		50	1750	2.1	0.6	5
	52	1837	1.8	0.0	4		50	1800	1.7	1.1	5
	53	1890	1.6	0.3	5		50	1850	1.6	1.0	5
	52	1942	1.4	0.0	4		50	1900	2.0	1.2	5
	53	1995	2.0	0.6	5		50	1950	1.7	0.7	5
	52	2047	1.7	0.5	5		50	2000	1.9	1.4	5
UWGL 005	53	2100	2.0	1.7	5	UEGL 005	50	2050	1.9	0.3	5
	52	2152	1.8	0.0	4		50	2100	2.0	1.2	5
	53	2205	1.9	0.0	4		50	2150	1.5	1.1	5
	52	2257	1.7	0.0	4		25	2175	2.7	0.4	1
	53	2310	2.2	0.0	4		50	2225	1.5	0.8	5
	52	2362	1.4	1.2	5		50	2275	1.5	0.9	5
	53	2415	1.7	0.0	4		50	2325	1.4	0.0	4
	52	2467	1.7	0.0	4		50	2375	1.6	0.0	4
	53	2520	1.5	0.0	4		50	2425	1.8	0.0	4
	52	2572	1.8	0.8	5		50	2475	1.7	0.0	4
UWGL 006	53	2625	2.0	1.0	5		50	2525	2.0	0.0	4
	52	2677	1.6	0.0	4	UEGL 006	50	2575	2.8	0.0	4
	53	2730	1.8	0.0	4		52	2627	1.9	0.0	4
	52	2782	1.8	0.8	5		53	2680	1.9	0.0	4
	53	2835	1.9	1.0	5		52	2732	1.6	0.0	4
	52	2887	1.8	0.9	5		53	2785	2.0	0.0	4
	53	2940	1.7	1.0	5		52	2837	2.0	0.0	4
	52	2992	1.9	0.7	5		53	2890	1.8	0.0	4
	53	3045	1.8	0.8	5		52	2942	2.2	0.0	4
	52	3097	1.8	1.2	5		53	2995	2.2	0.0	4
UWGL 007	53	3150	2.4	1.9	5		52	3047	2.3	0.0	4
	67	3217	2.0	0.8	5	UEGL 007	53	3100	2.8	0.0	4
	68	3285	1.8	1.1	5		55	3155	2.1	0.0	4
	67	3352	2.8	0.4	5		55	3210	2.3	0.0	4
	68	3420	2.2	0.8	5		55	3265	2.6	0.0	4
	67	3487	2.0	0.0	4		55	3320	2.7	0.0	4
	68	3555	2.9	0.2	5		55	3375	2.5	0.0	4
	67	3622	2.2	1.2	5		55	3430	2.6	0.0	4
	68	3690	2.2	0.0	4		55	3485	2.2	0.0	4

		WEST	GLEN					EAST	GLEN		
Reach Number	Distance Down. (m)	Cumulative Distance (m)	Channel Width (m)	Water Width (m)	Channel Type	Reach Number	Distance Down. (m)	Cumulative Distance (m)	Channel Width (m)	Water Width (m)	Channel Type
	67	3757	2.4	0.0	4		55	3540	2.6	0.0	4
WGLE 001	68	3825	3.9	3.4	5		55	3595	2.6	0.0	4
	35	3860	2.1	0.7	1	UEGL 008	55	3650	2.7	0.0	4
	23	3883	2.5	0.8	1		48	3698	2.2	0.0	4
	50	3933	3.1	1.6	3		47	3745	2.2	0.0	4
	55	3988	3.2	0.8	1		48	3793	2.4	0.0	4
	24	4012	2.8	1.1	1		47	3840	2.3	0.0	4
	55	4067	3.1	2.7	5		48	3888	2.4	0.0	4
	55	4122	2.7	1.9	5		47	3935	2.8	0.0	4
	47	4169	3.0	0.7	1		48	3983	2.7	0.0	4
	55	4224	2.9	2.1	5		47	4030	2.5	0.0	4
	55	4279	3.4	2.9	5		48	4078	2.7	0.0	4
WGLE 002	71	4350	3.2	1.4	3	UEGL 009	47	4125	2.8	0.0	4
	47	4397	3.9	1.7	5		48	4173	2.8	0.0	4
	45	4442	2.7	0.8	1		47	4220	2.6	0.0	4
	47	4489	2.8	1.1	5		48	4268	2.8	0.0	4
	47	4536	2.1	1.6	5		47	4315	3.0	0.0	4
	47	4583	2.2	1.9	5		48	4363	2.9	0.0	4
	47	4630	2.9	2.4	5		47	4410	3.0	0.0	4
	47	4677	3.1	2.2	5		48	4458	2.4	0.0	4
	47	4724	2.4	2.2	5		47	4505	2.9	0.0	4
	46	4770	2.5	2.3	5		48	4553	2.8	0.0	4
WGLE 003	55	4825	2.0	1.5	5	UEGL 010	47	4600	3.0	0.0	4
	50	4875	1.9	1.2	5		53	4653	2.9	0.6	5
	50	4925	2.5	2.3	5		52	4705	3.1	1.4	5
	50	4975	2.9	0.8	3		53	4758	2.8	0.0	4
	50	5025	2.9	2.6	5		52	4810	2.8	1.2	5
	50	5075	2.7	2.4	5		53	4863	2.8	0.0	4
	50	5125	2.1	0.9	3		52	4915	3.0	0.0	4
	50	5175	3.1	2.9	5		53	4868	2.9	0.0	4
	50	5225	2.4	1.1	5		52	5020	3.0	0.5	5
	50	5275	3.1	0.5	3		53	5073	2.8	0.0	4
WGLE 004	50	5325	2.4	1.9	5	UEGL 011	52	5125	2.9	0.0	4
	52	5377	2.1	1.2	5		50	5175	2.9	0.0	4
	53	5430	2.2	0.7	3		50	5225	3.0	0.0	4
	52	5482	2.0	0.6	3		50	5275	2.9	0.0	4
	53	5535	2.1	0.7	3		50	5325	2.4	0.0	4
	52	5587	2.3	2.0	5		50	5375	3.1	0.0	4
	53	5640	2.6	2.3	5		50	5425	3.0	0.0	4
	52	5692	2.0	0.5	5		50	5475	3.0	0.0	4
	53	5745	1.6	0.8	3		50	5525	2.7	0.0	4
	52	5797	2.1	1.8	5		50	5575	2.8	0.0	4
WGLE 005	53	5850	1.8	0.9	5	UEGL 012	50	5625	2.9	1.0	5
	52	5802	1.9	0.7	5		53	5678	3.2	1.0	5
	53	5955	2.0	1.0	5		52	5730	3.0	1.4	5
	52	6007	2.5	0.6	5		53	5783	2.5	0.7	5
	53	6060	2.6	2.0	5		52	5835	3.2	1.2	5
	52	6112	1.9	1.3	5		53	5888	2.2	0.0	4
	53	6165	2.9	0.8	5		52	5940	2.5	0.0	4
	52	6217	3.0	0.5	5		53	5993	3.0	1.1	5
	53	6270	3.2	2.9	5		52	6045	2.7	0.8	5
	52	6322	2.7	1.0	5		53	6098	2.4	1.0	5
WGLE 006	53	6375	3.4	1.2	5	UEGL 013	52	6150	2.4	0.6	5
	61	6436	2.2	1.9	5		50	6200	2.9	1.4	5
	61	6497	1.8	0.5	3		50	6250	2.8	1.2	5
	61	6558	3.1	2.6	5		50	6300	3.2	1.1	5
	60	6618	2.6	1.9	5		50	6350	2.6	0.0	4
	50	6668	3.0	2.6	5		50	6400	3.0	1.1	5
	28	6696	2.3	0.9	1		50	6450	3.1	0.9	5
	61	6757	3.1	2.8	5		50	6500	2.9	0.4	5
	61	6818	2.9	1.1	5		50	6550	3.3	0.0	4
	41	6859	3.0	1.4	1		50	6600	2.9	0.0	4
	60	6919	2.6	1.5	5	UEGL 014	50	6650	3.1	1.0	5
WGLE 007	31	6950	3.4	1.3	5		50	6700	2.7	0.0	4
	53	7003	4.2	2.1	2		50	6750	2.6	0.9	5
	11	7014	3.2	1.3	1		50	6800	2.8	1.3	5
	30	7044	2.5	1.3	1		50	6850	2.6	1.3	5
	53	7097	2.7	1.8	5		50	6900	2.8	1.1	5
	53	7150	3.2	2.5	5		50	6950	2.9	1.6	5

		WEST	GLEN					EAST	GLEN		
Reach Number	Distance Down. (m)	Cumulative Distance (m)	Channel Width (m)	Water Width (m)	Channel Type	Reach Number	Distance Down. (m)	Cumulative Distance (m)	Channel Width (m)	Water Width (m)	Channel Type
	53	7203	3.6	2.5	6		50	7000	2.7	1.4	5
	48	7251	2.9	1.4	1		50	7050	3.0	0.7	3
	53	7304	4.1	2.8	5		50	7100	2.5	2.0	5
	53	7357	3.5	2.6	5	EGLE 001	50	7150	2.4	1.2	5
	53	7410	3.2	1.7	5		65	7215	2.7	1.4	5
	54	7464	3.2	2.4	5		65	7280	2.4	1.3	5
WGLE 008	11	7475	2.9	1.5	5		65	7345	2.2	1.6	5
	47	7522	3.0	2.0	5		65	7410	2.7	1.2	5
	48	7570	3.6	2.6	5		65	7475	2.6	2.0	5
	47	7617	3.0	2.5	5		65	7540	3.1	1.0	5
	48	7665	4.2	2.9	1		65	7605	2.7	2.2	5
	47	7712	2.8	1.8	5		65	7670	3.0	2.0	5
	48	7760	3.1	2.8	5		65	7735	2.8	1.4	5
	47	7807	2.9	1.7	5	EGLE 002	65	7800	2.4	1.4	5
	48	7855	3.0	2.6	5		52	7852	3.0	1.3	5
	47	7902	2.8	2.0	5		53	7905	2.9	1.1	6
WGLE 009	48	7950	4.2	2.9	2		52	7957	2.4	1.8	5
	52	8002	3.1	1.2	3		53	8010	2.5	1.4	5
	53	8055	2.4	1.9	5		52	8062	2.1	1.5	5
	52	8107	3.2	2.7	5		53	8115	2.8	2.2	5
	53	8160	4.2	1.9	5		52	8167	2.5	1.9	5
	52	8212	3.8	0.6	3		53	8220	2.5	1.6	5
	53	8265	3.4	0.8	3		52	8272	2.7	1.9	5
	52	8317	3.1	1.5	5	EGLE 003	53	8325	2.4	1.8	5
	53	8370	2.6	1.7	5		52	8377	3.7	3.2	5
	52	8422	2.7	1.4	5		53	8430	2.7	1.1	5
WGLE 010	53	8475	4.1	3.8	5		52	8482	3.0	2.6	5
	10	8485	3.0	0.8	1		53	8535	3.2	1.8	5
	49	8534	3.0	2.1	5		52	8587	3.1	2.0	5
	49	8583	2.6	2.2	5		53	8640	2.8	1.6	5
	40	8623	3.3	2.9	1		52	8692	2.9	2.1	5
	49	8672	3.2	2.7	5		53	8745	3.4	2.8	5
	9	8681	2.7	1.0	1		52	8797	2.8	1.7	5
	50	8731	3.7	1.4	1	EGLE 004	53	8850	3.0	2.0	6
	49	8780	4.2	3.5	1		55	8905	2.8	2.1	6
	49	8829	3.4	1.2	1		55	8960	3.1	1.8	6
	47	8876	2.8	1.4	1		55	9015	2.8	2.5	5
	49	8925	2.6	1.9	5		55	9070	3.0	2.4	5
WGLE 011	50	8975	3.6	2.8	5		55	9125	3.2	2.6	5
	58	9033	3.0	2.1	5		55	9180	3.0	2.6	5
	58	9091	3.4	2.9	5		55	9235	2.5	1.9	5
	59	9150	3.1	2.8	5		55	9290	2.8	2.5	5
	58	9208	3.6	2.9	2		55	9345	2.8	2.4	5
	30	9238	3.8	0.6	1	EGLE 005	55	9400	2.6	1.1	6
	20	9258	3.4	1.8	5		100	9500	2.7	1.9	5
	58	9316	3.0	2.4	5		47	9547	2.9	2.3	5
	20	9336	3.1	0.7	1		47	9594	2.9	1.6	1
	47	9383	2.8	0.9	1		26	9620	2.7	2.0	5
	17	9400	3.0	1.6	1		47	9667	2.5	1.9	5
	20	9420	2.5	1.6	1		46	9713	2.4	1.9	5
	14	9434	2.4	1.9	5		47	9760	3.0	2.2	5
	59	9493	2.9	1.1	1		47	9807	3.0	2.2	5
	20	9513	3.8	3.3	5		47	9854	3.4	2.8	5
WGLE 012	12	9525	3.9	3.6	5	EGLE 006	46	9900	2.6	2.0	5
	46	9571	3.8	2.5	1		50	9950	3.2	1.4	5
	46	9617	2.4	0.9	1		50	10000	3.0	2.0	5
	46	9663	3.6	3.2	5		50	10050	2.3	1.3	5
	47	9710	3.4	2.7	5		50	10100	3.5	2.9	5
	46	9756	2.9	1.6	1		50	10150	2.6	0.7	3
	39	9795	3.9	3.5	5		50	10200	2.9	2.5	5
	46	9841	3.7	3.4	5		50	10250	3.2	2.5	5
	47	9888	3.8	3.5	5		50	10300	3.5	3.0	5
	47	9935	3.5	3.0	5		50	10350	2.7	1.7	5
WGLE 013	65	10000	3.9	3.0	6		50	10400	3.1	2.6	5
	35	10035	2.4	0.7	1		50	10450	3.0	1.8	5
	62	10097	2.1	0.5	3	EGLE 007	50	10500	2.8	1.9	5
	63	10160	2.4	0.3	1		50	10550	2.8	2.1	5
	20	10180	2.4	0.4	1		50	10600	3.2	2.6	5
	26	10206	2.1	0.7	6		50	10650	3.7	3.2	5

Appendix D River Glen physical habitat survey results

		WEST	GLEN					EAST	GLEN		
Reach	Distance	Cumulative	Channel	Water	Channel	Reach	Distance	Cumulative	Channel	Water	Channel
Number	Down.	Distance	Width	Width	Type	Number	Down.	Distance	Width	Width	Type
	(m)	(m)	(m)	(m)			(m)	(m)	(m)	(m)	
	24	10230	1.9	0.0	4		50	10700	3.0	2.4	6
	43	10273	2.1	0.0	4		50	10750	3.1	2.7	6
	43	10316	2.3	0.0	4		50	10800	2.7	2.2	6
	43	10359	2.4	0.0	4		50	10850	3.2	2.7	6
	43	10402	2.0	0.0	4		50	10900	3.0	2.7	6
	43	10445	2.4	0.0	4		50	10950	3.5	3.1	6
	43	10488	2.2	0.0	4	EGLE 008	50	11000	3.2	2.5	6
WGLE 014	37	10525	2.2	0.0	4		60	11060	4.4	2.2	5
	50	10575	2.3	0.0	4		60	11120	3.6	2.1	5
	50	10625	3.2	0.0	4		60	11180	5.9	2.5	5
	50	10675	2.3	0.0	4		60	11240	3.9	2.4	5
	50	10725	3.2	0.0	4		60	11300	3.3	2.2	5
	50	10775	3.0	0.0	4		60	11360	5.0	3.3	5
	50	10825	2.4	0.0	4		60	11420	4.8	3.5	5
	50	10875	2.6	0.0	4		60	11480	4.7	3.8	5
	50	10925	2.6	0.0	4		60	11540	4.1	2.4	5
	50	10975	2.5	0.0	4	EGLE 009	60	11600	4.6	2.7	5
WGLE 015	50	11025	2.9	0.0	4		50	11650	4.9	2.6	5
	50	11075	2.7	0.0	4		50	11700	3.0	1.8	5
	50	11125	2.7	0.0	4		50	11750	3.6	1.7	5
	50	11175	3.2	0.0	4		50	11800	3.7	1.9	5
	50	11225	2.6	0.0	4		50	11850	4.0	1.8	5
	50	11275	3.1	0.0	4		50	11900	3.7	1.6	5
	50	11325	3.0	0.0	4		50	11950	3.5	2.1	5
	50	11375	2.7	0.0	4		50	12000	4.6	1.5	5
	50	11425	2.9	0.0	4		50	12050	3.3	1.1	5
	50	11475	2.9	0.0	4	EGLE 010	50	12100	3.7	1.3	5
WGLE 016	50	11525	2.7	0.0	4		50	12150	3.4	1.7	5
	15	11540	3.4	2.7	2		50	12200	3.3	2.5	5
	50	11590	3.8	2.8	5		50	12250	3.0	1.8	5
	50	11640	2.5	0.0	4		50	12300	3.3	1.9	5
	24	11664	3.5	0.0	4		50	12350	4.0	1.4	5
	32	11696	3.5	0.0	4		50	12400	4.2	2.7	5
	50	11746	3.4	0.0	4		50	12450	3.1	1.9	5
	50	11796	4.0	0.0	4		50	12500	3.9	2.0	5
	50	11846	4.0	0.0	4		50	12550	4.0	2.2	5
	50	11896	4.5	0.0	4	EGLE 011	50	12600	3.4	2.6	5
	50	11946	4.4	0.0	1		59	12659	4.1	2.6	5
	42	11988	4.1	0.8	1		59	12718	4.0	2.4	5
WGLE 017	37	12025	3.8	2.4	5		59	12777	4.4	2.4	5
	50	12075	3.8	2.4	5		59	12836	5.4	1.7	6
	50	12125	5.5	1.7	6		59	12895	4.2	2.4	5
	50	12175	3.6	1.8	5		59	12954	4.1	2.8	5
	50	12225	3.5	1.7	1		59	13013	4.6	1.4	5
	48	12273	4.7	2.0	5		59	13072	5.1	2.9	5
	50	12323	3.3	1.6	6		59	13131	3.6	1.9	5
	50	12373	3.5	1.9	5		59	13190	3.3	1.8	6
	50	12423	3.9	1.7	5	EGLE 012	60	13250	4.1	2.5	5
	50	12473	3.7	2.3	5		65	13315	5.0	3.0	5
	50	12523	4.7	2.8	5		65	13380	4.0	2.3	5
	51	12574	3.7	1.9	5		66	13446	2.7	1.8	5
WGLE 018	51	12625	3.1	2.0	5		65	135[illegible]	4.6	4.0	5
	46	12671	2.9	0.8	1		66	13577	4.4	2.6	1
	48	12719	2.6	1.5	5		42	13619	5.6	3.6	5
	46	12765	2.7	1.4	1		65	13684	3.5	1.5	5
	46	12811	2.8	0.9	1	EGLE 013	66	13750	2.7	1.8	5
	40	12851	3.3	1.5	5		57	13807	3.7	2.4	5
	45	12896	3.5	1.5	5		57	13864	3.5	2.2	5
	46	12942	5.2	1.3	5		58	13922	4.7	3.1	5
	46	12988	2.7	1.2	1		57	13979	5.8	2.2	1
	10	12998	2.2	0.7	1		35	14014	4.6	2.5	1
	20	13018	3.6	0.8	1		20	14034	4.6	2.7	5
	37	13055	3.9	2.1	5		58	14092	3.0	2.2	5
WGLE 019	45	13100	3.6	0.8	5		48	14140	4.8	2.5	1
	48	13148	3.9	1.6	5		35	14175	4.4	2.4	1
	48	13196	3.8	1.5	5		19	14194	4.1	2.4	5
	48	13244	4.3	1.2	3		58	14252	3.8	2.7	5
	48	13292	3.7	1.3	1	EGLE 014	48	14300	4.1	1.9	1
	33	13325	4.2	2.0	1		40	14340	3.8	2.0	1

		WEST	GLEN					EAST	GLEN		
Reach Number	Distance Down. (m)	Cumulative Distance (m)	Channel Width (m)	Water Width (m)	Channel Type	Reach Number	Distance Down. (m)	Cumulative Distance (m)	Channel Width (m)	Water Width (m)	Channel Type
	13	13338	3.6	1.8	5		42	14382	3.6	1.0	1
	48	13386	4.2	2.3	5		18	14400	4.3	2.4	5
	48	13434	3.2	1.3	1		46	14446	3.8	2.3	1
	48	13482	3.5	1.5	5		25	14471	3.1	1.6	5
	48	13530	3.3	0.6	1		47	14518	5.0	2.7	5
	48	13578	3.5	0.4	3		46	14564	3.6	2.4	5
WGLE 020	47	13625	4.2	2.4	5		47	14611	4.2	3.2	5
	52	13677	3.7	1.5	3		46	14657	4.7	3.6	5
	53	13730	3.4	1.9	5		47	14704	3.8	3.0	5
	52	13782	4.0	1.1	6	EGLE 015	46	14750	4.0	3.1	5
	53	13835	6.3	2.1	6		50	14800	4.2	3.6	5
	52	13887	4.5	0.9	3		50	14850	4.2	2.4	5
	53	13940	4.5	2.0	5		50	14900	3.9	2.2	5
	52	13992	4.6	2.0	5		50	14950	5.4	3.5	5
	53	14045	4.7	2.1	5		50	15000	7.4	3.0	5
	52	14097	4.1	1.8	5		50	15050	5.2	2.1	5
WGLE 021	53	14150	5.2	3.7	5		50	15100	4.2	3.5	5
	48	14198	5.9	3.8	5		50	15150	2.9	2.5	5
	47	14243	6.2	4.0	5		50	15200	3.1	2.6	5
	46	14289	4.6	0.7	3	EGLE 016	50	15250	4.8	3.8	5
	47	14336	5.2	4.1	5		50	15300	3.7	3.2	5
	46	14382	5.9	1.5	3		50	15350	2.9	2.2	5
	47	14429	4.1	0.0	4		50	15400	3.0	2.4	5
WGLE 022	46	14475	4.1	0.0	4		50	15450	2.8	2.3	5
	50	14525	5.0	0.0	4		50	15500	4.1	3.0	5
	50	14575	4.4	0.0	4		50	15550	3.0	2.4	5
	50	14625	4.3	0.0	4		50	15600	3.4	3.0	5
	50	14675	4.9	0.0	4		50	15650	3.5	2.8	1
	50	14725	4.5	0.0	4		50	15700	3.8	2.3	5
	50	14775	4.6	0.0	4	EGLE 017	50	15750	4.1	3.2	5
	50	14825	3.9	0.0	4		53	15803	3.9	2.7	5
	50	14875	5.0	0.0	4		54	15857	3.1	2.4	5
	50	14925	4.2	0.0	4		53	15910	3.2	2.7	5
WGLE 023	50	14975	4.4	0.0	4		54	15964	3.8	2.6	5
	52	15027	4.7	0.0	4		53	16017	5.7	3.2	1
	52	15079	4.6	0.0	4		15	16032	4.9	3.4	5
	52	15131	5.3	0.0	4		54	16086	3.9	2.9	1
	52	15183	4.4	0.0	4		53	16139	3.3	2.6	5
	53	15236	3.8	0.0	4		54	16193	3.6	2.9	1
	52	15288	4.6	0.0	4		53	16246	4.8	2.7	1
	52	15340	5.0	0.0	4	EGLE 018	54	16300	4.1	1.3	5
	52	15392	4.1	0.0	4		44	16344	4.5	0.3	1
	52	15444	3.9	0.0	4		36	16380	3.6	3.0	5
	53	15497	4.0	0.0	4		44	16424	3.2	2.6	5
WGLE 024	53	15550	3.8	0.0	4		44	16468	2.9	0.7	1
	50	15600	4.0	0.0	4		44	16512	3.1	2.1	5
	50	15650	5.3	0.0	4		44	16556	3.8	1.3	1
	50	15700	5.1	0.0	4		48	16604	2.9	2.7	5
	50	15750	5.2	0.0	4		44	16648	2.6	1.6	5
	50	15800	4.9	0.0	4		44	16692	3.0	0.7	1
	50	15850	5.6	0.0	4		40	16732	2.7	1.4	5
	50	15900	5.8	0.0	4	EGLE 019	43	16775	2.6	1.5	5
	50	15950	5.4	0.0	4		55	16830	3.2	2.4	5
	50	16000	3.9	0.0	4		55	16885	3.2	2.6	5
WGLE 025	50	16050	5.2	0.0	4		55	16940	3.7	3.3	5
	50	16100	6.1	0.0	4		55	16995	4.4	3.3	5
	50	16150	6.1	0.0	4		55	17050	3.3	1.2	1
	50	16200	4.8	0.0	4		55	17105	2.8	2.2	5
	50	16250	4.1	0.0	4		55	17160	3.6	1.1	1
	50	16300	4.1	0.0	4		22	17182	3.1	1.7	5
	50	16350	4.6	0.0	4		56	17238	3.5	0.9	1
	50	16400	3.6	0.0	4	EGLE 020	37	17275	3.3	1.7	5
	50	16450	3.5	0.0	4		41	17316	4.3	3.7	5
	50	16500	3.8	0.0	4		41	17357	3.6	3.2	5
	50	16550	4.2	0.0	4		41	17398	3.5	3.1	5
WGLE 026	50	16600	4.4	0.0	4		41	17439	4.5	4.0	5
	52	16652	3.8	0.0	4		41	17480	4.9	4.1	5
	53	16705	4.6	0.0	4		41	17521	4.4	3.8	5
	52	16757	3.8	0.0	4		41	17562	5.0	4.6	5

		WEST	GLEN					EAST	GLEN		
Reach Number	Distance Down. (m)	Cumulative Distance (m)	Channel Width (m)	Water Width (m)	Channel Type	Reach Number	Distance Down. (m)	Cumulative Distance (m)	Channel Width (m)	Water Width (m)	Channel Type
	53	16810	5.1	0.0	4		41	17603	4.3	3.1	2
	52	16862	4.2	0.0	4		41	17644	4.8	4.3	5
	53	16915	4.3	0.0	4		41	17685	5.2	4.7	5
	52	16967	4.1	0.0	4		41	17726	5.3	1.1	1
	53	17020	4.2	0.0	4	EGLE 021	24	17750	5.3	1.4	1
	52	17072	4.9	0.0	4		45	17795	4.2	0.6	1
WGLE 027	53	17125	3.7	0.0	4		36	17831	4.7	0.6	1
	50	17175	4.1	0.0	4		22	17853	3.3	1.3	1
	50	17225	4.4	0.0	4		21	17874	3.4	0.2	1
	50	17275	4.2	0.0	4		26	17900	2.7	1.7	1
	50	17325	3.4	0.0	4		53	17953	4.1	0.8	1
	50	17375	3.9	0.0	4		44	17997	3.7	0.4	1
	50	17425	5.2	0.0	4		54	18051	2.3	1.6	5
	50	17475	3.5	0.0	4		53	18104	3.8	0.6	1
	50	17525	3.3	0.0	4		45	18149	4.3	0.8	1
	50	17575	3.0	0.0	4		47	18196	3.3	2.3	5
WGLE 028	50	17625	3.1	0.0	4	EGLE 022	54	18250	3.8	2.5	5
	52	17677	3.0	0.0	4		73	18323	4.1	3.3	5
	53	17730	3.2	0.0	4		72	18395	4.1	3.8	5
	52	17782	2.9	0.0	4		73	18468	2.8	0.0	4
	53	17835	3.2	0.0	4		72	18540	4.0	3.6	2
	52	17887	3.6	0.0	4		73	18613	2.7	0.0	1
	53	17940	3.6	0.0	4		43	18656	3.0	2.1	5
	52	17992	3.2	0.0	4		72	18728	3.1	2.1	5
	53	18045	3.2	0.0	4	EGLE 023	72	18800	2.1	0.0	4
	52	18097	3.2	0.0	4		46	18846	3.2	0.0	4
WGLE 029	53	18150	2.8	0.0	4		48	18894	3.9	0.7	1
	55	18205	3.6	0.0	4		18	18912	3.3	1.9	1
	55	18260	3.4	2.0	5		46	18958	3.5	1.5	1
	55	18315	3.3	0.0	4		16	18974	3.1	2.1	5
	55	18370	4.5	0.0	4		46	19020	3.5	1.8	5
	55	18425	3.1	1.8	5		47	19067	3.9	2.1	5
	55	18480	3.1	1.9	5		46	19113	3.2	1.2	1
	55	18535	2.9	2.2	5		46	19159	4.5	1.1	5
	55	18590	3.8	1.5	5		47	19206	3.0	2.3	5
	55	18645	4.5	3.7	5		30	19236	3.9	3.3	5
WGLE 030	55	18700	4.0	3.3	5		46	19282	4.3	2.8	5
	55	18755	5.5	3.3	6		47	19329	3.5	0.9	1
	55	18810	5.9	3.3	6	EGLE 024	21	19350	3.4	2.7	5
	55	18865	4.8	2.9	6		40	19390	3.8	0.9	1
	55	18920	5.4	3.5	6		40	19430	4.2	3.9	5
	55	18975	5.3	3.3	6		40	19470	4.8	3.7	5
	55	19030	4.9	3.3	6		40	19510	4.9	1.2	1
	55	19085	5.7	3.3	6		15	19525	4.2	3.6	2
	55	19140	5.8	2.0	6		35	19560	3.3	0.8	1
	55	19195	5.5	1.5	1		17	19577	3.5	1.7	1
WGLE 031	55	19250	4.8	2.4	5		26	19603	4.6	0.9	1
	30	19280	5.2	2.5	1		19	19622	4.7	0.8	1
	50	19330	5.5	2.4	2		25	19647	3.8	1.5	1
	50	19380	5.0	3.2	2		21	19668	4.1	1.9	1
	25	19405	4.8	3.2	1		27	19695	3.7	2.1	1
	50	19455	4.0	1.7	5		20	19715	3.9	1.8	5
	15	19470	4.8	2.2	1		30	19745	4.7	3.9	5
	45	19515	5.0	1.5	1		30	19775	4.2	3.5	2
	37	19552	4.5	1.5	1		20	19795	3.6	3.0	2
	37	19589	3.8	1.6	1		108	19903	4.0	1.3	1
	48	19637	4.8	2.5	1		6	19909	5.4	3.8	2
	14	19651	4.4	2.0	1	EGLE 025	41	19950	3.8	3.0	5
	34	19685	3.6	2.8	2		40	19990	3.6	2.7	5
	20	19705	4.1	2.5	1		37	20027	2.3	0.8	1
	30	19735	5.2	3.5	1		40	20067	3.9	2.6	5
WGLE 032	15	19750	4.0	2.8	5		17	20084	4.1	3.0	5
	50	19800	3.6	2.7	5		37	20121	3.5	2.5	5
	10	19810	4.0	2.7	1		38	20159	3.9	2.1	5
	45	19855	4.3	2.6	1		37	20196	3.2	0.6	1
	50	19905	5.0	4.2	5		12	20208	3.6	0.5	1
	50	19955	3.8	2.8	5		40	20248	2.8	0.4	1
	50	20005	5.1	4.1	5		16	20264	3.3	0.3	1
	50	20055	3.8	1.8	3		44	20308	2.8	0.6	1

		WEST	GLEN					EAST	GLEN		
Reach Number	Distance Down. (m)	Cumulative Distance (m)	Channel Width (m)	Water Width (m)	Channel Type	Reach Number	Distance Down. (m)	Cumulative Distance (m)	Channel Width (m)	Water Width (m)	Channel Type
	50	20105	5.5	3.2	1		42	20350	3.2	1.3	1
	50	20155	4.6	2.6	5		37	20387	3.5	2.7	5
	50	20205	4.3	2.2	5	EGLE 026	38	20425	4.7	2.8	5
	30	20235	4.6	0.8	1		53	20478	4.8	3.5	5
WGLE 033	15	20250	4.7	2.8	5		53	20531	4.9	2.5	5
	14	20264	2.1	0.8	1		53	20584	5.8	0.7	1
	37	20301	4.2	2.2	1		53	20637	6.1	3.9	5
	48	20349	4.0	1.5	1		53	20690	5.3	2.4	1
	50	20399	4.3	3.7	5		53	20743	5.0	2.6	1
	50	20449	4.0	3.2	5		15	20758	5.6	2.5	1
	26	20475	5.4	0.4	1		35	20793	5.2	1.8	1
	25	20500	6.1	0.0	4		25	20818	5.3	1.9	1
	50	20550	4.3	0.0	4		25	20843	5.6	1.9	1
	50	20600	4.5	0.0	4		25	20868	3.9	1.4	1
	50	20650	4.8	0.0	4		53	20921	4.7	1.8	1
	50	20700	2.1	0.0	4	EGLE 027	54	20975	5.3	3.0	5
WGLE 034	50	20750	2.5	1.6	5		52	21027	4.8	2.9	5
	56	20806	4.5	4.1	5		30	21057	5.5	1.5	1
	55	20861	4.7	1.7	5		53	21110	5.9	4.8	5
	56	20917	4.8	0.0	4		52	21162	4.8	1.1	1
	55	20972	4.4	0.0	4		53	21215	5.1	3.4	5
	56	21028	4.2	0.0	4		35	21250	4.8	1.3	1
	55	21083	5.0	0.0	4		52	21302	5.3	1.2	1
	56	21139	3.2	0.0	4		12	21314	3.4	1.3	1
	55	21194	4.0	0.0	4		53	21367	4.0	1.3	1
WGLE 035	56	21250	3.9	0.0	1		52	21419	4.3	3.4	5
	79	21329	4.2	0.0	4		53	21472	3.9	1.2	1
	78	21407	2.8	0.0	1	EGLE 028	53	21525	4.1	3.0	5
	79	21486	4.3	0.0	4		50	21575	4.4	1.9	1
	78	21564	3.8	0.0	4		16	21591	4.3	1.4	1
	79	21643	3.9	0.0	4		19	21610	4.7	1.8	1
	78	21721	4.7	0.0	4		70	21680	5.3	2.7	1
WGLE 036	79	21800	4.8	0.0	4		70	21750	4.6	1.9	1
	50	21850	4.3	2.5	5		66	21816	2.6	1.9	5
	50	21900	4.5	3.7	5		66	21882	3.8	1.1	5
	15	21915	4.6	1.2	1		23	21905	4.4	1.2	1
	50	21965	5.0	0.6	1		65	21970	5.0	1.2	5
	50	22015	4.8	3.6	5		9	21979	5.4	1.5	1
	50	22065	4.6	4.1	5	EGLE 029	46	22025	4.8	1.8	1
	30	22095	8.2	4.5	1		52	22077	2.9	1.1	5
	50	22145	8.8	5.0	1		52	22129	3.4	2.8	5
	50	22195	8.0	5.1	2		51	22180	4.9	3.5	5
	36	22231	8.0	4.4	1		50	22230	4.6	2.7	5
	50	22281	5.5	4.2	1		10	22240	4.8	0.9	1
	12	22293	5.8	3.8	1		29	22269	3.4	1.9	1
	50	22343	5.8	4.3	5		29	22298	3.7	2.5	5
WGLE 037	7	22350	8.0	3.9	5		29	22327	5.3	4.7	2
	100	22450	8.8	5.1	5		29	22356	3.8	2.1	5
	37	22487	8.8	5.2	1		29	22385	5.0	4.3	2
	27	22514	5.5	4.2	1		21	22406	3.8	0.7	1
	46	22560	8.0	3.8	1		29	22435	3.4	2.0	5
	39	22599	8.4	4.1	1		31	22466	2.9	0.9	1
	30	22629	5.2	3.8	1		29	22495	3.3	1.3	5
	18	22647	5.5	1.8	1	EGLE 030	30	22525	3.8	2.5	5
	46	22693	8.0	5.2	2		53	22578	4.4	1.8	5
	32	22725	8.4	2.8	1		27	22605	4.2	0.8	1
	56	22781	5.7	2.8	1		60	22665	4.1	2.8	5
	35	22816	8.0	2.7	1		60	22725	5.8	4.2	2
	49	22865	8.3	5.8	1		41	22766	4.7	1.9	1
	46	22911	5.9	5.0	3		42	22808	5.3	4.4	3
	21	22932	5.8	2.8	1		41	22849	4.5	3.8	3
	46	22978	5.4	5.0	5		42	22891	4.8	4.3	3
WGLE 038	47	23025	7.3	6.3	2		10	22901	4.8	3.2	1
	30	23055	5.6	2.4	1		41	22942	4.5	3.9	3
	28	23083	4.5	3.6	1		42	22984	4.4	3.8	3
	45	23128	5.5	4.1	3	EGLE 031	41	23025	4.8	3.6	3
	25	23153	3.7	2.8	1		48	23073	4.0	3.5	5
	47	23200	5.0	2.5	1		48	23121	3.8	3.1	5
	45	23245	5.0	4.0	5		48	23169	3.8	3.1	3

Appendix D River Glen physical habitat survey results

		WEST	GLEN					EAST	GLEN		
Reach Number	Distance Down. (m)	Cumulative Distance (m)	Channel Width (m)	Water Width (m)	Channel Type	Reach Number	Distance Down. (m)	Cumulative Distance (m)	Channel Width (m)	Water Width (m)	Channel Type
	45	23290	5.3	4.5	5		47	23216	3.6	2.9	5
	33	23323	6.5	5.0	1		48	23264	4.3	2.7	5
	32	23355	5.1	3.8	3		48	23312	4.8	3.2	5
	47	23402	5.0	1.4	1		48	23360	4.9	3.7	5
	45	23447	5.3	3.6	3		32	23392	5.3	1.6	5
	19	23466	5.3	4.0	1		48	23440	5.9	4.7	5
	45	23511	4.8	4.1	6		40	23480	4.7	3.6	1
WGLE 039	39	23550	4.9	3.5	6		48	23528	4.1	3.5	5
	45	23595	6.3	2.4	1	EGLE 032	47	23575	3.9	2.7	5
	18	23613	5.4	2.3	1		48	23623	3.9	2.9	5
	25	23638	6.3	5.4	6		48	23671	3.5	2.1	5
	14	23652	6.3	2.6	1		48	23719	3.9	3.2	5
	37	23689	6.0	2.4	1		48	23767	3.7	3.0	5
	25	23714	5.3	3.5	6		15	23782	4.3	3.1	1
	31	23745	5.8	1.8	1		48	23830	3.5	0.4	1
	25	23770	5.5	4.7	6		48	23878	2.9	1.3	3
	27	23797	6.0	5.0	1		35	23913	2.9	1.2	1
	45	23842	5.8	2.2	1		44	23957	3.5	1.0	1
	25	23867	5.0	3.0	1		48	24005	2.8	0.0	4
	32	23899	5.8	3.5	1		48	24053	2.9	0.0	4
	47	23946	6.0	3.1	1		48	24101	3.2	0.0	4
	25	23971	5.9	4.7	6	EGLE 033	49	24150	4.4	0.0	4
	43	24014	5.6	3.6	1		52	24202	5.0	0.0	4
	25	24039	5.7	2.5	1		53	24255	4.5	0.0	4
	31	24070	5.5	3.0	1		52	24307	3.6	0.0	4
WGLE 040	30	24100	5.7	3.1	6		53	24360	4.4	0.0	4
	36	24136	5.9	2.8	1		52	24412	3.3	0.0	4
	37	24173	5.2	4.0	1		53	24465	3.7	0.0	4
	37	24210	5.2	3.6	6		52	24517	4.9	0.0	4
	37	24247	5.1	3.8	1		53	24570	4.7	0.0	4
	36	24283	5.9	2.4	3		52	24622	5.2	0.0	4
	37	24320	5.6	2.9	3	EGLE 034	53	24675	4.1	0.0	4
	37	24357	5.4	4.8	3		52	24727	3.9	3.2	2
	36	24393	5.3	2.8	1		53	24780	5.1	0.0	4
	37	24430	5.4	4.1	6		52	24832	4.5	0.0	4
	22	24452	4.4	2.2	1		53	24885	3.8	0.0	4
	37	24489	5.4	4.3	6		52	24937	4.2	0.0	4
	15	24504	4.0	2.3	1		53	24990	4.5	0.8	5
	36	24540	5.2	4.5	6		52	25042	4.4	1.9	5
	37	24577	4.8	4.0	6		53	25095	4.8	2.8	5
	37	24614	5.1	3.9	6		52	25147	3.7	2.4	5
WGLE 041	36	24650	4.7	3.8	3	EGLE 035	53	25200	4.3	0.0	4
	55	24705	5.0	3.8	3		52	25252	6.5	0.0	4
	55	24760	4.7	2.7	3		53	25305	3.9	0.0	4
	55	24815	4.7	3.9	3		52	25357	4.2	0.0	4
	55	24870	4.8	3.5	3		53	25410	3.8	0.0	4
	55	24925	5.0	4.0	3		52	25462	3.5	0.0	4
	55	24980	5.0	4.0	3		53	25515	3.6	0.0	4
	55	25035	5.0	4.0	6		52	25567	3.0	0.0	4
	55	25090	4.6	3.6	6		53	25620	3.8	0.0	4
	55	25145	4.8	3.1	6		52	25672	4.1	0.0	4
WGLE 042	55	25200	5.2	3.2	6	EGLE 036	53	25725	2.9	0.0	4
	50	25250	5.0	4.3	6		50	25775	3.9	0.0	4
	50	25300	5.5	4.4	6		50	25825	4.2	0.0	4
	51	25351	5.1	2.4	3		50	25875	4.1	-0.0	4
	50	25401	5.3	4.5	6		50	25925	4.2	0.0	4
	50	25451	5.0	3.6	6		50	25975	4.1	0.0	4
	51	25502	4.9	3.4	3		50	26025	3.5	0.0	4
	47	25549	5.1	3.0	1		50	26075	3.2	0.0	4
	50	25599	5.9	4.6	6		50	26125	4.2	0.0	4
	50	25649	4.7	3.3	3		50	26175	2.1	0.0	4
WGLE 043	51	25700	4.6	3.6	6		50	26225	2.3	0.0	4
	57	25757	5.1	2.9	6	EGLE 037	50	26275	2.2	0.0	4
	58	25815	6.0	5.0	2		58	26333	3.7	0.0	4
	57	25872	5.6	4.2	6		58	26391	4.0	0.0	4
	58	25930	5.6	5.3	2		59	26450	6.4	0.0	4
	57	25987	4.9	4.1	6		58	26508	5.6	0.0	4
	58	26045	4.2	2.5	3		58	26566	4.9	0.0	4
	57	26102	4.6	3.1	6		59	26625	5.2	0.0	4

		WEST	GLEN					EAST	GLEN		
Reach Number	Distance Down. (m)	Cumulative Distance (m)	Channel Width (m)	Water Width (m)	Channel Type	Reach Number	Distance Down. (m)	Cumulative Distance (m)	Channel Width (m)	Water Width (m)	Channel Type
	58	26160	5.7	4.6	6		58	26683	4.9	0.0	4
	57	26217	5.0	3.1	6		58	26741	4.8	0.0	4
WGLE 044	58	26275	5.2	4.1	6	EGLE 038	59	26800	5.1	0.0	4
	57	26332	4.4	3.8	6		58	26858	5.5	0.0	4
	57	26389	5.1	4.1	6		58	26916	5.8	0.0	4
	57	26446	5.5	3.3	3		59	26975	5.2	0.0	4
	56	26502	3.6	1.9	1		58	27033	4.8	0.0	4
	57	26559	3.6	3.3	1		58	27091	5.2	0.0	4
	39	26598	3.9	3.2	1		59	27150	4.8	0.0	4
	57	26655	4.2	3.1	2		58	27208	5.7	0.0	4
	57	26712	4.0	3.3	6		58	27266	5.8	0.0	4
	57	26769	3.0	1.8	6	EGLE 039	59	27325	5.6	0.0	4
WGLE 045	56	26825	4.9	4.1	2		72	27397	4.6	0.0	4
	90	26915	4.8	2.7	6		72	27469	4.4	0.0	4
	90	27005	5.4	4.7	2		72	27541	4.1	0.0	4
	40	27045	6.4	4.7	6		72	27613	5.4	0.0	4
	40	27085	5.3	4.4	3		73	27686	4.8	0.0	4
	40	27125	5.6	4.4	6		72	27758	4.9	0.0	4
	47	27172	7.4	4.2	1		72	27830	4.5	0.0	4
	39	27211	6.0	5.2	1		72	27902	4.4	0.0	4
	64	27275	5.6	4.7	2	EGLE 040	73	27975	4.5	0.0	4
	26	27301	6.2	4.0	1		58	28033	4.5	0.0	4
WGLE 046	24	27325	7.7	5.8	2		58	28091	3.4	0.0	4
	5	27330	5.8	4.1	1		59	28150	4.0	0.0	4
	38	27368	5.8	3.8	1		58	28208	4.0	0.0	4
	62	27430	5.0	4.5	6		58	28266	4.1	0.0	4
	43	27473	7.5	5.5	1		59	28325	4.1	0.0	4
	20	27493	6.2	5.1	1		58	28383	3.7	0.0	4
	44	27537	6.3	4.1	1		58	28441	3.8	0.0	4
	63	27600	6.1	5.2	3	EGLE 041	59	28500	4.2	0.0	4
	62	27662	5.5	4.5	3		62	28562	4.3	0.0	4
	63	27725	6.1	5.1	6		63	28625	5.0	0.0	4
	62	27787	6.7	6.1	3		62	28687	3.5	0.0	4
WGLE 047	63	27850	5.4	4.4	6		63	28750	3.4	0.0	4
	48	27898	5.1	3.2	1		62	28812	4.4	0.0	4
	48	27946	6.2	3.6	1		63	28875	4.9	0.0	4
	47	27993	5.9	3.8	1		62	28937	4.8	1.2	5
	45	28038	6.0	2.3	1	EGLE 042	63	29000	5.1	0.0	4
	62	28100	5.4	3.9	6		55	29055	5.4	0.0	4
	43	28143	6.0	2.7	1		56	29111	3.9	0.0	4
	40	28183	5.3	2.7	1		55	29166	5.4	0.0	4
	49	28232	5.3	2.8	1		56	29222	4.4	0.0	4
	47	28279	5.0	2.7	1		55	29277	4.6	0.0	4
	63	28342	5.6	1.7	1		56	29333	4.6	0.0	4
WGLE 048	33	28375	5.5	1.8	1		55	29388	5.1	1.5	5
	50	28425	4.9	3.5	6		56	29444	4.9	0.0	4
	50	28475	5.8	4.1	1	EGLE 043	56	29500	4.3	0.0	4
	36	28511	6.1	3.8	1		57	29557	4.5	0.0	4
	50	28561	5.6	4.5	6		57	29614	5.8	4.6	5
	50	28611	5.8	3.8	3		57	29671	7.2	0.0	4
	50	28661	6.4	4.5	3		46	29717	4.9	3.7	5
	50	28711	6.3	3.6	1		56	29773	5.4	0.0	4
	50	28761	7.1	5.8	2		57	29830	6.4	0.0	4
	32	28793	5.8	3.2	1		57	29887	4.9	0.0	4
	37	28830	5.5	4.5	1		57	29944	5.6	0.0	4
WGLE 049	45	28875	5.8	2.5	1	EGLE 044	56	30000	4.6	0.0	4
	35	28910	4.9	4.1	1		58	30058	6.2	0.0	4
	66	28976	5.5	3.8	6		58	30116	4.5	0.0	4
	67	29043	7.1	6.1	6		58	30174	4.6	0.0	4
	20	29063	5.6	4.3	1		58	30232	4.4	0.0	4
	34	29097	6.8	4.2	1		58	30290	4.9	0.0	4
	67	29164	5.9	5.3	6		58	30348	4.4	3.6	5
	10	29174	6.0	3.3	1		58	30406	3.9	0.5	1
	21	29195	6.1	5.6	1		46	30454	4.0	0.0	4
	67	29262	7.5	5.4	3		59	30513	4.1	1.6	1
WGLE 050	38	29300	6.0	3.5	3	EGLE 045	12	30525	4.1	3.1	5
	50	29350	5.1	4.0	1		55	30580	4.2	2.1	5
	51	29401	6.9	4.7	6		55	30635	3.9	3.1	5
	17	29418	6.3	3.8	1		55	30690	3.2	0.0	4

Appendix D River Glen physical habitat survey results

		WEST	GLEN					EAST	GLEN		
Reach Number	Distance Down. (m)	Cumulative Distance (m)	Channel Width (m)	Water Width (m)	Channel Type	Reach Number	Distance Down. (m)	Cumulative Distance (m)	Channel Width (m)	Water Width (m)	Channel Type
	50	29468	7.0	4.1	6		55	30745	3.5	0.0	4
	31	29499	6.7	4.3	1		55	30800	3.8	0.0	4
	51	29550	5.6	4.5	2		55	30855	2.7	0.0	4
	49	29599	7.6	4.7	1		55	30910	4.6	1.3	5
	50	29649	7.1	5.7	3		55	30965	4.9	3.2	5
	49	29698	7.2	5.7	1		55	31020	4.8	1.3	5
	51	29749	6.5	5.2	6	EGLE 046	55	31075	4.7	0.8	5
	50	29799	6.4	5.0	6		55	31130	6.1	0.0	4
WGLE 051	51	29850	7.1	5.2	6		55	31185	5.6	0.0	4
	55	29905	6.4	5.6	5		55	31240	5.8	0.0	4
	55	29960	6.1	4.4	5		55	31295	4.8	0.0	4
	26	29986	6.5	3.7	1		55	31350	5.3	0.0	4
	55	30041	6.2	3.1	6		55	31405	5.1	0.0	4
	55	30096	6.5	5.1	2		55	31460	6.5	0.0	4
	55	30151	6.9	5.8	6		55	31515	6.6	0.0	4
	55	30206	7.2	4.3	3		55	31570	6.6	0.0	4
	55	30261	7.4	5.2	2	EGLE 047	55	31625	6.6	0.0	4
	55	30316	7.2	6.2	2		50	31675	6.3	0.0	4
	55	30371	4.7	3.5	3		50	31725	6.7	0.0	4
WGLE 052	54	30425	7.1	5.0	6		50	31775	6.2	0.0	4
	44	30469	6.8	5.9	2		50	31825	6.5	0.0	4
	39	30508	6.8	5.3	1		50	31875	6.3	0.0	4
	44	30552	6.5	3.8	3		50	31925	5.3	0.0	4
	44	30596	5.7	3.8	6		50	31975	5.3	0.0	4
	40	30636	7.5	5.4	1		50	32025	5.2	0.0	4
	44	30680	7.0	5.1	6		50	32075	5.3	0.0	4
	44	30724	6.6	3.6	3	EGLE 048	50	32125	5.3	0.0	4
	44	30768	6.3	5.3	2		52	32177	5.8	0.0	4
	21	30789	7.5	2.4	1		53	32230	5.3	0.0	4
	47	30836	6.7	4.4	1		52	32282	6.2	0.0	4
	44	30880	6.5	2.8	3		53	32335	5.5	0.0	4
WGLE 053	45	30925	6.3	4.0	1		52	32387	5.0	0.0	4
	53	30978	6.2	5.4	5		53	32440	4.6	0.0	4
	53	31031	6.3	5.4	5		52	32492	5.7	0.0	4
	23	31054	6.3	4.9	1		53	32545	5.2	0.0	4
	52	31106	7.4	5.7	2		52	32597	6.2	0.0	4
	53	31159	6.8	5.4	5	EGLE 049	53	32650	5.4	0.0	4
	53	31212	7.2	5.3	6		50	32700	4.8	0.0	4
	53	31265	8.2	6.0	6		50	32750	5.4	0.0	4
	53	31318	7.9	6.8	6		50	32800	5.2	1.6	5
	53	31371	8.7	7.4	6		50	32850	5.5	3.8	5
	52	31423	8.0	6.5	6		50	32900	5.4	1.0	5
WGLE 054	52	31475	10.4	8.3	6		50	32950	5.5	0.0	4
	55	31530	8.4	5.9	6		50	33000	4.5	0.0	4
	55	31585	7.8	5.5	3		50	33050	4.8	2.2	2
	55	31640	8.3	6.4	6		50	33100	5.1	1.9	2
	55	31695	7.9	6.3	6	EGLE 050	50	33150	6.3	0.0	4
	55	31750	7.5	6.5	6		50	33200	6.2	0.0	4
	55	31805	9.7	7.0	6		50	33250	6.2	0.0	4
	55	31860	9.0	5.4	3		50	33300	6.1	0.0	4
	55	31915	8.1	6.4	6		50	33350	6.4	0.0	4
	55	31970	8.0	5.9	6		50	33400	6.6	0.0	4
WGLE 055	55	32025	7.9	4.9	6		50	33450	7.3	0.0	4
	50	32075	7.3	5.6	6		50	33500	6.2	1.4	5
	50	32125	8.1	6.3	6		50	33550	6.8	0.0	4
	100	32225	5.2	4.2	6		50	33600	4.7	3.0	2
	34	32259	6.1	4.5	1	EGLE 051	50	33650	5.7	0.0	4
	46	32305	6.4	5.2	1		47	33697	5.8	0.0	4
	45	32350	6.8	5.5	6		48	33745	5.7	2.2	5
	45	32395	6.9	5.7	6		47	33792	6.5	0.0	4
	45	32440	7.8	6.0	6		48	33840	7.2	0.0	4
	45	32485	7.2	6.1	6		47	33887	5.5	0.0	4
	32	32517	6.8	4.7	1		48	33935	6.0	0.0	4
	45	32562	7.6	6.1	6		47	33982	6.3	2.1	5
	44	32606	7.6	5.9	6		48	34030	5.8	2.3	5
WGLE 056	44	32650	6.1	5.3	6		47	34077	6.1	2.5	5
	46	32696	7.4	2.6	6	EGLE 052	48	34125	5.8	0.0	4
	47	32743	5.9	4.9	6		50	34175	6.7	0.0	4
	46	32789	5.5	4.9	6		50	34225	6.0	0.0	4

		WEST	GLEN		
Reach Number	Distance Down. (m)	Cumulative Distance (m)	Channel Width (m)	Water Width (m)	Channel Type
	23	32812	6.9	5.6	1
	47	32859	6.2	5.1	1
	26	32885	6.2	4.1	1
	47	32932	5.2	4.6	6
	18	32950	6.3	2.3	1
	46	32996	6.0	4.5	2
	35	33031	6.4	2.9	1
	49	33080	6.6	5.1	1
	48	33128	6.5	5.7	1
WGLE 057	47	33175	6.4	4.0	1
	39	33214	5.8	4.1	1
	42	33256	5.7	5.0	6
	41	33297	6.3	5.6	6
	36	33333	6.1	5.2	1
	42	33375	6.5	5.2	6
	18	33393	5.8	4.9	1
	44	33437	5.6	4.9	1
	41	33478	5.8	5.4	6
	45	33523	6.5	3.2	1
	42	33565	5.6	4.5	1
	41	33606	6.5	4.5	3
	38	33644	5.0	4.3	1
	40	33684	6.0	3.3	1
WGLE 058	41	33725	5.4	4.4	6
	44	33769	5.0	4.4	2
	44	33813	5.7	4.8	2
	44	33857	5.7	4.9	5
	43	33900	7.4	4.6	6
	44	33944	6.5	4.8	6
	44	33988	8.0	5.5	6
	44	34032	6.7	5.4	6
	43	34075	7.4	4.8	6
	44	34119	6.9	5.4	3
	44	34163	6.7	4.2	1
	44	34207	5.9	4.3	6
WGLE 059	43	34250	6.4	4.2	6
	50	34300	7.4	5.5	6
	50	34350	7.2	4.1	6
	80	34430	5.3	4.1	1
	20	34450	5.6	4.2	5
	50	34500	6.4	5.4	3
	50	34550	6.3	5.5	5
	50	34600	5.7	4.8	5
	60	34660	6.4	5.4	1
	40	34700	5.7	4.8	2
WGLE 060	50	34750	7.5	4.8	1
	50	34800	5.8	4.6	5
	50	34850	6.7	5.2	5
	50	34900	6.8	5.5	5
	50	34950	7.5	4.4	5
	50	35000	7.5	5.7	3
	50	35050	9.3	4.3	1
	100	35150	6.6	5.4	5
	50	35200	6.1	4.7	2
WGLE 061	50	35250	7.6	6.1	5
	55	35305	7.6	2.8	6
	55	35360	7.8	6.6	6
	55	35415	7.0	3.9	6
	34	35449	7.9	5.7	1
	55	35504	9.1	6.3	6
	55	35559	7.4	4.9	6
	55	35614	7.7	5.6	6
	55	35669	7.8	6.5	6
WGLE 062	56	35725	6.9	6.0	6
	61	35786	9.5	6.2	6
	61	35847	7.9	6.0	6
	61	35908	7.5	6.4	6
	61	35969	8.1	5.9	6
	61	36030	7.0	5.0	6

		EAST	GLEN		
Reach Number	Distance Down. (m)	Cumulative Distance (m)	Channel Width (m)	Water Width (m)	Channel Type
	50	34275	5.5	0.0	4
	50	34325	5.4	0.0	4
	50	34375	5.6	0.0	4
	50	34425	5.3	0.0	4
	50	34475	5.8	0.0	4
	50	34525	5.1	0.0	4
	50	34575	6.0	0.0	4
EGLE 053	50	34625	6.1	0.0	4
	53	34678	6.3	0.0	4
	52	34730	6.3	0.0	4
	53	34783	5.4	0.0	4
	52	34835	6.1	0.0	4
	53	34888	5.1	1.6	5
	52	34940	4.7	1.4	5
	53	34993	5.5	3.3	5
	52	35045	4.7	2.6	5
	53	35098	4.8	2.2	5
EGLE 054	52	35150	4.8	2.2	5
	55	35205	5.0	3.6	5
	55	35260	6.8	3.8	5
	55	35315	5.3	2.6	5
	55	35370	5.3	2.1	5
	55	35425	6.3	1.3	5
	55	35480	5.4	3.9	5
	55	35535	5.9	3.4	5
	55	35590	6.3	5.2	5
	55	35645	5.8	4.3	5
EGLE 055	55	35700	5.3	2.1	5
	51	35751	4.5	1.7	1
	35	35786	5.2	4.3	5
	51	35837	5.8	0.0	4
	20	35857	6.1	0.2	1
	12	35869	5.9	0.4	1
	23	35892	5.1	1.1	1
	32	35924	5.7	0.8	1
	23	35947	6.2	1.1	1
	50	35997	8.3	5.6	5
	51	36048	6.4	4.7	5
	51	36099	6.0	4.9	5
	51	36150	5.6	4.5	5
EGLE 056	50	36200	6.1	4.0	5
	49	36249	5.6	1.0	1
	10	36259	5.8	1.6	1
	49	36308	4.8	1.0	1
	49	36357	5.0	3.4	5
	49	36406	5.3	3.9	5
	49	36455	6.2	2.9	5
	49	36504	6.7	5.3	5
	49	36553	6.4	4.8	5
	49	36602	5.7	1.7	1
	49	36651	6.8	3.4	5
EGLE 057	49	36700	6.8	0.4	5
	52	36752	5.3	3.3	5
	53	36805	5.2	2.6	5
	52	36857	6.1	3.4	5
	53	36910	6.5	2.9	5
	52	36962	6.6	1.1	5
	53	37015	6.6	1.3	5
	52	37067	5.9	1.1	1
	53	37120	6.8	2.6	5
	52	37172	6.5	0.8	5
EGLE 058	53	37225	7.4	1.1	5
	45	37270	5.4	4.4	5
	46	37316	5.9	1.2	5
	45	37361	6.6	2.6	5
	46	37407	5.8	4.1	5
	45	37452	7.4	1.4	1
	40	37492	6.9	4.2	5
	46	37538	7.0	0.7	1

		WEST	GLEN					EAST	GLEN		
Reach	Distance	Cumulative	Channel	Water	Channel	Reach	Distance	Cumulative	Channel	Water	Channel
Number	Down.	Distance	Width	Width	Type	Number	Down.	Distance	Width	Width	Type
	(m)	(m)	(m)	(m)			(m)	(m)	(m)	(m)	
	61	36091	6.9	4.8	6		45	37583	6.5	4.5	5
	61	36152	7.1	5.1	6		46	37629	6.9	5.3	5
	61	36213	6.8	5.0	6		46	37675	7.5	4.9	5
WGLE 063	62	36275	7.2	5.9	6						
	58	36333	6.8	5.4	6						
	58	36391	6.5	5.5	6			RIVER	GLEN		
	59	36450	6.8	6.7	6						
	58	36508	7.5	6.0	6	GLEN 001	0	0	7.5	5.3	2
	58	36566	7.8	6.3	2		50	50	7.6	6.5	1
	59	36625	7.8	6.8	5		50	100	6.3	5.0	5
	58	36683	7.8	6.9	5		50	150	6.4	5.5	5
	58	36741	7.5	6.5	5		50	200	7.9	7.3	5
WGLE 064	199	36940	8.4	0.0	4		50	250	8.1	7.7	5
	290	37230	9.5	0.0	4		50	300	8.0	7.6	5
	35	37265	8.2	0.0	4		50	350	7.5	7.4	5
WGLE 065	35	37300	8.2	0.0	4		50	400	9.1	8.9	5
	47	37347	4.0	0.0	4		50	450	8.9	8.8	5
	47	37394	6.0	0.0	4	GLEN 002	50	500	10.0	9.8	5
	47	37441	5.5	4.7	5		50	550	9.4	9.2	5
	47	37488	9.2	5.6	5		50	600	10.5	10.4	5
	48	37536	7.1	5.7	6		50	650	11.5	11.0	5
	22	37558	6.8	2.5	1		50	700	12.6	12.2	5
	47	37605	6.5	4.8	5		50	750	12.0	11.7	5
	47	37652	7.1	5.1	5		50	800	12.9	12.3	5
	47	37699	6.9	5.1	5		40	840	13.2	12.6	5
	48	37747	7.6	5.4	5		90	930	12.8	12.0	5
WGLE 066	28	37775	6.8	5.2	5		50	980	11.8	11.2	5
	15	37790	7.7	4.7	1	GLEN 003	100	1080	13.0	12.6	5
	47	37837	6.9	3.5	3		50	1130	12.7	12.3	5
	41	37878	6.3	2.6	1		50	1180	11.5	11.0	5
	47	37925	5.1	3.5	3		50	1230	12.5	11.7	5
	25	37950	5.1	3.3	1		80	1310	13.2	12.9	5
	48	37998	6.1	3.7	1		70	1380	14.7	14.4	5
	47	38043	5.3	2.4	3		50	1430	12.6	12.3	5
	47	38090	6.5	4.1	5		40	1470	13.2	12.8	5
	48	38138	5.3	1.2	1		70	1540	12.7	12.1	5
	47	38185	6.0	3.3	3	GLEN 004	60	1600	14.1	13.6	5
	47	38232	6.6	3.7	6		120	1720	12.3	8.3	5
	47	38279	6.3	2.3	1		50	1770	8.0	7.2	5
WGLE 067	46	38325	6.2	3.5	6		50	1820	6.6	7.1	5
	41	38366	4.1	3.2	6		50	1870	8.0	7.5	5
	41	38407	6.4	3.0	6		50	1920	10.0	8.4	5
	40	38447	5.6	2.6	6		50	1970	10.6	8.8	5
	41	38488	4.0	2.8	6		50	2020	8.9	5.5	5
	20	38508	4.4	2.4	1		50	2070	8.7	7.4	5
	41	38549	4.9	3.2	2		50	2120	12.0	10.2	5
	40	38589	4.2	2.8	2	GLEN 005	50	2170	13.3	12.7	5
	41	38630	4.6	3.4	2						
	41	38671	4.8	3.4	6						
	41	38712	5.5	3.0	1						
	41	38753	5.8	3.2	6						
	32	38785	5.9	2.6	1						
WGLE 068	40	38825	4.7	3.3	6						
	41	38866	4.9	3.3	6						
	41	38907	4.2	2.4	3						
	41	38948	4.8	2.9	5						
	15	38963	4.4	2.7	1						
	41	39004	4.7	3.1	6						
	41	39045	5.3	3.1	3						
	41	39086	6.8	3.1	3						
	41	39127	5.1	3.2	6						
	41	39168	4.8	3.1	3						
	41	39209	6.0	3.3	6						
	41	39250	5.2	1.8	6						

flow	flow	Shilling.	Shilling.	Shilling.	Shilling.	Shilling.	Shilling.	Shilling.	Shilling.	Shilling.	Shilling.
cfs	cumecs	%time	gross	trout	trout	trout	dace	dace	dace	chub	chub
		exceed.	area	fry	juv	adult	fry	juv	adult	fry	juv+ad
0.1	0.0028	96									
0.2	0.0057	96									
0.3	0.0085	96									
0.4	0.0113	96									
0.5	0.0142	95	15259	36.41	5.74	3.85	4.45	1.37	3.27	0.00	0.00
0.6	0.0170	95	15603	38.20	6.11	4.27	4.79	1.52	3.52	0.00	0.00
0.7	0.0198	95	15915	39.58	6.45	4.65	5.13	1.67	3.83	0.00	0.00
0.8	0.0227	95	16203	40.60	6.75	4.99	5.48	1.80	4.13	0.00	0.00
0.9	0.0255	94	16471	41.25	7.03	5.34	5.81	1.92	4.43	0.00	0.00
1.0	0.0283	94	16723	40.75	7.30	5.65	6.06	1.99	4.71	0.00	0.01
1.5	0.0425	91	17374	42.29	8.60	6.84	7.24	2.29	6.37	0.63	0.07
1.8	0.0510	88	17460	43.09	9.36	7.39	7.77	2.48	7.48	1.31	0.11
1.9	0.0538	87	17491	43.20	9.58	7.58	7.96	2.49	7.77	1.58	0.12
2.0	0.0567	87	17518	43.23	9.83	7.79	8.17	2.62	8.20	1.65	0.13
2.2	0.0623	85	17565	43.13	10.27	8.09	8.55	2.76	9.02	1.92	0.19
2.4	0.0680	83	17616	42.91	10.68	8.41	8.90	2.99	9.91	2.48	0.26
2.5	0.0708	82	17640	42.69	10.89	8.56	9.09	3.07	10.33	2.61	0.30
2.6	0.0737	81	17661	42.43	11.09	8.72	9.18	3.13	10.51	2.72	0.32
2.8	0.0793	80	17705	41.90	11.46	9.03	9.34	3.19	10.80	2.98	0.36
3.0	0.0850	78	17748	41.54	11.84	9.21	9.50	3.24	12.15	3.07	0.40
3.5	0.0992	75	17841	40.48	12.66	9.87	9.78	3.51	13.99	3.33	0.51
4.0	0.1134	69	17935	39.64	13.47	10.29	10.07	3.69	15.55	3.71	0.61
4.5	0.1275	65	18015	38.49	14.22	10.72	10.23	4.23	15.57	3.99	0.69
5.0	0.1417	61	18095	37.49	14.88	11.18	10.39	4.72	18.48	4.26	0.77
5.5	0.1559	59	18160	36.21	15.52	11.62	10.61	5.19	19.96	4.48	0.83
5.7	0.1615	58	18185	35.63	15.77	11.75	10.66	5.28	20.41	4.60	0.84
6.0	0.1700	57	18223	34.88	16.09	11.97	10.81	5.65	21.20	4.74	0.88
6.5	0.1842	54	18268	33.30	16.60	12.33	11.02	6.21	22.53	4.98	0.94
7.0	0.1984	52	18307	31.85	17.10	12.63	11.23	6.80	23.71	5.22	1.00
8.0	0.2267	48	18384	29.37	17.96	13.25	11.39	8.05	25.77	5.25	1.10
9.0	0.2550	44	18456	27.78	18.61	13.87	11.46	9.38	27.70	5.02	1.20
10.0	0.2834	42	18526	26.40	19.03	14.78	11.55	10.85	29.50	5.24	1.29
11.0	0.3117	39	18595	25.10	19.32	15.64	11.66	12.30	31.19	5.29	1.37
12.0	0.3401	37	18660	23.91	19.53	16.44	11.71	13.90	32.78	4.92	1.43
13.0	0.3684	34	18721	22.87	19.57	17.26	11.59	15.63	34.30	4.48	1.55
14.0	0.3967	32	18780	21.99	19.53	18.21	11.46	17.43	35.61	4.39	1.79
15.0	0.4251	29	18837	21.12	19.49	19.13	11.34	19.20	36.98	4.37	2.04
16.0	0.4534	27	18883	20.44	19.23	20.27	10.89	20.77	38.03	4.42	2.90
20.0	0.5668	22	19091	18.27	18.37	24.27	10.35	26.97	42.43	4.55	6.36
25.0	0.7085	17	19310	16.84	18.21	34.27	10.02	29.36	46.84	4.66	10.13
30.0	0.8501	14	19505	15.50	18.06	44.56	9.60	28.39	49.87	5.39	15.26
35.0	0.9918	11	19696	14.26	17.90	48.35	8.88	25.25	51.98	6.79	22.76
40.0	1.1335	9	19880	13.28	17.79	46.98	7.70	21.30	52.86	7.69	29.63
45.0	1.2752	8	20044	12.52	17.68	44.42	6.26	18.03	52.17	8.67	32.78
50.0	1.4169	7	20188	11.95	17.53	41.95	5.29	15.67	49.66	9.35	34.03
55.0	1.5586	6	20324	11.53	17.37	39.66	4.94	14.05	46.57	9.23	33.28
60.0	1.7003	6	20453	11.32	17.06	37.23	4.73	12.10	43.25	9.24	30.94
65.0	1.8420	5	20576	11.21	16.89	34.91	4.73	10.48	39.71	9.15	27.77
70.0	1.9837	5	20721	11.17	16.82	32.91	4.46	9.30	35.94	9.25	24.41
75.0	2.1254	5	20872	11.13	16.76	31.01	4.05	8.36	32.26	9.51	21.08
80.0	2.2671	4	21016	11.11	16.73	29.40	3.72	7.72	28.68	9.64	18.00
85.0	2.4088	4	21154	11.20	16.68	28.14	3.62	7.11	25.32	9.85	15.21
90.0	2.5504	4	21288	11.07	16.68	27.95	3.63	6.47	22.71	10.20	13.37
95.0	2.6921	4	21417	11.00	16.69	27.80	3.68	5.87	20.67	10.43	12.09
100.0	2.8338	4	21584	10.95	16.71	27.65	3.81	5.32	19.09	10.46	11.08
105.0	2.9755	4	21752	10.83	16.73	27.64	3.87	4.82	17.89	10.26	10.27

flow cfs	flow cumecs	Shilling. %time exceed.	Essen. gross area	Essen. trout fry	Essen. trout juv	Essen. trout adult	Essen. dace fry	Essen. dace juv	Essen. dace adult	Essen. chub fry	Essen. chub juv+ad
0.1	0.0028	96									
0.2	0.0057	96									
0.3	0.0085	96									
0.4	0.0113	96									
0.5	0.0142	95									
0.6	0.0170	95									
0.7	0.0198	95									
0.8	0.0227	95									
0.9	0.0255	94									
1.0	0.0283	94									
1.5	0.0425	91									
1.8	0.0510	88	12222	84.87	14.90	9.78	60.19	3.47	20.20	0.08	0.00
1.9	0.0538	87	12252	84.84	14.94	9.80	62.98	3.53	20.48	0.10	0.00
2.0	0.0567	87	12291	84.40	14.98	9.83	64.61	3.62	20.87	0.12	0.00
2.2	0.0623	85	12335	83.31	15.03	9.86	66.89	3.76	21.31	0.17	0.00
2.4	0.0680	83	12418	82.17	15.13	10.04	69.26	4.11	21.91	0.21	0.00
2.5	0.0708	82	12436	81.19	15.15	10.06	70.34	4.17	22.23	0.25	0.00
2.6	0.0737	81	12486	79.95	15.15	10.10	71.47	4.26	22.39	0.28	0.00
2.6	0.0793	80	12516	77.46	15.15	10.19	73.36	4.37	22.83	0.34	0.00
3.0	0.0850	78	12574	75.92	15.53	10.30	75.34	4.67	23.15	0.42	0.00
3.5	0.0992	75	12620	66.56	15.34	10.47	81.03	5.26	24.75	0.44	0.00
4.0	0.1134	69	12804	62.42	15.53	10.63	86.16	6.26	26.34	0.46	0.00
4.5	0.1275	65	12941	56.02	15.66	10.92	89.54	7.18	27.58	0.50	0.00
5.0	0.1417	61	13072	49.84	15.77	11.01	92.92	7.75	28.88	0.55	0.00
5.5	0.1559	59	13125	44.11	15.75	11.13	93.51	8.67	30.04	0.55	0.00
5.7	0.1615	58	13156	42.17	15.71	11.20	93.64	9.44	30.46	0.56	0.00
6.0	0.1700	57	13173	39.87	15.73	11.26	93.90	10.31	31.31	0.63	0.00
6.5	0.1842	54	13258	36.42	15.61	11.29	91.38	10.98	32.17	0.65	0.00
7.0	0.1984	52	13309	34.23	15.68	11.51	89.07	11.44	33.53	0.67	0.00
8.0	0.2267	48	13494	30.28	15.66	11.78	86.27	13.15	36.09	0.77	0.00
9.0	0.2550	44	13671	27.48	15.21	12.02	85.51	14.51	38.10	0.84	0.00
10.0	0.2834	42	13834	24.80	14.81	12.26	84.82	15.79	40.32	0.92	0.00
11.0	0.3117	39	14004	23.31	14.26	12.42	84.63	17.27	41.48	1.00	0.00
12.0	0.3401	37	14175	21.74	13.72	12.58	84.55	18.64	42.82	1.07	0.00
13.0	0.3684	34	14302	20.79	13.20	12.68	83.02	19.90	43.77	1.16	0.04
14.0	0.3967	32	14429	19.80	12.71	12.79	81.55	21.02	44.06	1.24	0.12
15.0	0.4251	29									
16.0	0.4534	27									
20.0	0.5668	22									
25.0	0.7085	17									
30.0	0.8501	14									
35.0	0.9918	11									
40.0	1.1335	9									
45.0	1.2752	8									
50.0	1.4169	7									
55.0	1.5586	6									
60.0	1.7003	6									
65.0	1.8420	5									
70.0	1.9837	5									
75.0	2.1254	5									
80.0	2.2671	4									
85.0	2.4088	4									
90.0	2.5504	4									
95.0	2.6921	4									
100.0	2.8338	4									
105.0	2.9755	4									

flow cfs	flow cumecs	Manth. %time exceed.	Brace. gross area	Brace. trout fry	Brace. trout juv	Brace. trout adult	Brace. dace fry	Brace. dace juv	Brace. dace adult	Brace. chub fry	Brace. chub juv+ad
0.1	0.0028	85									
0.2	0.0057	74	7174	26.79	3.13	1.85	1.74	0.00	0.52	0.00	0.00
0.3	0.0085	68	8725	23.84	3.19	1.86	2.49	0.00	0.59	0.00	0.00
0.4	0.0113	67	9459	22.91	3.49	2.01	3.77	0.00	0.68	0.00	0.00
0.5	0.0142	65	9710	22.56	3.88	2.21	5.18	0.00	0.79	0.00	0.00
0.6	0.0170	63	10414	21.19	4.03	2.28	6.30	0.00	0.88	0.00	0.00
0.7	0.0198	61	10672	20.63	4.31	2.43	7.70	0.00	0.99	0.00	0.00
0.8	0.0227	60	10869	19.98	4.57	2.56	8.94	0.00	1.12	0.00	0.00
0.9	0.0255	59	11050	19.22	5.04	2.80	10.06	0.00	1.31	0.00	0.00
1.0	0.0283	57	11202	19.22	5.04	2.80	11.13	0.00	1.50	0.00	0.00
1.5	0.0425	53	11719	14.83	5.82	3.30	16.40	0.00	2.49	0.00	0.00
1.8	0.0510	51	11948	13.98	6.10	3.51	18.72	0.00	3.03	0.00	0.00
1.9	0.0538	50	12017	13.61	6.19	3.58	19.41	0.00	3.27	0.00	0.00
2.0	0.0567	50	12094	13.55	6.29	3.65	20.36	0.00	3.43	0.00	0.00
2.2	0.0623	49	12201	13.13	6.43	3.76	21.48	0.00	3.81	0.00	0.00
2.4	0.0680	48	12304	12.58	6.57	3.88	22.67	0.00	4.26	0.00	0.00
2.5	0.0708	47	12361	12.47	6.63	3.94	23.20	0.00	4.49	0.00	0.00
2.6	0.0737	47	12402	12.37	6.68	3.98	23.43	0.00	4.71	0.00	0.00
2.8	0.0793	46	12484	11.83	6.81	4.08	23.75	0.00	5.10	0.00	0.00
3.0	0.0850	45	12572	11.49	6.93	4.18	24.07	0.00	5.47	0.00	0.00
3.5	0.0992	44	12753	10.66	6.96	4.35	24.69	0.00	6.41	0.00	0.00
4.0	0.1134	41	12929	9.90	7.01	4.52	25.36	0.00	7.30	0.00	0.00
4.5	0.1275	39	13048	9.03	6.93	4.64	26.41	0.00	8.01	0.00	0.00
5.0	0.1417	38	13153	8.16	6.85	4.76	27.36	0.00	8.64	0.00	0.00
5.5	0.1559	36	13241	7.49	6.73	4.80	27.25	0.00	9.19	0.00	0.00
5.7	0.1615	36	13276	7.24	6.68	4.83	27.18	0.00	9.43	0.00	0.00
6.0	0.1700	35	13325	6.79	6.60	4.85	27.09	0.00	9.76	0.00	0.00
6.5	0.1842	33	13402	6.61	6.44	4.89	26.21	0.00	10.33	0.00	0.00
7.0	0.1984	32	13478	6.42	6.30	4.94	25.30	0.00	10.82	0.00	0.00
8.0	0.2267	29	13617	5.98	5.97	4.96	24.07	0.00	11.94	0.00	0.00
9.0	0.2550	27	13743	5.48	5.70	4.96	21.07	0.00	12.99	0.00	0.00
10.0	0.2834	25	13861	4.95	5.42	4.90	19.62	0.00	13.44	0.00	0.00
11.0	0.3117	23	13970	4.57	5.18	4.83	18.25	0.00	13.84	0.00	0.00
12.0	0.3401	22	14072	3.80	4.85	4.70	17.43	0.00	14.25	0.00	0.00
13.0	0.3684	21	14169	3.02	4.52	4.54	16.99	0.00	14.68	0.00	0.00
14.0	0.3967	20	14260	2.78	4.31	4.46	15.75	0.00	15.01	0.00	0.00
15.0	0.4251	20	14348	2.58	4.10	4.31	14.47	0.00	15.19	0.00	0.00
16.0	0.4534	18	14417	2.25	3.89	4.12	13.23	0.00	15.15	0.00	0.00
20.0	0.5668	16	14701	0.95	3.03	3.60	8.42	0.00	14.99	0.00	0.00
25.0	0.7085	13	14923	0.71	2.43	3.08	7.51	0.00	14.00	0.00	0.00
30.0	0.8501	12	15083	0.55	1.91	2.60	7.52	0.00	12.56	0.00	0.00
35.0	0.9918	11	15251	0.34	1.66	2.13	4.35	0.00	11.11	0.00	0.00
40.0	1.1335	10	15391	0.27	1.41	1.74	2.00	0.00	9.60	0.00	0.00
45.0	1.2752	9	15519	0.22	1.13	1.51	2.28	0.00	7.96	0.00	0.00
50.0	1.4169	8	15613	0.13	0.91	1.36	0.97	0.00	6.69	0.00	0.00
55.0	1.5586	8									
60.0	1.7003	8									
65.0	1.8420	7									
70.0	1.9837	7									
75.0	2.1254	7									
80.0	2.2671	7									
85.0	2.4088	6									
90.0	2.5504	6									
95.0	2.6921	6									
100.0	2.8338	6									
105.0	2.9755	6									

flow	flow	But.Cog.	Creet.	Creet.	Creet.	Creet.	Creet.	Creet.	Creet.	Creet.	Creet.
cfs	cumecs	%time	gross	trout	trout	trout	dace	dace	dace	chub	chub
		exceed.	area	fry	juv	adult	fry	juv	adult	fry	juv+ad
0.1	0.0028	90	5360	23.27	2.74	1.49	3.08	0.00	0.00	0.00	0.00
0.2	0.0057	80	5805	27.34	3.80	2.05	5.43	0.00	0.07	0.00	0.00
0.3	0.0085	72	6107	26.82	4.52	2.43	7.25	0.00	0.27	0.00	0.00
0.4	0.0113	68	6347	24.76	5.08	2.72	8.64	0.00	0.61	0.00	0.00
0.5	0.0142	64	6526	22.27	5.56	2.98	9.94	0.00	1.07	0.00	0.00
0.6	0.0170	61	6673	20.27	5.98	3.20	10.92	0.00	1.57	0.00	0.00
0.7	0.0198	59	6810	18.60	6.35	3.39	11.81	0.00	2.04	0.00	0.00
0.8	0.0227	57	6935	17.34	6.68	3.56	12.58	0.00	2.51	0.00	0.00
0.9	0.0255	55	7050	16.17	6.98	3.72	13.18	0.00	2.96	0.00	0.00
1.0	0.0283	54	7146	15.41	7.27	3.87	13.76	0.00	3.38	0.00	0.00
1.5	0.0425	48	7534	13.49	8.18	4.51	15.54	0.00	5.12	0.00	0.00
1.8	0.0510	44	7713	12.60	8.33	4.80	15.55	0.00	5.81	0.00	0.00
1.9	0.0538	43	7776	12.24	8.37	4.91	15.56	0.00	6.13	0.00	0.00
2.0	0.0567	42	7837	11.96	8.39	4.99	15.57	0.00	6.37	0.00	0.00
2.2	0.0623	40	7881	11.76	8.37	5.11	15.29	0.00	6.79	0.00	0.00
2.4	0.0680	38	8027	11.51	8.34	5.23	15.00	0.00	7.24	0.00	0.00
2.5	0.0708	37	8079	11.42	8.32	5.31	14.86	0.00	7.44	0.00	0.00
2.6	0.0737	36	8122	11.11	8.27	5.37	14.98	0.00	7.60	0.00	0.00
2.8	0.0793	35	8206	10.47	8.17	5.46	15.21	0.00	8.02	0.00	0.00
3.0	0.0850	33	8294	9.79	8.06	5.59	15.43	0.00	8.43	0.00	0.00
3.5	0.0992	30	8490	8.47	7.76	5.73	15.50	0.00	9.31	0.00	0.00
4.0	0.1134	27	8674	6.99	7.55	5.86	15.55	0.00	10.16	0.00	0.00
4.5	0.1275	25	8836	5.90	7.11	5.88	15.48	0.00	10.80	0.00	0.00
5.0	0.1417	23	8983	4.74	6.66	5.92	15.36	0.00	11.62	0.00	0.00
5.5	0.1559	22	9106	4.43	6.38	5.89	13.71	0.00	12.39	0.00	0.00
5.7	0.1615	21	9173	4.31	6.28	5.88	13.18	0.00	12.52	0.00	0.00
6.0	0.1700	20	9234	3.99	6.12	5.83	12.00	0.00	13.03	0.00	0.00
6.5	0.1842	29	9331	3.92	5.92	5.68	12.11	0.00	13.41	0.00	0.00
7.0	0.1984	18	9427	3.80	5.82	5.51	12.21	0.00	13.81	0.00	0.00
8.0	0.2267	16	10161	3.51	5.58	5.36	13.16	0.00	13.99	0.00	0.00
9.0	0.2550	14	10260	3.33	5.40	5.30	14.45	0.00	14.05	0.00	0.00
10.0	0.2834	13	10351	2.99	5.34	5.20	15.79	0.00	14.05	0.00	0.00
11.0	0.3117	11	10437	2.74	5.18	5.10	16.89	0.00	13.82	0.00	0.00
12.0	0.3401	10	10518	2.28	4.99	5.00	15.67	0.07	13.46	0.00	0.00
13.0	0.3684	10	10594	1.89	4.80	4.86	14.46	0.20	13.12	0.00	0.00
14.0	0.3967	9	10658	1.71	4.60	4.73	13.01	0.47	12.37	0.00	0.00
15.0	0.4251	8	10724	1.53	4.37	4.59	10.55	1.32	11.00	0.00	0.00
16.0	0.4534	8	10778	1.38	4.19	4.46	8.21	3.15	9.97	0.00	0.00
20.0	0.5668	6	11009	0.80	3.42	3.93	5.78	13.36	6.18	0.00	0.00
25.0	0.7085	5									
30.0	0.8501	4									
35.0	0.9918	4									
40.0	1.1335	3									
45.0	1.2752	3									
50.0	1.4169	3									
55.0	1.5586	3									
60.0	1.7003	3									
65.0	1.8420	3									
70.0	1.9837	3									
75.0	2.1254	3									
80.0	2.2671	3									
85.0	2.4088	3									
90.0	2.5504	3									
95.0	2.6921	3									
100.0	2.8338	3									
105.0	2.9755	3									

flow cfs	flow cumecs	Imham %time exceed.	Eden. gross area	Eden. trout fry	Eden. trout juv	Eden. trout adult	Eden. dace fry	Eden. dace juv	Eden. dace adult	Eden. chub fry	Eden. chub juv+ad
0.1	0.0028	95									
0.2	0.0057	90	4270	19.45	2.94	1.72	1.75	0.00	0.54	0.00	0.00
0.3	0.0085	82	4885	19.84	3.46	2.04	2.45	0.00	0.72	0.00	0.00
0.4	0.0113	77	5454	19.48	3.83	2.27	2.93	0.00	1.00	0.00	0.00
0.5	0.0142	70	6024	19.84	4.11	2.45	3.12	0.00	1.36	0.00	0.00
0.6	0.0170	66	6574	20.09	4.33	2.59	3.20	0.00	1.71	0.00	0.00
0.7	0.0198	62	6976	20.59	4.60	2.76	3.33	0.00	2.04	0.00	0.00
0.8	0.0227	60	7212	21.06	4.93	2.98	3.53	0.00	2.37	0.00	0.00
0.9	0.0255	57	7397	21.36	5.24	3.19	3.80	0.00	2.57	0.00	0.00
1.0	0.0283	55	7572	21.66	5.50	3.38	3.94	0.00	2.99	0.00	0.00
1.5	0.0425	49	8197	23.80	6.54	4.25	4.54	0.00	5.06	0.00	0.00
1.8	0.0510	45	8430	25.00	6.98	4.63	4.61	0.19	6.28	0.00	0.00
1.9	0.0538	44	8575	25.37	7.11	4.77	4.63	0.25	6.58	0.00	0.00
2.0	0.0567	43	8674	25.83	7.26	4.91	4.67	0.32	7.19	0.00	0.00
2.2	0.0623	41	8843	26.24	7.43	5.12	4.11	0.58	7.99	0.00	0.00
2.4	0.0680	39	9000	26.63	7.63	5.33	3.53	0.81	8.78	0.00	0.00
2.5	0.0708	39	9082	26.85	7.73	5.43	3.21	0.94	9.19	0.00	0.00
2.6	0.0737	38	9150	26.81	7.80	5.51	3.11	1.04	9.51	0.00	0.00
2.8	0.0793	36	9281	27.04	7.91	5.67	2.89	1.27	10.23	0.00	0.00
3.0	0.0850	35	9426	27.14	8.07	5.86	2.68	1.48	10.91	0.00	0.00
3.5	0.0992	31	9613	26.24	8.33	6.52	3.09	1.97	12.41	0.00	0.00
4.0	0.1134	29	9927	25.14	8.68	7.43	3.58	2.46	14.08	0.00	0.00
4.5	0.1275	26	10143	24.68	9.10	8.13	4.04	2.79	15.38	0.00	0.00
5.0	0.1417	24	10350	24.26	9.51	9.00	4.56	3.18	16.84	0.00	0.00
5.5	0.1559	22	10458	24.10	9.81	9.97	4.91	3.19	18.00	0.00	0.20
5.7	0.1615	21	10639	24.01	9.98	10.21	5.03	3.21	18.40	0.00	0.26
6.0	0.1700	21	10748	23.88	10.21	10.77	5.29	3.22	19.20	0.00	0.38
6.5	0.1842	19	11002	23.41	10.47	11.40	5.49	3.35	20.41	0.00	0.59
7.0	0.1984	18	11256	22.97	10.69	11.93	5.70	3.48	21.00	0.00	0.78
8.0	0.2267	15	11871	22.49	10.98	12.15	6.25	3.69	22.32	0.00	1.19
9.0	0.2550	14	12141	21.95	11.56	12.70	7.36	4.12	24.10	0.00	1.44
10.0	0.2834	13	12334	21.70	12.15	13.73	8.31	4.86	25.73	0.00	1.67
11.0	0.3117	11	12511	21.76	12.11	15.10	9.26	5.40	27.16	0.00	1.81
12.0	0.3401	10	12681	21.74	13.24	16.63	10.25	5.92	28.48	0.00	2.08
13.0	0.3684	10	12843	21.70	13.72	18.35	11.08	6.36	29.65	0.05	2.79
14.0	0.3967	9	13000	21.42	14.13	20.61	12.48	8.33	31.97	0.35	4.73
15.0	0.4251	8	13153	21.19	14.56	22.98	13.81	10.32	34.00	0.66	6.78
16.0	0.4534	8	13297	20.68	14.79	24.01	13.50	10.48	34.63	0.93	9.52
20.0	0.5668	6	13870	18.57	16.14	28.81	12.27	10.97	37.37	2.19	20.64
25.0	0.7085	5	14556	15.30	16.87	34.51	13.03	10.15	38.55	3.62	29.20
30.0	0.8501	5	15234	13.80	17.23	36.76	13.77	8.93	37.22	4.10	30.65
35.0	0.9918	4	15853	14.17	17.80	35.84	15.18	7.58	34.91	4.44	30.92
40.0	1.1335	4	16461	14.47	18.27	35.20	16.42	6.17	32.78	5.75	29.72
45.0	1.2752	3	17203	14.07	18.42	33.76	16.93	5.29	30.21	6.46	27.20
50.0	1.4169	3	18266	13.45	18.26	35.16	16.69	4.67	27.52	6.71	24.34
55.0	1.5586	3	19510	13.82	18.04	34.97	17.93	4.48	25.10	6.54	21.84
60.0	1.7003	3	20396	14.23	18.21	32.74	20.30	4.42	23.70	6.52	20.62
65.0	1.8420	3	21022	14.69	18.67	31.78	22.04	5.02	23.12	6.70	19.40
70.0	1.9837	3	21535	14.62	19.31	32.12	24.17	5.64	22.99	7.11	17.98
75.0	2.1254	3	21946	14.27	20.08	32.92	24.91	6.17	23.18	7.56	17.21
80.0	2.2671	3	22324	13.91	20.81	32.88	25.96	7.32	23.64	8.05	16.75
85.0	2.4088	3	22672	13.58	21.46	32.14	25.36	8.22	24.27	8.47	16.52
90.0	2.5504	3									
95.0	2.6921	3									
100.0	2.8338	3									
105.0	2.9755	3									