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RIVER ALLEN HABITAT MAPPING SURVEY

REPORT TO NATIONAL RIVERS AUTHORITY WESSEX REGION

by

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Executive Summary

In a previous report to NRA Wessex Region, (Johnson, Elliott, Gustard and Clausen, 1993) results were presented from an application of the Instream Flow Incremental Methodology (IFIM), using the Physical Habitat Simulation (PHABSIM) model, to investigate instream flow requirements for the River Allen, Dorset. Using the IFIM in conjunction with a groundwater model provided by Groundwater Development Consultants, Cambridge, the impact of the historical groundwater pumping regime upon the availability of physical habitat to life-stages of trout and salmon was simulated. PHABSIM simulations were based on data collected from two study sites on the Allen, during 1992, by NRA Wessex Region staff.

We report here on the results of a habitat mapping survey of a 2km long reach of the Allen. The survey was conducted in order to advise on extrapolation of IFIM results based on PHABSIM data sets collected from the two existing study sites, which lie within the reach surveyed for this report.

The habitat mapping survey was conducted using visual observations of the distribution of habitat types along the survey reach, made from the banks and by wading. After making initial observations at the study sites three habitat types; pools, shallow (fast) glides and deep (slow) glides were defined. The distribution of these habitat types along the 2km survey reach was then mapped. At each of the study sites a habitat type was assigned to each of the transects used in the PHABSIM simulations.

The aim of this survey was to provide data to extrapolate PHABSIM Weighted Usable Area (WUA) vs Discharge results from the study sites to the portion of the Allen most impacted by abstraction (Newman and Symonds, 1991). The extrapolation technique, known as 'habitat mapping' was developed by the U.S. Fish & Wildlife Service (Bovee (1982)). Using Fry/Juvenile trout as an example we demonstrate here that WUA vs Discharge relationships very similar to those generated by the standard PHABSIM simulations can be produced using data averaged by habitat type and extrapolated by habitat mapping. Using this habitat mapping technique, we have generated a corresponding WUA vs Discharge for the 2km long survey reach. Results indicate that WUA vs Discharge relationships produced using data from either of the two sites, and by the habitat mapping along the 2km reach are in close agreement.

The main outputs and conclusions of this report may be summarised thus:

- Habitat type classification system
- Map of distribution of habitat types along 2km survey reach
- WUA vs Discharge curves based on habitat mapping of data from the upstream and downstream study sites
- Comparison of results at study sites with results of full PHABSIM simulations.
- WUA vs Discharge curve for the 2km survey reach

Acknowledgements

We acknowledge the assistance of Graham Lightfoot, Dave Bird and Nick Berry of NRA Wessex Region for their assistance in conducting the habitat mapping survey.

1 Introduction

Under a previous commission from NRA Wessex Region (Johnson, Elliott, Gustard & Clausen, 1993) an initial assessment of instream flow requirements for the River Allen, Dorset was made using the Instream Flow Incremental Methodology (IFIM) (Bovee,1982). The IFIM is implemented using the Physical Habitat Simulation (PHABSIM) model. For the initial assessment, PHABSIM hydraulic data were collected from two study sites on the Allen. Relevant features of the Allen catchment are shown in Figure 1.1 below (reproduced from Newman & Symonds,1991). The positions of the two PHABSIM study sites, upstream of Didlington Mill (grid ref. SU007080), and 400m downstream of Loverley Mill (grid.ref. SU003075) are shown in Figure 1.2 below.

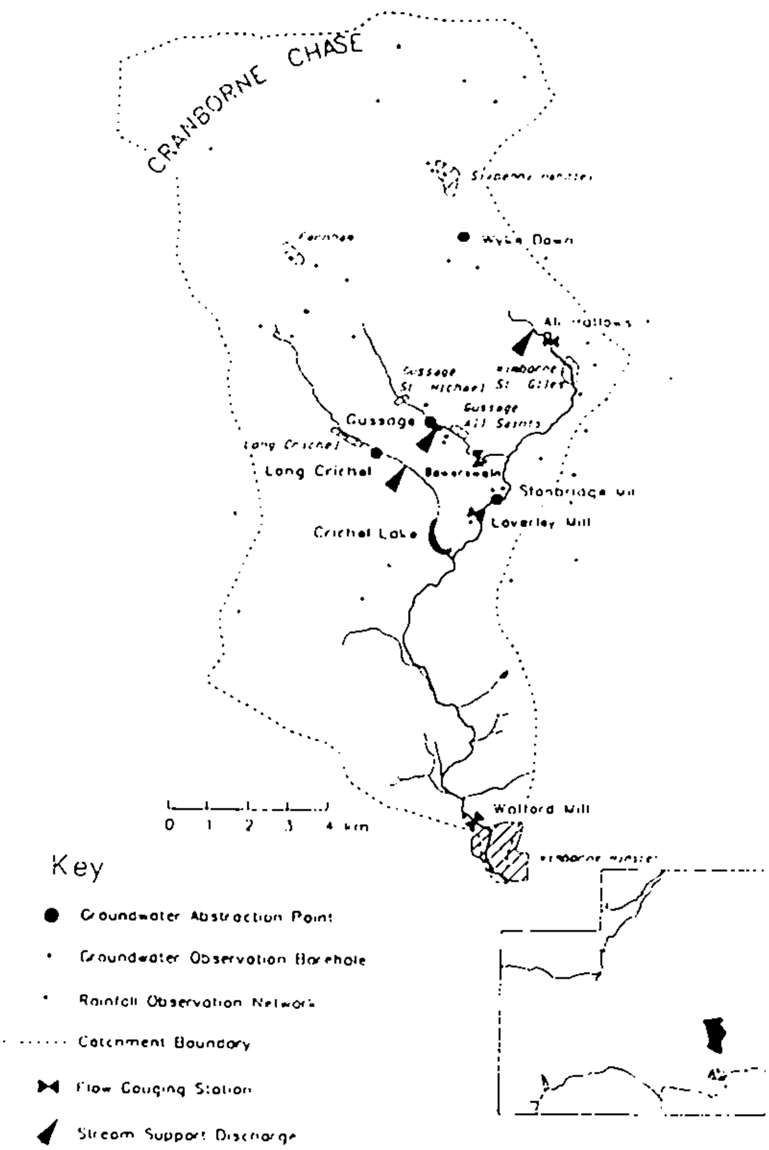

Figure 1.1 River Allen Catchment

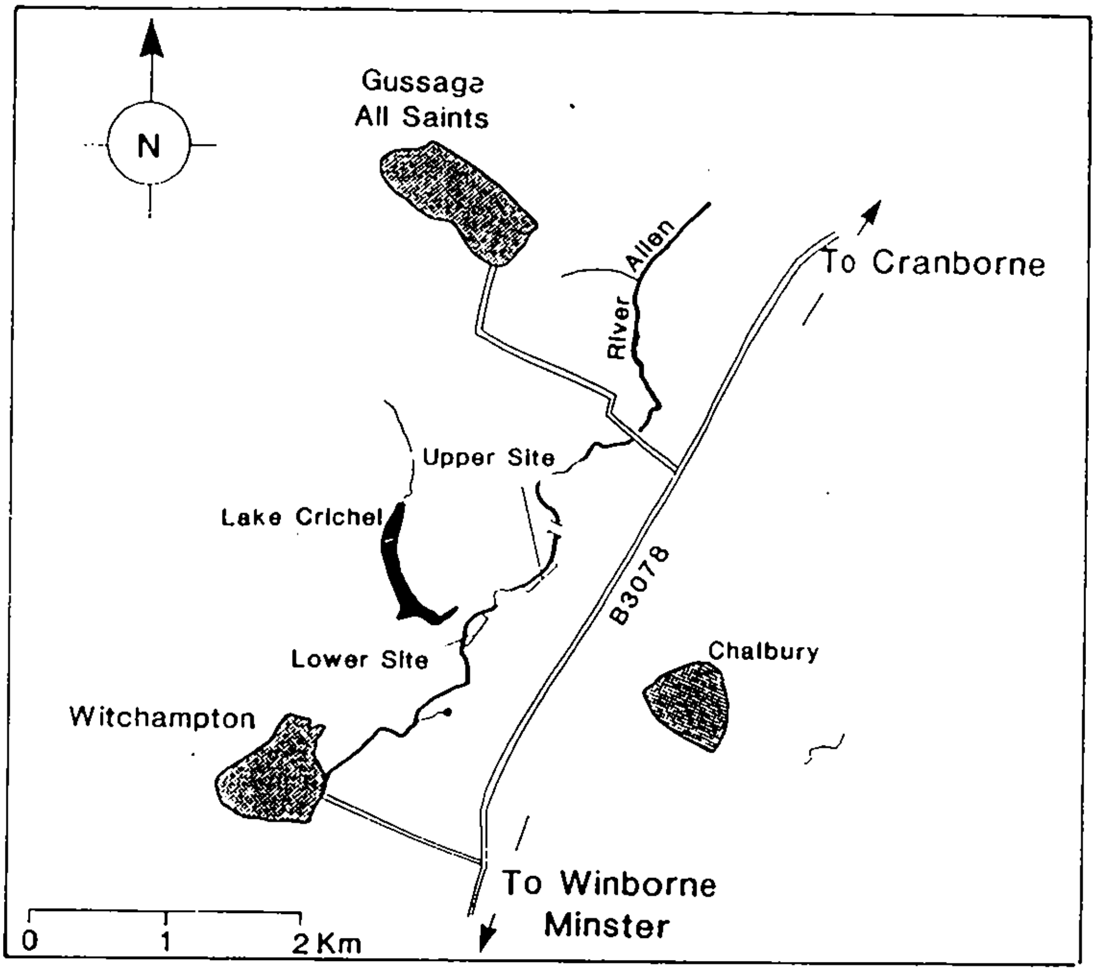

Figure 1.2 *Location of PHABSIM study sites*

Using data collected from the two study sites during 1992 by NRA Wessex Region staff, PHABSIM hydraulic models were calibrated to predict depths and velocities for a range of simulation discharges. Output from PHABSIM hydraulic models were combined with habitat suitability data for life-stages of trout and salmon to give Weighted Usable Area (WUA) vs Discharge relationships for each life-stage. Species habitat suitability curves used in these simulations, produced by NRA Wessex Region, were based on observations made by wading and snorkelling in chalk streams similar to the Allen. In Figure 1.3 below, we give an example of PHABSIM output showing WUA vs Discharge for life-stages of trout at the downstream study site.

A technique known as 'habitat mapping' for constructing WUA vs Discharge curves for a river reach based on the relative distribution of habitat types (eg. pool, riffle, glide), (Bovee, 1982) has been used widely in IFIM applications in the US. The first step in the habitat mapping approach is to construct a WUA vs Discharge curve corresponding to each habitat type on the basis of field observations (of depth, mean column velocity, and substrate type) made at points across transects representing each habitat type. For a given reach of

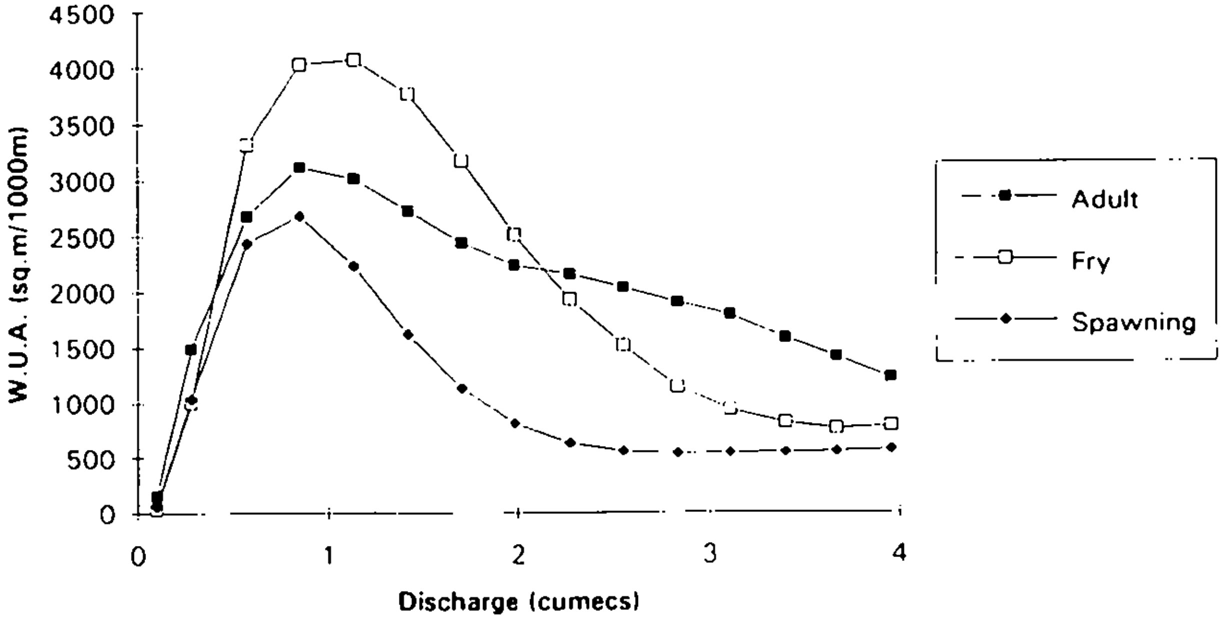

Figure 1.3 *WUA vs Discharge for life-stages of trout, downstream site.*

river a WUA vs Discharge curve may be constructed by combining individual WUA vs Discharge curves corresponding to each habitat type according to the relative proportions of the reach represented by each habitat type.

2 Habitat Mapping Survey

The habitat mapping survey was conducted on 28th April 1993. The reach surveyed covers 2.2km, beginning immediately downstream of Loverley Mill and finishing at Didlington Mill (see Figure 1.1).

2.1 CLASSIFICATION OF HABITAT TYPES

Before the locations of the two PHABSIM study reaches used in the initial assessment were chosen, a stretch of the Allen thought to be impacted by groundwater abstraction was observed visually. The upstream study site was then chosen to be a 'representative reach', about 100m long, which was considered to contain all of those habitat types present in the longer stretch observed. The downstream site was chosen as a reach where the impact of abstraction was thought to be most pronounced.

Prior to conducting the habitat mapping survey it was necessary to develop a system for classifying habitat types present in the 2.2km long survey reach. Since it was intended to complete the habitat mapping survey over the 2.2km reach in a single day it was necessary to limit the complexity of the classification system to promote ease of application.

After making observations at the upstream 'representative reach' study site, it was decided that habitats would be classified as belonging to one of the following three habitat types:

Habitat Type	Abbreviation
Pools	P
Shallow (fast) glide	SG
Deep (slow) glide	DG

2.2 CLASSIFICATION OF HABITAT TYPES REPRESENTED BY TRANSECTS AT STUDY SITES

Having established the classification system described above, a habitat classification was assigned to the habitat type present at each of the transects used for the PHABSIM simulations at the two study sites. Results for the up and downstream sites are given in Tables 2.1 and 2.2 below:

Table 2.1 *Upstream Site : Classification of Habitat Types*

Transect No.	Habitat Type
2	DG
3	DG
4	P
5	DG
6	DG
7	DG
8	SG
9	SG
10	SG
11	SG
12	SG

Table 2.2 *Downstream Site : Classification of Habitat Types*

Transect No.	Habitat Type
2	SG
3	SG
4	SG
5	DG
6	SG
7	SG
8	SG

2.3 RESULTS OF HABITAT MAPPING SURVEY

Having classified the habitat types represented by the transects at the study sites, the habitat mapping survey along the 2.2km reach (see Figure 1.2) was undertaken. While distances were recorded by an observer on the bank, habitat types were classified using observations made by wading in the channel.

Each time a new habitat type was observed, the distance from the beginning of the survey reach was recorded. Results giving the relative proportion of each habitat type within the survey reach are given in Table 2.3 below:

Table 2.3 *Distribution of Habitat Types in Survey Reach*

Habitat Type	Total Length Represented (m)	Proportion
P	213.0	0.10
SG	713.0	0.32
DG	1274.0	0.58

A schematic representation of the distribution of habitat types along the survey reach is shown in Figure 2.1 below:

Total length of reach = 2200 m

Total length of pools = 213 m (9.7 % of total habitat)
Total length of shallow glides = 713 m (32.4 % of total habitat)
Total length of deep glides = 1274 m (57.9 % of total habitat)

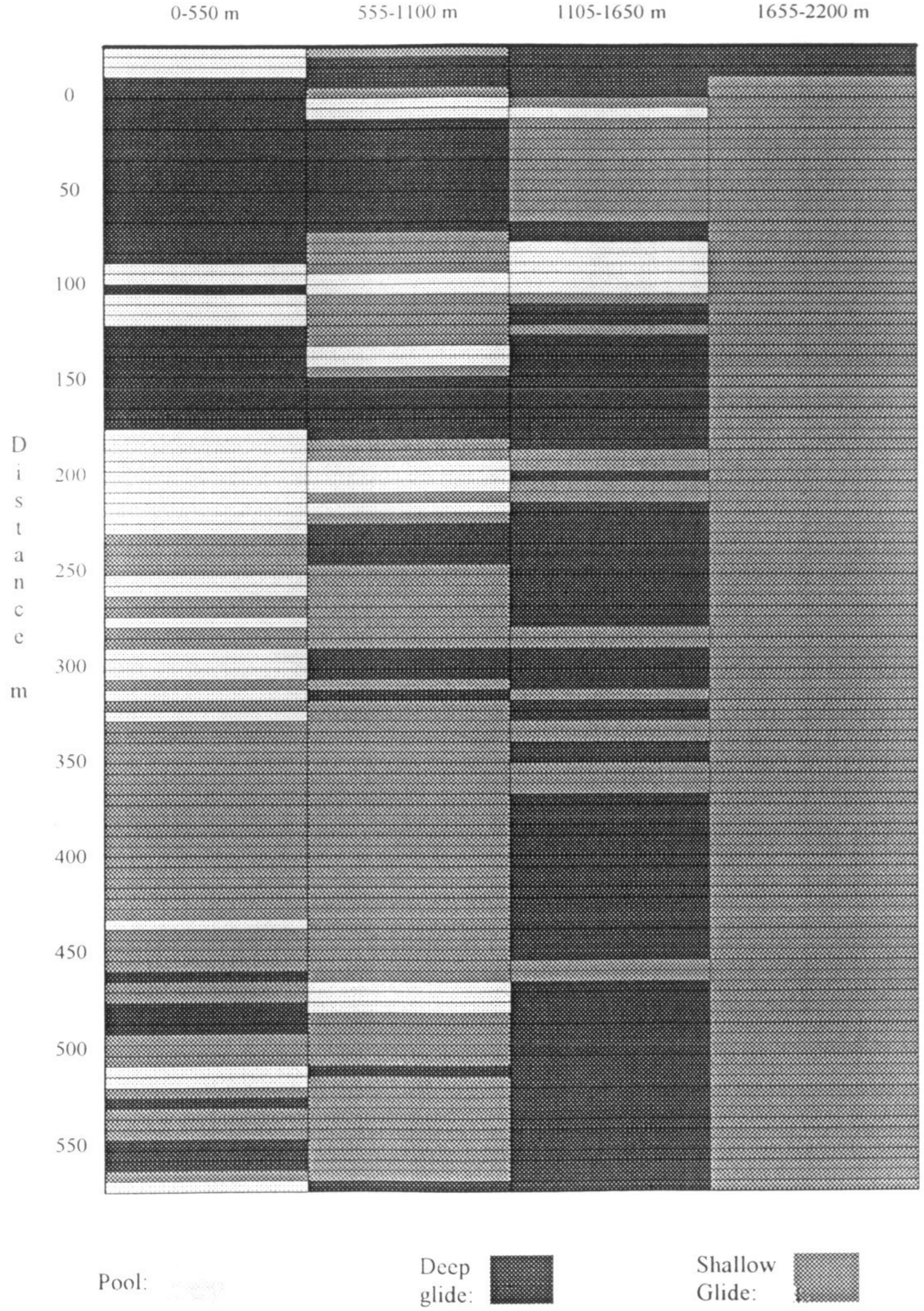

Figure 2.1 *Distribution of Habitat Types Along Survey Reach*

3 Phabsim simulations

In this section we present WUA vs Discharge results from PHABSIM simulations based on a habitat mapping approach. Outputs from the two study sites are compared with the results from standard PHABSIM simulations. Finally, a corresponding WUA vs Discharge relationship for the 2.2km long survey reach is constructed. Results presented here are limited to the single case of fry/juvenile trout.

3.1 AVERAGE WUA VS DISCHARGE FOR HABITAT TYPES

The first step in using a habitat mapping approach to PHABSIM simulation is to define a WUA vs Discharge curve corresponding to each of the three habitat types. From previous PHABSIM simulation outputs (see Johnson, Elliott, Gustard and Clausen, 1993) we are able to extract individual WUA vs Discharge relationships for each transect in the study reaches. Using the classification given in Tables 2.1, 2.2 we construct a WUA vs Discharge curve corresponding to each habitat type by averaging over the individual 'ample' WUA vs Discharge curves corresponding to the transects representing each class. The resulting averaged WUA vs Discharge curves for fry/juvenile trout corresponding to each of the three habitat types are shown in Figure 3.1 below:

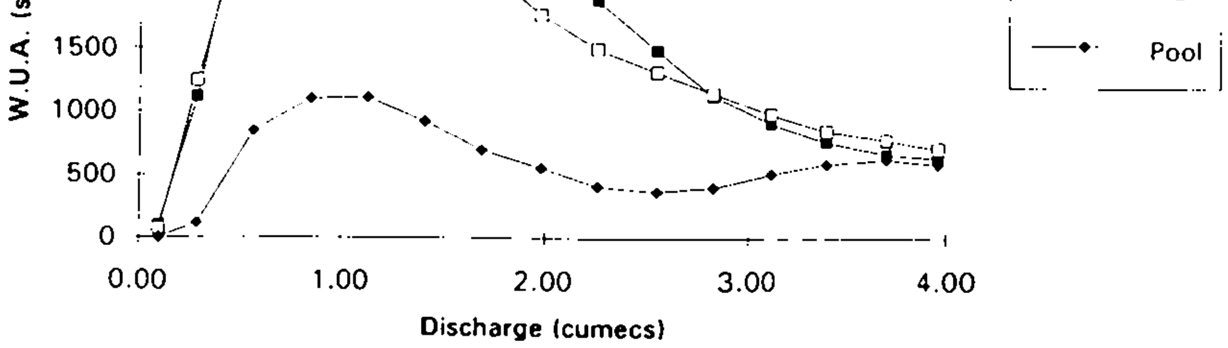

Figure 3.1 Averaged WUA vs Discharge Curves for Fry/Juvenile Trout

3.2 HABITAT MAPPED WUA VS DISCHARGE FOR STUDY SITES

As a test of the validity of using the habitat mapping approach to PHABSIM simulation, we will compare WUA vs Discharge outputs produced by habitat mapping with those produced using the standard method of PHABSIM application. For a given reach we construct a WUA vs Discharge curve as a composite of the three WUA vs Discharge curves corresponding to each habitat type. The curves for each habitat type are combined to reflect the proportion of the reach which they represent. All results are presented in the standard normalised PHABSIM units of $m^2/1000m$.

For a given reach with the following distribution of habitat types:

PP = Proportion of reach represented by Pool habitat
PSG = Proportion of reach represented by Shallow Glide habitat
PDG = Proportion of reach represented by Deep Glide habitat

we construct the composite WUA vs Discharge (Q) curve as

$$WUA(Q) = PP \times WUA_P(Q) + PSG \times WUA_{SG}(Q) + PDG \times WUA_{DG}(Q) \quad (3.1)$$

where WUA_P, WUA_{SG}, WUA_{DG} are the individual, averaged, WUA vs Q curves corresponding to each of the habitat types, as shown in Figure 3.1 in the previous sub-section. In order to construct the habitat mapped WUA vs Q curves for the up and downstream study sites, we must define the parameters PP, PSG and PDG in Equation (3.1).

In the standard PHABSIM simulation runs used for the initial assessment parameters known as 'upstream weighting factors' were defined, one per transect. These parameters control the areas up and downstream of each transect over which point values of habitat suitability, computed at data points across the transect, are assigned in the calculation of WUA. For the simulation runs in the initial assessment, the value of all upstream weighting factors was chosen as the default value of 0.5. The effect of this choice is to assign habitat suitability values at a given transect over an area which extends half-way to the neighbouring transects up and downstream. In order to make the comparison between the standard PHABSIM simulation results and the habitat mapping results consistent we have assumed in defining the parameters PP,PSG,PDG for the study sites, that the habitat type represented by a given transect extends half way to the neighbouring transects up and downstream. Making this assumption gives the following distribution of habitat types for the two study sites:

Site	PP	PSG	PDG
Upstream	0.103	0.461	0.436
Downstream	0.000	0.840	0.160

Using these values in Equation (3.1), together with WUA_P,WUA_{SG}, WUA_{DG} as shown in Figure 3.1, we can compute WUA vs Q curves for the two sites. Results giving comparison with standard PHABSIM simulations are shown in Figures 3.2, 3.3 for the up and downstream study sites respectively.

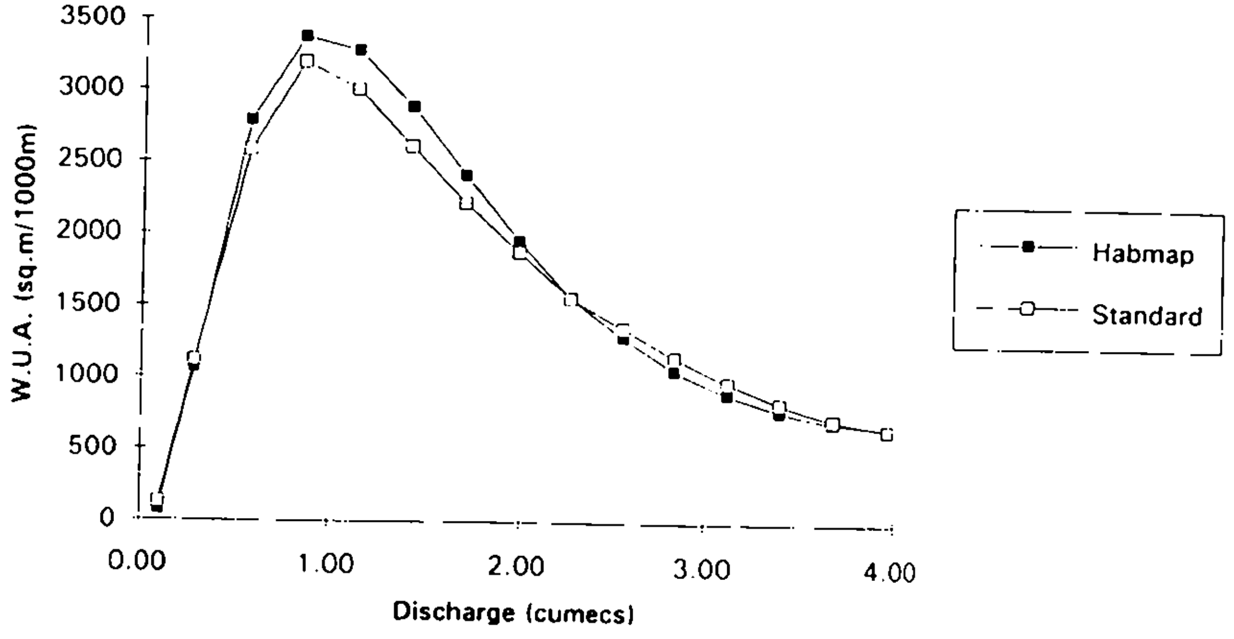

Figure 3.2 *Upstream Site : WUA vs Q for Fry/Juvenile Trout - Comparison of standard and habitat mapping results*

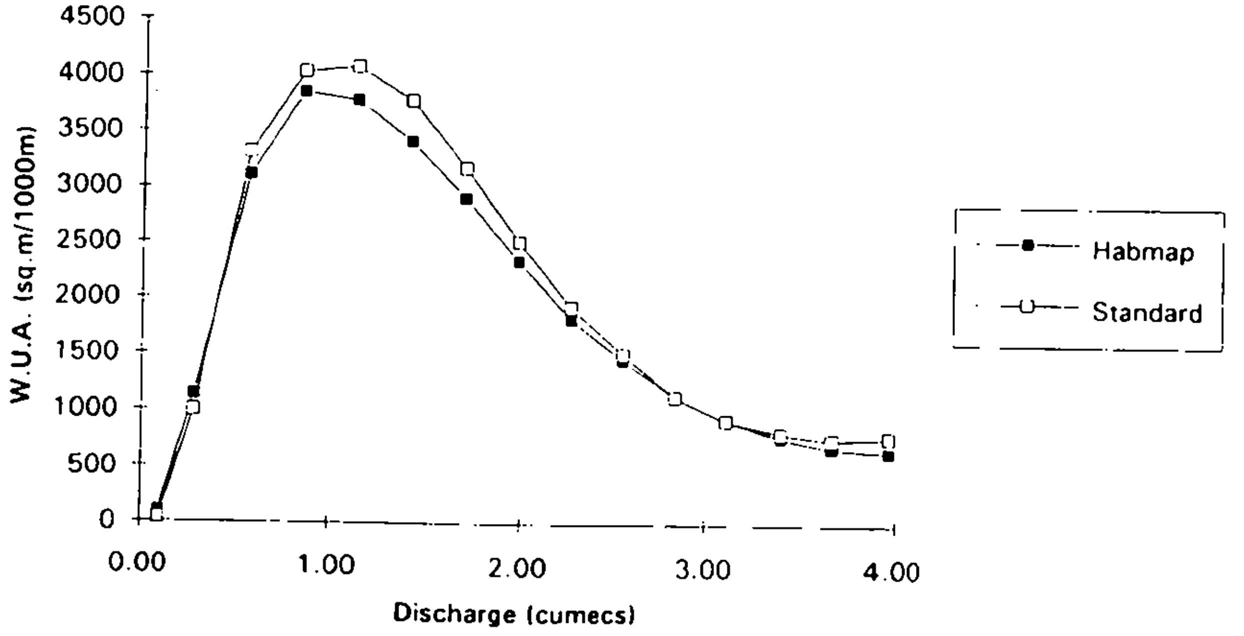

Figure 3.3 *Downstream Site : WUA vs Q for Fry/Juvenile Trout - Comparison of standard and habitat mapping results*

3.3 EXTRAPOLATION TO SURVEY REACH

We now proceed to construct a corresponding WUA vs Q curve for the 2.2km survey reach using the same WUA_P, WUA_{SG}, WUA_{DG} functions as in the computation of WUA vs Q at the study sites, but with the parameters PP,PSG PDG in Equation (3.1) defined as those values given in Table 2.3 (PP=0.10, PSG=0.32, PDG=0.58). Results are shown in Figure 3.4 below, together with the results of the corresponding PHABSIM habitat mapping results at the two study sites.

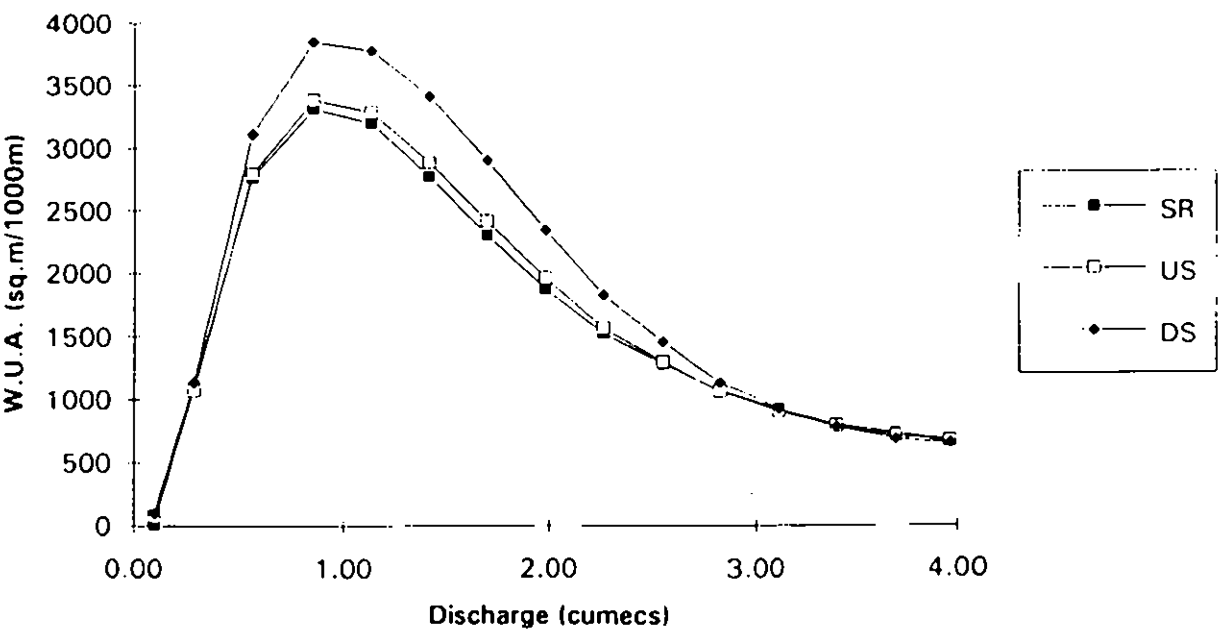

Figure 3.4 *WUA vs Q for Fry/Juvenile Trout : PHABSIM Habitat Mapping Outputs, Upstream Site(US), Downstream Site(DS) and Survey Reach (SR)*

4 Conclusions

The outputs shown in Section 3 demonstrate that the results of standard PHABSIM simulations at the two study sites agree closely with corresponding estimates using a habitat mapping approach. Applying the same methodology to the 2.2km survey reach produces results very similar to those at either study site.

In applying PHABSIM outputs in a time-series analysis of the availability of WUA, (see Johnson, Elliott, Gustard and Clausen, 1993) the shape of the WUA vs Q function, rather than the absolute values of WUA, determines the form of the WUA duration curve (giving the percentage of time that given WUA values are exceeded). It may be noted from figure 3.4 that in addition to fairly close agreement of absolote values, the similarity in shape of the three curves is very pronounced. Consequently we suggest that it is appropriate to extrapolate the results of the initial assessment reported in Johnson, Elliott, Gustard and Clausen to the 2.2km reach surveyed for this report.

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Newman & Symonds 1991. The River Allen - A Case Study. In Procs. BHS 3rd National Hydrology Symposium, Southampton, 1991.