The Distribution and Population Status of Cape Whitefish *Barbus andrewi* in the Upper Hex River, Worcester and the Associated Impact of Smallmouth Bass *Micropterous dolomieui*.

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1. ABSTRACT

The Cape Whitefish, *B. andrewi* is Critically Endangered due to various factors. These are: effects of the alien invasive fish smallmouth bass *M. dolomieui;* habitat fragmentation and degradation; water abstraction; bulldozing; siltation and pesticides. Hypotheses concerning *B. andrewi* and *M. dolomieui* were examined. These include: the population of *B. andrewi* downstream of the causeway is smaller than that upstream of the causeway; there are fewer size classes of *B. andrewi* downstream of the causeway; only large *B. andrewi* are found downstream of the causeway*; M.dolomieui* competes for microhabitat with *B. andrewi.* A snorkelling survey was conducted on 9 km of the Upper Hex River, Worcester, Western Cape during a period of low flow in late summer. A road causeway (Appendix 2, Plates 7 & 8) separates the two sections of the river. The upstream (4.5 km) section contains 345 *B. andrewi*, numerous individuals of two other indigenous fish species, Redfin minnow *Pseudobarbus burchelli* and Cape Kurper *Sandelia capensis* and only five *M. dolomieui*. The downstream section (4.5 km) contains many *M. dolomieui* and five *B. andrewi*. To test for significant differences between frequency counts of certain *M. dolomieui* and *B. andrewi* habitat variables a Chi squared test of independence for two- way classification was conducted. When comparing shade, cover, leaves, branches, substratum, water depth, focal point depth and flow there were no significant differences between the habitats of *M. dolomieui* and *B. andrewi*, if they coexisted they would have to compete for habitat. It is shown that *M. dolomieui* does not coexist with the indigenous fishes of the Upper Hex River.

2. INTRODUCTION

According to Impson and Hamman (2000) the conservation status of freshwater fishes in the Western Cape, South Africa has followed two trends in the twenty-year period from 1977 – 1996. First, overall conservation status has deteriorated. Second, the number of endangered and critically endangered endemic species has grown from one in 1977 to nine in 1987. Endemic Western Cape freshwater fish populations are regarded as highly threatened. The Western Cape is home to the largest concentration, percentage-wise, of threatened indigenous freshwater fishes worldwide (Impson, 1998). Concern for the indigenous freshwater fishes of Southern Africa prompted Skelton to produce two Red Data Books for South African fishes (1977,1987). These books show that the Western Cape is a hotspot for threatened endemic fish species in South Africa.

Of particular concern to Cape Nature Conservation are Cape Whitefish, *Barbus andrewi* (Impson, *pers com*, 2002, Figure 1). This critically endangered (Skelton, 1998) barbine cyprinid is endemic to the Berg and Breede River systems of the Western Cape (Impson, 2001). *B. andrewi* reach up to 60cm in length and about three and a half kilograms in weight (Skelton, 1998). B. andrewi were originally widespread in both systems (Harrison, 1952, cited by Impson, 2001). At present the only viable breeding population of *B. andrewi* is found in the Upper Hex River, a tributary of the Breede River system (Impson, *pers com*, 2002).

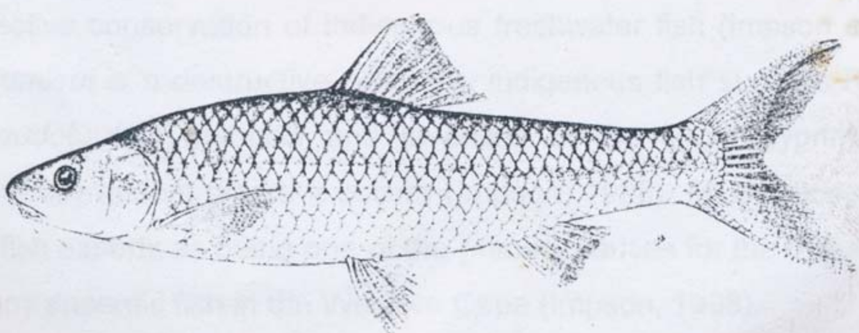
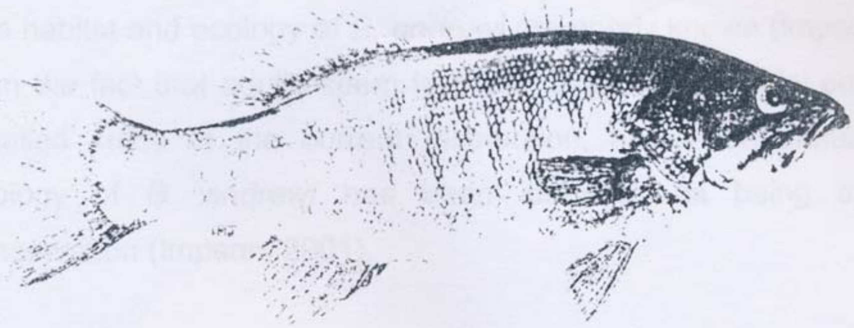


Figure 1: Cape Whitefish, *B. andrewi* (Skelton, 1987).

Factors responsible for the marked decline in the distribution and abundance of *B. andrewi* include the impact of invasive alien fish, especially Smallmouth bass *Micropterus dolomieui* (Figure 2), water abstraction for agriculture, siltation, bulldozing of the river bed and the inflow of pesticides.

Figure 2: Smallmouth Bass, *M. dolomieui* (De Moor & Bruton, 1988).



In an effort to improve fishing in the middle reaches of rivers, *M. dolomieui* was introduced to South Africa in 1937. Twenty-nine survived the journey to Jonkershoek hatchery from Lewistown hatchery, Maryland USA (De Moor & Bruton, 1988). By 1939/40 *M. dolomieui* was reported to be present in both the Berg and Breede Rivers (De Moor & Bruton, 1988). Cambray (1977, cited by De Moor & Bruton, 1988) and Stuart (1985, cited by Demoor and Bruton, 1988) both report drastic declines in indigenous species after the introduction of *M. dolomieui*.

The impact of invasive alien fish is possibly the greatest constraint to the effective conservation of indigenous freshwater fish (Impson *et al*, 1999). *M. dolomieui* is a destructive predator, indigenous fish such as Redfin minnow, *Pseudobarbus burchelli* and juveniles of the larger cyprinid species are generally absent where it occurs (Impson, 1998). *M. dolomieui* are regarded by fish experts as being one of the primary causes for the threatened status of many endemic fish in the Western Cape (Impson, 1998).

The term habitat is defined by Ward (1992, *cited by* Wadeson, 1994) as being the abiotic environment of a species. Rankin (1986) observed the habitat selection of *M. dolomieui* in shallow pools of the Flat River, Michigan, during summer (1981,1982). He concluded that *M. dolomieui* preferred areas of water deeper than 0.45m, with velocities less than 0.15m/s and gravel to boulder sized substrata. He found they had no preference for sunlit or shaded habitats. Impson's paper (1998) reports on the present distribution of *M. dolomieui* in the Western Cape and the impacts it has had on the local indigenous fish fauna.

The habitat and ecology of *B. andrewi* are poorly known (Impson, 2001) apart from the fact that adults seem to prefer large, deep, rocky pools in rivers. A detailed study of the current distribution, population status, biology and ecology of *B. andrewi* has been identified as being crucial to their conservation (Impson, 2001).

This study was designed to contribute to this knowledge base by addressing several key questions regarding the population of *B. andrewi* in the Upper Hex River, including:

- what is the distribution range of *B. andrewi* in the Hex River;
- what is the population size of *B. andrewi* in the Hex River;
- what is the size range of *B. andrewi* in the Hex River;
- do *B. andrewi* coexist with *M. dolomieui*;
- what can be done to help conserve *B. andrewi*;
- what other indigenous species are present in the study area; are they abundant, common or rare;
- what habitat do *B. andrewi* prefer?

Several hypotheses are examined, these are:

1. the population size of *B. andrewi* downstream of the causeway is smaller than that upstream of the causeway;
2. there are fewer size classes of *B. andrewi* downstream of the causeway than upstream of the causeway;
3. only large *B. andrewi* are found downstream of the causeway;
4. *M. dolomieui* competes for microhabitat with *B. andrewi*.

The competitive exclusion principle (Barnes, 1991) states that coexisting species must differ in their trophic niches. The concept states that if two species compete for the same resource in a homogeneous and constant environment, one is certain to become extinct – to be competitively excluded by the other. This study will aim to show that *M.dolomieui* competes for the same habitat as *B. andrewi*.

3. THE STUDY SITE

The study site begins 8 km out of Worcester, on the Upper Hex River, and passes through Glen Heatlie farm (4 km) continuing into Kanet Vlei farm (4 km). Much of the floodplain is used for grape farming. There is a thick belt of riparian vegetation, mainly exotic *Acacia,* on both bulldozed banks of the river. Between the two farms, in the region of the causeway, Working for Water has been clearing alien invasive vegetation (Impson, pers com, 2002). The loss of roots to hold and bind the soil has resulted in topsoil erosion of sediments into the river. The study site is in the Winter Rainfall Region, and data were collected during late summer when water flow in the river was low.

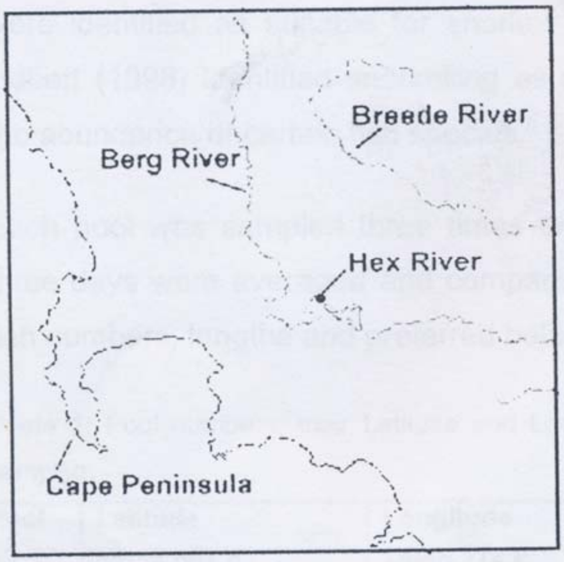


Figure 3: Map of the South Western Cape showing the position of the Berg, Breede and Hex Rivers. The black dot denotes the study site.

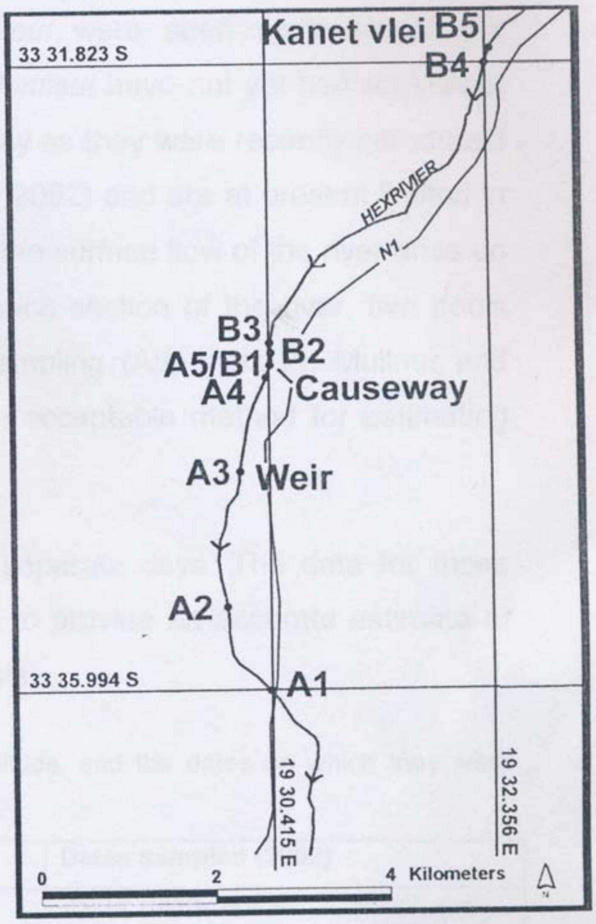


Figure 4: Map of the Hex River. Study sites A1- A5 indicate pools in which *M. dolomieui* are prevalent. Study sites B1- B5 contain *B. andrewi, P. burchelli* and *S. capensis* (Appendix 2).

4. METHOD

Fieldwork was carried out on nine kilometers of the Upper Hex River, a tributary of the Breede River System near Worcester in the Western Cape, South Africa. For the purpose of this study, the Upper Hex River was divided into two sections. The first section was from the N1 highway (33°35.94 S; 19°30.415 E) upstream to a road causeway (33°33.642 S; 19°30.626 E), this section was 4.5 km in length and contained *M.dolomieui*. The second section, upstream of the causeway to Kanet vlei (33°31.739 S; 19°32.422 E), was also 4.5 km in length. *B. andrewi*, *Pseudobarbus burchelli* (Redfin minnow) and *Sandelia capensis* (Cape kurper) occur in this section. *M. dolomieui* have recently crossed the causeway barrier (Appendix 2, Plate 7) and moved upstream, five small (20cm) *M. dolomieui* were seen upstream of the causeway during the study period. *M. dolomieui* have not yet had an impact on the fish fauna upstream of the causeway as they were recently introduced (after November 2001, Impson, *pers com*, 2002) and are at present limited in number and size. Upstream of Kanet vlei the surface flow of the river dries up completely due to water abstraction. In each section of the river, five pools were identified as suitable for snorkel sampling (Appendix 2). Mullner and Hubert (1998) identified snorkelling as an acceptable method for estimating the abundance of certain fish species.

Each pool was sampled three times on separate days. The data for these three days were averaged and compared to provide an accurate estimate of fish numbers, lengths and preferred habitats.

Table 1: Pool numbers, their Latitude and Longitude, and the dates on which they were sampled.

Pool	Latitude	Longitude	Dates sampled (2002)
A1	33°35.994 S	19°30.415 E	26/03; 02/04; 03/04;
A2	33°35.805 S	19°30.141 E	26/03; 02/04; 03/04;
A3	33°34.248 S	19°30.370 E	26/03; 02/04; 03/04;
A4	33°33.717 S	19°30.592 E	26/03; 02/04; 03/04;
A5	33°33.562 S	19°30.702 E	26/03; 02/04; 04/04;
B1	33°33.562 S	19°30.702 E	27/03; 02/04; 04/04;
B2	33°33.562 S	19°30.702 E	27/03; 02/04; 04/04;
B3	33°33.514 S	19°30.733 E	27/03; 03/04; 04/04;
B4	33°31.823 S	19°32.356 E	27/03; 03/04; 04/04;

B5	33°31.739 S	19°32.422 E	27/03; 03/04; 04/04;

4.1 Collection of data on abundances, lengths, focal-point depths and visibility.

Pools were snorkelled by two snorkellers, one following the right bank and one the left. Using a technique described in the Instream Flow Incremental Methodology (IFIM) (King & Tharme, 1994), snorkellers deployed numbered cork floats attached to a five-ounce lead weight by a piece of string where fish were spotted. The length of each fish was estimated (cm) using a ruler under water and the number of fish were counted (where shoals of fish were encountered, the whole shoal was counted and an average length estimated). The focal-point depth (depth off the bottom at which fish was swimming) was estimated. The number of the deployed float as well as the number and length of the fish and the focal point depth were recorded, whilst snorkelling, on white plexiglass using Hb pencils. Time in and time out of the water was noted.

Underwater visibility was measured as described by Mullner (1998) using a piece of white plexiglass with a black letter "A" (75 × 55mm, 15mm line thickness). One snorkeller held the plexiglass, while the other snorkeller moved downstream to the point at which the "A" becomes obscured. Distance was recorded to the nearest 0.1m.

Collected data were entered into tables according to marker number, species of fish, number of fish, length of fish and focal-point depth (Appendix 3).

4.2 Collection of data on habitat use.

Habitat data were collected for the areas where the fish were first seen. Each numbered float was systematically revisited. At each float the following information was collected and recorded:

1. A modified Channel Index Code (CIC) (King & Tharme, 1994) was used to describe the effect of sunlight, the refuge value and the dominant particle size (Table 2).
2. The total water depth was measured using a depth stick (centimeter calibrations).
3. The water temperature was measured at the focal-point water depth using an alcohol 100 degree centigrade thermometer.

4. The flow was visually categorised (Table 3).
5. Any comments were recorded on the data sheet.

Table 2: Modified Channel Index Code (after King & Tharme, 1994).

Hundreds	**Effect of sunlight**	
1	Shade (> 50 % of area)	
2	No shade	
3	Partly shaded (< 50 % of area)	
Tens	Refuge Value (Overhead/ instream cover)	
1	No cover	
2	Overhead cover only (includes riparian vegetation and trees, overhanging banks)	
3	Hydraulic cover only (cobbles, boulders, roots)	
4	Hydraulic and overhead cover (includes any combination of above and combination cover such as deep crevices in bedrock)	
5	Aquatic vegetation (can act as hydraulic or overhead cover; if either 2 or 3 is present with this category, the combined code of 4 is used)	
Units	**Description of dominant particle by percentage area**	**Modified Wentworth grade limits (mm)**
1	Sand and Fines	$x < 2$
2	Gravel	$2 < x < 32$
3	Cobble	$32 < x < 512$
4	Boulder	$x > 512$
5	Bedrock	Slabs

Table 3: Categories of visually distinct flow types observed in the studied pools (King & Schael, 2001). King and Schael (2001) describe pools as having slow, smooth flow with a water velocity of less than 0.1 ms^{-1}.

Flow type	**Definition**
Barely perceptible flow (BPF)	Smooth surface flow; only perceptible through the movement of floating objects.
No flow (NF)	No water movement.
Smooth boundary turbulent (SBT)	The water surface remains smooth; medium to slow streaming flow takes place throughout the water profile; turbulence can be seen as the upward movement of the suspended particles.

4.3 Mapping of the pools.

Before collecting the markers a map was drawn of each pool (Appendix 1). The length and width of the pool was measured. The map consists of a template and overlays of tracing paper. The template outlines the dimensions of the pool, and any obvious features including trees, slabs of rock, grass overhangs and the thalweg. Overlays are then placed over this base map to show the different flow types, water depths, substratum types and markers. The markers for each of the three data-collection days on the same pool are all drawn in on a final pool map to aid investigation of patterns in the positions of the fish.

4.4 Data analysis methods

The raw data were transferred onto Excel spreadsheets. The frequencies of fish species occurring upstream and downstream of the causeway were counted. The totals were graphed in the form of two pie charts to give a visual representation of the number and composition of fish species occurring upstream and downstream of the causeway (Figures 5 & 6). *B. andrewi* length data were grouped into classes, frequencies were counted per class (Figure 7).

Table 4: Habitat-type description used to compare habitat preference between *M. dolomieui* and *B. andrewi*.

1: Submerged or overhead trees, submerged roots, bushes or overhead cover from concrete (causeway). Water depth medium to deep. No flow (NF), or barely perceptible flow (BPF).
2: Cobbles and/or boulders. Smooth boundary turbulent (SBT) flow (inflow of pool). Shallow to medium water depth.
3: Slabs of rock, boulders, cobbles or sand. Deepest area of pool (thalweg). BPF or NF.
4: Boulders and/or cobbles. Water depth shallow. BPF.
5: Silt or silted cobbles and/or boulders. Water depth, very shallow to shallow. NF.
6: Boulders and/or cobbles, may be silted. Water depth medium. BPF.

Each pool map was divided into six possible habitats (Table 4). A 1cm × 1cm transparent grid was placed over each template map and the proportion of each habitat occurring in each pool was calculated and converted into a percentage. In pools upstream of the causeway, where *B. andrewi* occurred, all the percentages for habitat-type one were added, and this total was then divided by the number of pools to give an average percentage for habitat type one. This was repeated for each habitat type and for pools downstream of the causeway where *M. dolomieui* occurred. The number of *M.dolomieui* and the number of *B. andrewi* occurring in each of these habitat types were counted and converted into percentages of the total number of either *M. dolomieui* or *B. andrewi* occurring in each pool. These percentages were added for all pools in which *M.dolomieui* or *B. andrewi* occurred to give a total percentage for all pools. These total percentages were divided by the number of pools counted to give an average percentage of *M.dolomieui* and *B. andrewi* for each habitat type. The average percentage area of each habitat type was graphed against the average percentage number of fish occurring in each habitat type for *M.dolomieui* and *B. andrewi* (Figure 8).

A Chi squared test of independence for two-way classification using contingency tables was conducted using Statistica 5.5, to test for significant differences between frequency counts of certain *M .dolomieui* and *B. andrewi* habitat variables (Table 8).

A description of *B. andrewi* habitat was produced using information from the *B. andrewi* habitat description table (Table 6). A description of *M. dolomieui* habitat was also produced using information from the *M. dolomieui* habitat description table (Table 7).

5. RESULTS

Results are subdivided into four sections. First the relative abundance and composition of fish fauna within the study sites are examined. Underwater visibility is discussed in section two. *M. dolomieui* and *B. andrewi* habitat are described in section three. Finally statistical chi-squared tests are discussed in section four.

5.1 Relative abundance and composition of fish fauna.

Two of the five species of fish occurring in the pools upstream of the causeway were the alien invasives, *M. dolomieui* and *O. mykiss* (Figure 5). They contributed little to the overall number of fish. This is because *M. dolomieui* were observed for the first time upstream of the causeway during this study. There were five small *M. dolomieui* (20cm), it is suggested that they had insufficient time since their introduction upstream of the causeway to have had any impacts on the indigenous fish species in this section of the river. M. dolomieui were not present upstream of the causeway before November 2001 (Impson, pers com, 2002). *S. capensis* and *P. burchelli* were present, both are indigenous fish species. The most abundant category of fish observed were juveniles (714 fish). This category included *P. burchelli* and *B. andrewi* juveniles. It is only possible to tell the difference between these two species at a size of 4 –5 cm when *P. burchelli* will begin to display adult markings. Three hundred and forty-five adult *B. andrewi* were counted. Of interest to CNC were *Galaxias zebratus,* which were absent in the study sites.

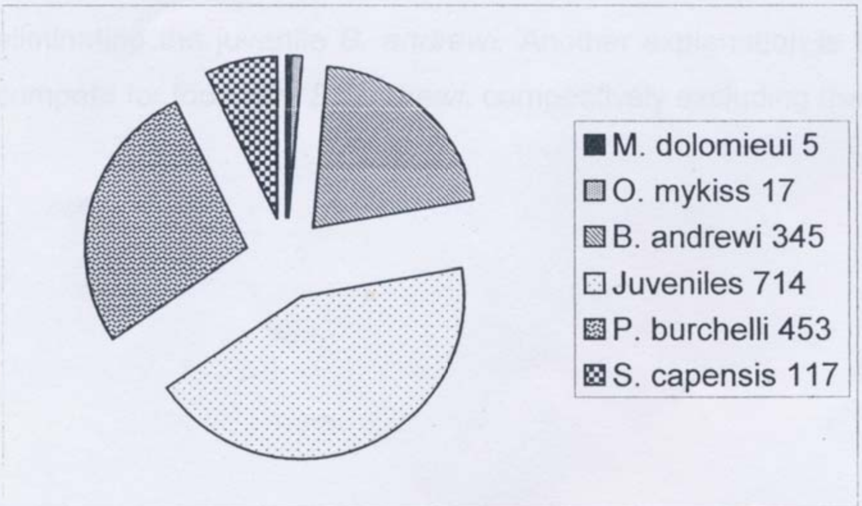


Figure 5: The relative abundance of each of the five species of fish upstream of the causeway from three snorkel surveys conducted over five days. Counts from the three

surveys were combined and an average was taken to give an accurate estimate of fish numbers.

M. dolomieui have been present downstream of the causeway for at least 20 years (Impson, *pers com* 2002). *M. dolomieui* are the most numerous species (190 fish) with *O. mykiss* (4 fish) and *B. andrewi* (5 fish) comprising only a very small part of the total (Figure 6).

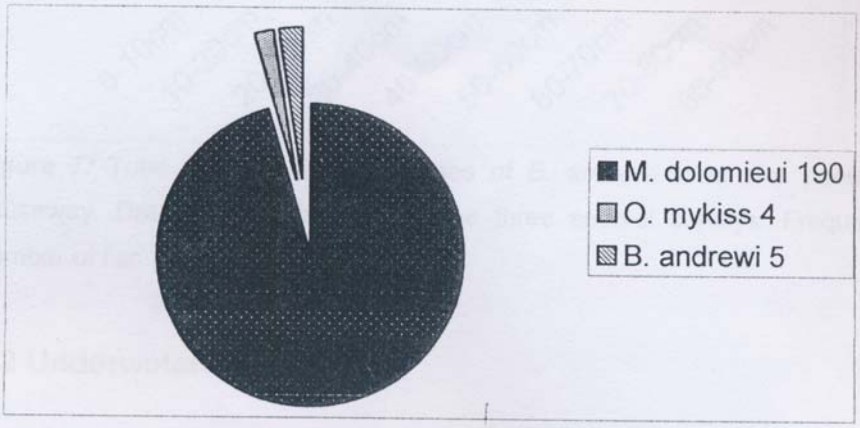


Figure 6: The relative abundance of each of the five species of fish downstream of the causeway from three snorkel surveys conducted over five days. Counts from the three surveys were combined and an average was taken to give an accurate estimate of fish numbers.

There was a well represented size range of *B. andrewi* upstream of the causeway, varying in length from 10 cm to 90 cm (Figure 7). The most abundant size class is 20 cm – 30 cm. There were fewer large *B. andrewi*. Downstream of the causeway there were five *B. andrewi,* comprising one size class (20 cm – 30 cm). This could be as a result of predation by *M. dolomieui* eliminating the juvenile *B. andrewi*. Another explanation is that *M. dolomieui* compete for food with *B. andrewi*, competitively excluding them.

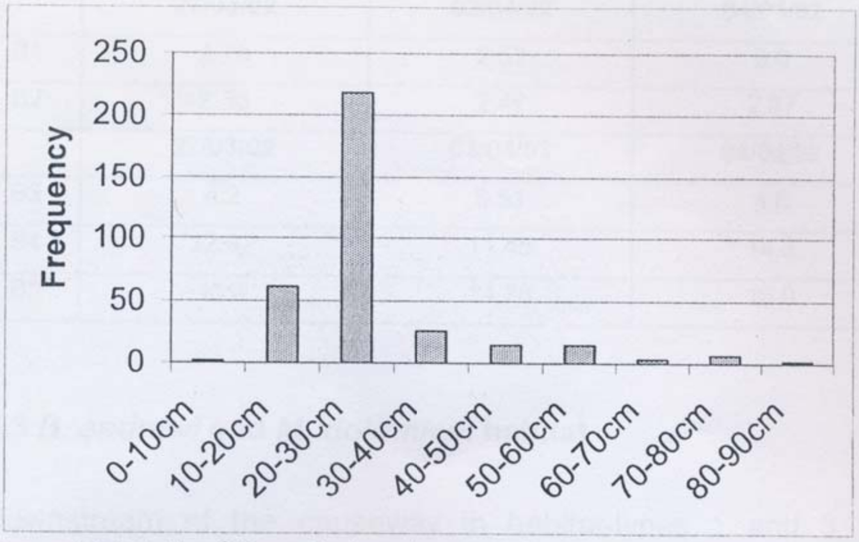


Figure 7: Total number of size classes of *B. andrewi* in all five pools upstream of the causeway. Data was averaged over the three snorkel surveys. Frequency refers to the number of fish.

5.2 Underwater visibility.

Underwater visibility ranged from 2.11 m to 6.50 m in pools A1 to B3. Underwater visibility was good, when two snorkellers collected data within a pool, they were confident that few fish were missed. The collected data is a good representation of what fish fauna occur within the pools. Visibility was best in pools B4 and B5, with snorkellers being able to spot fish up to 16 m away. There was limited siltation in pools B4 and B5, and thus hardly any silt in suspension within the water column. This is believed to be the reason for the good visibility. Other factors affecting visibility are the angle of the sun and amount of cloud cover. Early in the morning and late in the afternoon, the angle of the sun is low on the horizon, little light is able to penetrate into the pools during these times. Visibility was greatest at midday when the suns rays shone down perpendicularly into the pools. Visibility decreased with an increase in cloud cover as less light was able to penetrate through the clouds.

Table 5: Underwater visiblity (m) for the five days of study.

Pool	26/03/02	02/04/02	03/04/02
A1	3.75	3.12	2.11
A2	3.94	3.37	2.84
A3	4.87	2.61	3.87
A4	4.38	3.57	2.37
	26/03/02	**02/04/02**	**04/04/02**
A5	6.50	2.8	4.2

	27/03/02	02/04/02	04/04/02
B1	2.78	2.53	3.0
B2	2.56	2.47	2.87
	27/03/02	03/04/02	04/04/02
B3	4.2	3.51	4.8
B4	12.92	11.45	14.3
B5	15.4	14.78	16.0

5.3 *B. andrewi* and *M. dolomieui* habitat

Downstream of the causeway in habitat-types 1 and 3, the percentage abundance of *M. dolomieui* is greater than the percentage habitat area (Figure 8). Habitat-type 1 comprises just under ten percent of the habitat area, with forty eight percent of *M. dolomieui* occurring in this habitat-type. Habitat-type 3 comprises sixteen percent of the habitat area, with twenty-seven percent of *M. dolomieui*. In the five pools downstream of the causeway, seventy-five percent of *M. dolomieui* occur within habitat-types 1 and 3 (twenty-six percent of the total habitat area). Within the six habitat-types available to M. dolomieui in the five pools downstream of the causeway, habitat-types 1 and 3 are preferred.

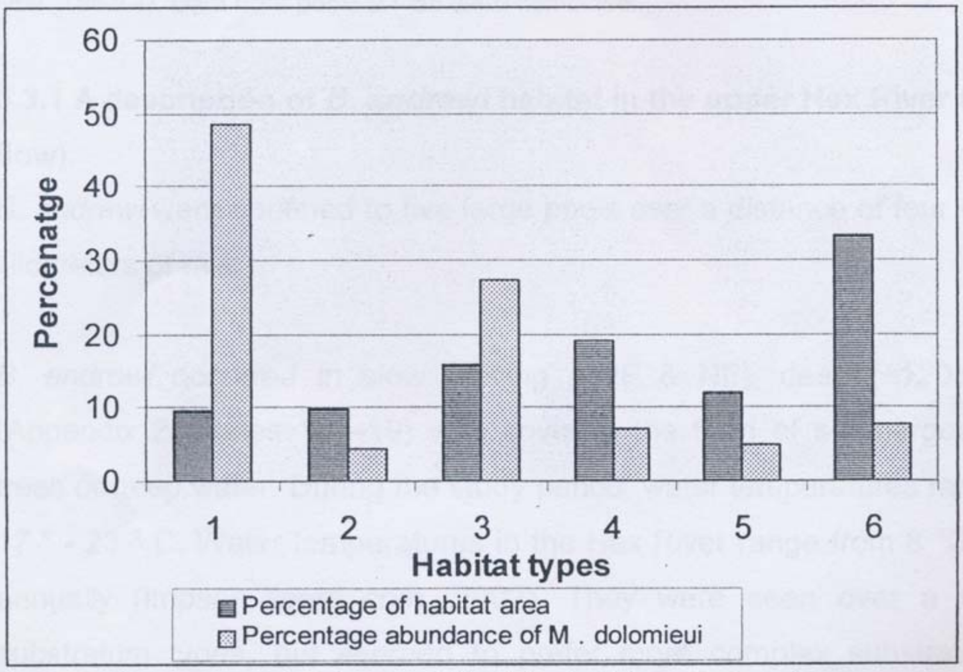


Figure 8: Percentage abundance of *M. dolomieui* downstream of the causeway, for each habitat type (Table 4). Data from pools A1- A5 were combined.

Upstream of the causeway, in habitat-type 3, the percentage abundance of *B. andrewi* is greater than the percentage habitat area (Figure 9). Habitat-type 3 comprises twenty-two percent of the habitat area, with seventy-two percent of *B. andrewi* occurring within this habitat-type. There are no B. andrewi in habitat-types 2, 4 and 5 (Figure 9). Within the six habitat-types available to *B. andrewi* in the five pools downstream of the causeway, habitat-type 3 is preferred. Both *M. dolomieui* and *B. andrewi* favour habitat-type 3.

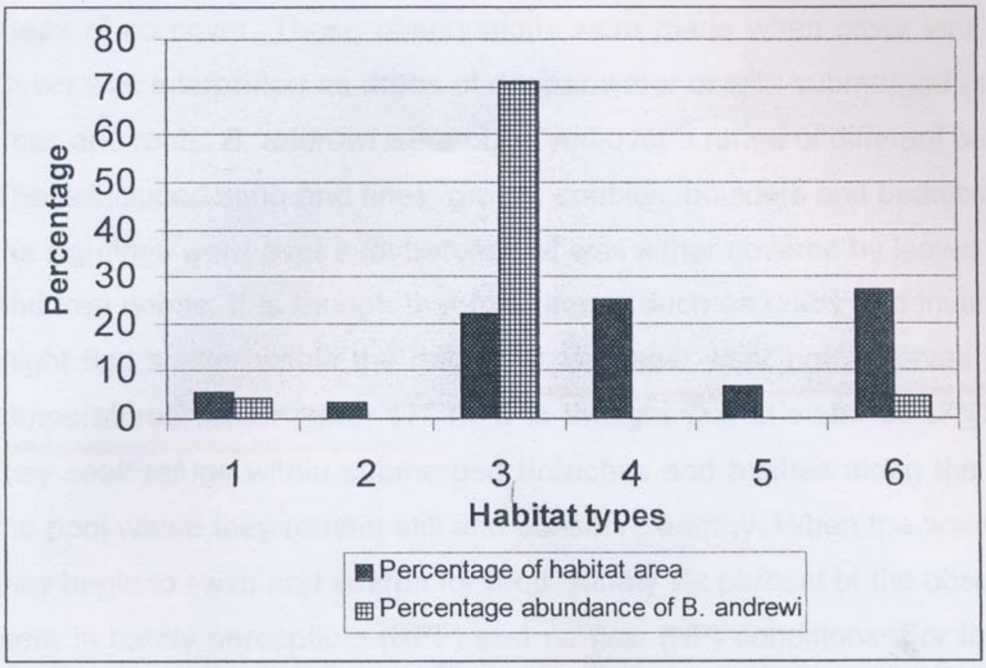


Figure 9: Percentage abundance of *B. andrewi* upstream of the causeway, for each habitat type (Table 4). Data from pools B1-B5 were combined.

5.3.1 A description of *B. andrewi* habitat in the upper Hex River (low flow).

B. andrewi were confined to five large pools over a distance of four and a half kilometers of river.

B. andrewi occurred in slow moving (BPF & NF), deep (+120cm) pools (Appendix 2, Plates 15 –19) with cover in the form of submerged bushes, trees or deep water. During the study period, water temperatures ranged from 17 ° - 23 ° C. Water temperatures in the Hex River range from 8 °C to 25 °C annually (Impson, *pers com*, 2002). They were seen over a variety of substratum types, but seemed to prefer more complex substratum types (where debris and leaves were found). It is thought that more macro-invertebrates occurred in areas of more complex substratum type as there are more niches and food available for them is this type of environment. *B.*

andrewi are omnivorous (Skelton, 1998) and will feed on macro invertebrates. This presents an area for further research.

B. andrewi preferred the deeper parts of the pools (120 cm +). The focal-point depth was between 0.3 and 0.8m. *B. andrewi* were observed in both shade and direct sunlight an equal number of times but were most often observed in areas of no cover. These observations were made when cover was nearby. Cover was interpreted as areas of deeper water or with submerged branches, trees and roots. *B. andrewi* were observed over a range of different bed types. These included sand and fines, gravel, cobbles, boulders and bedrock. Half of the sightings were over substratum that was either covered by leaves or plant and tree debris. It is though that food items, such as crabs and invertebrates might find shelter within the debris. *B. andrewi* were not observed in water temperatures colder than 17° C. It is thought that in water of 17°C or less they seek refuge within submerged branches and bushes along the sides of the pool where they remain still and conserve energy. When the water warms they begin to swim and search for food. Ninety six percent of the observations were in barely perceptible (BPF) and no flow (NF) conditions. For these flow types, water velocities range from 0.00-0.10 m/s (King & Schael, 2001).

Table 6: Summary of habitat description of *B. andrewi* in the upper Hex River (low flow).

Variable	Description
Flow	BPF & NF – slow moving water.
Cover	Submerged bushes, trees or deep water.
Substrate	Sand & fines, gravel, cobbles, boulders and bedrock. Often covered by leaves, plant and tree debris.
Shade	No influence.
Water temp.	17° - 23° C
Water depth	Greater than 120 cm.
Focal-point depth	30 – 80 cm.

5.3.2 A description of M. dolomieui habitat on the Upper Hex River (low flow).

M. dolomieui were dominant in the five pools downstream of the causeway.

M. dolomieui occurred in slow moving (BPF & NF), deep (+100 cm) pools with cover in the form of submerged bushes, trees, overhead riparian vegetation, cobbles and boulders or deep water. M. dolomieui were observed in water temperatures ranging from 18.7°-25° C. They were seen over a variety of substratum types, but seemed to prefer substrates that gave cover (eg. submerged trees).

M. dolomieui preferred the deeper parts of the pools (100cm +). The focal point depth was between 30 and 80 cm. *M. dolomieui* preferred areas that were shaded or partly shaded, it is though that they used shade to conceal themselves, as a form of cover. Cover was interpreted as areas of deeper water or with submerged branches, trees and roots. *B. andrewi* were observed over a range of different bed types. These included sand and fines, gravel, cobbles, boulders and bedrock, most observations were made over cobbles and boulders. *M. dolomieui* were not observed in water temperatures colder than 18.7° C. Ninety five percent of the observations were in barely perceptible (BPF) and no flow (NF) conditions.

Table 7: Summary of habitat description of *M. dolomieui* in the upper Hex River (low flow).

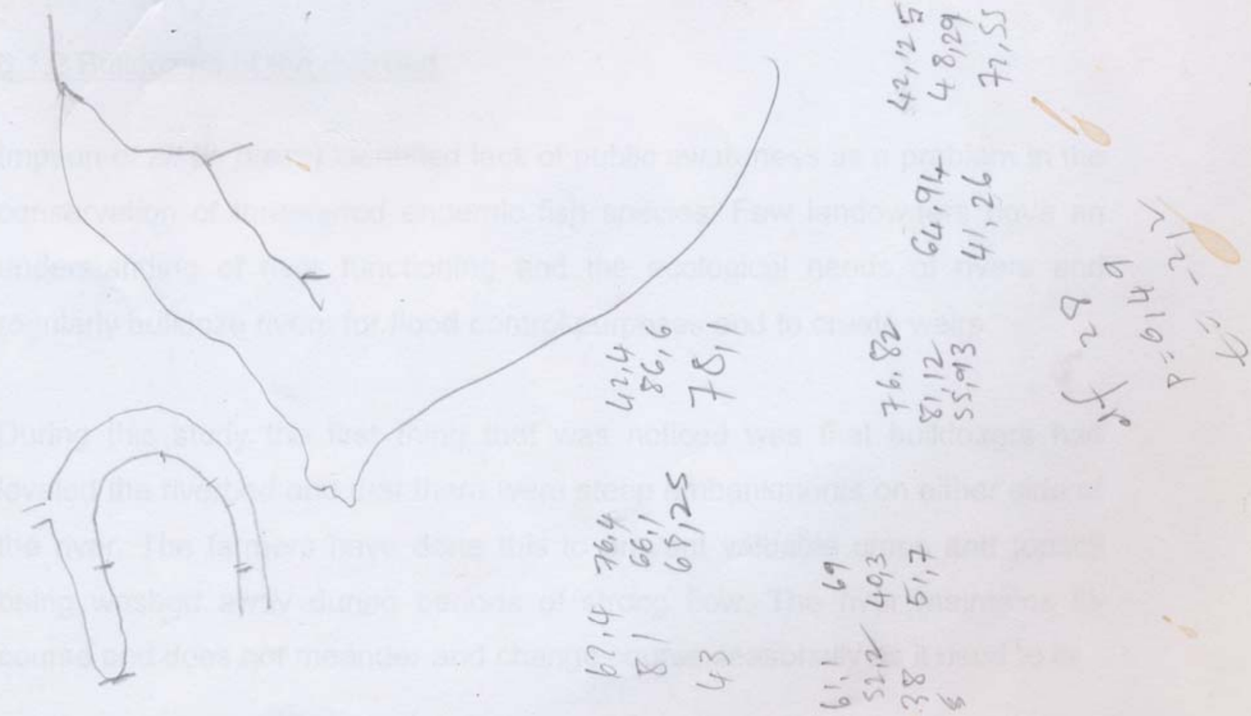
Variable	Description
Flow	BPF &NF – slow moving water.
Cover	Submerged bushes, trees, overhead cover (riparian vegetation), cobbles & boulders and deeper water.
Substrate	Prefer cobbles and boulders, also sand and fines, gravel and bedrock.
Shade	Prefer shaded or partly shaded.
Water temp.	18.7°-25° C
Water depth	Greater than 100 cm
Focal-point depth	10 – 50 cm

5.4 Statistics: Chi-squared tests.

Chi-squared tests of independence for two-way classification were conducted comparing *M. dolomieui* and *B. andrewi* habitat type variables (Table 8). One significant result was obtained for a Pearson Chi square comparison between water temperature downstream of the causeway (*M. dolomieui*) and water temperature upstream of the causeway (*B. andrewi*). The M-L Chi square comparison for the same data showed there to be no significant difference. All other results were not significant. *M. dolomieui* and *B.andrewi* habitat types are the same.

Table 8: Results of Chi-squared tests of independence for two way classification comparisons between *M. dolomieui* and *B. andrewi* variables. Significant results in bold.

Variables	Pearson Chi-square	p	M-L Chi-square	p	d.f.
Bass shade / Whitefish shade	5.319	0.256	5.942	0.256	4
Bass cover / Whitefish cover	3.718	0.988	4.303	0.988	12
Bass leaves / Whitefish leaves	2.489	0.114	3.245	0.812	1
Bass branches/ Whitefish branches	0.056	0.14	0.055	0.813	1
Bass fines / Whitefish fines	0.095	0.757	0.181	0.669	1
Bass gravel / Whitefish gravel	0.01	0.918	0.01	0.918	1
Bass cobble / Whitefish cobble	3.1818	0.148	3.685	0.158	2
Bass boulder / Whitefish boulder	2.6	0.272	2.984	0.224	2
Bass bedrock / Whitefish bedrock	0	1	0	1	1
Bass depth T / Whitefish depth T	572.674	1	2113.448	1	1660
Bass depth F / Whitefish depth F	87.731	0.999	45.381	1	144
Bass temp. / Whitefish temp.	59.4	**0.001**	40.86	0.089	30
Bass flow / Whitefish flow	1.738	0.942	2.927	0.817	6



6. DISCUSSION

6.1 Factors negatively affecting the indigenous fish fauna of the upper Hex River:

Both the upstream and downstream sections of the study site are affected by the same anthropogenic activities. These include the following:

6.1.1 The abstraction of water for irrigation.

Due to the irregular pattern of rainfall in the Cape, endemic fish are extremely vulnerable to water extraction (Gaigher *et al*., 1980). In the winter rainfall region, the dry hot summer period coincides with the period of greatest water need for agricultural purposes. Water extraction can also increase the effects of agricultural pollutants by concentrating them (Gaigher *et al*., 1980). According to Skelton (1977) water extraction is one of the main causes in the decline of threatened Cape fish species. Similarly, some highly sensitive tributaries have abstraction points that remove the entire surface flow of the river during dry months (Impson *et al.*, *in press*).

During summer,there is very little water in the upper Hex River. This problem is exacerbated further upstream. Upstream of Kanet vlei (Figure 4) the river barely flows because vast volumes of water are pumped directly out of the river to use as irrigation water.

6.1.2 Bulldozing of the riverbed.

Impson *et al.* (*in press*) identified lack of public awareness as a problem in the conservation of threatened endemic fish species. Few landowners have an understanding of river functioning and the ecological needs of rivers and regularly bulldoze rivers for flood control purposes and to create weirs.

During this study the first thing that was noticed was that bulldozers had leveled the riverbed and that there were steep embankments on either side of the river. The farmers have done this to prevent valuable crops and topsoil being washed away during periods of strong flow. The river maintains its course and does not meander and change course seasonally as it used to in the past. Most of the deep pools that were once numerous in the Hex River have been filled in. By bulldozing the river farmers effectively remove the pools and deeper areas in the river which were home to *B. andrewi*. The present state is that over 4.5 km of study area, only five pools remain that are suitable for *B. andrewi*.

6.1.3 The inflow of pesticides and fertilizers.

Pesticides and fertilizers washed off crops and agricultural fields and deposited into the river may accumulate in the tissues of indigenous fish via biomagnification. This could lead to mortality. This provides an area for further research.

6.1.4 Siltation as a result of topsoil erosion.

Siltation results in an increase in turbidity and an unstable substratum, which negatively affects macrophytes and invertebrates (Gaigher *et al*., 1980). Apart from affecting the food source of fish, sand and silt deposition also reduces cover, available breeding sites and changes water temperature (Gaigher *et al*., 1980). According to Skelton (1977), this factor is also causing the decline of threatened Cape fish species. Working for Water has cleared alien *Acacia* trees in the area around the causeway. The loss of roots to hold and bind the soil has resulted in topsoil being eroded and deposited into the river. This deposition has filled pools B1, B2 and B3 upstream of the causeway with sediment making them much shallower than previously (Impson, *pers com*, 2002). Pools downstream of the causeway are also silted.

6.2 Impact of *M.dolomieui* on Indigenous fish of the upper Hex River.

The clearest indication of the impact that *M. dolomieui* has had on the indigenous fish of the upper Hex River is given by the distribution of the fish species within the river. *M. dolomieui* dominate the fish fauna downstream of the causeway (Figures 5 & 6). It is suggested that the only reason they do not dominate the fish fauna above the causeway is that they have only recently managed to overcome this obstacle. Endemic species are only able to survive in areas where natural barriers have prevented invasion by *M. dolomieui* (De Moor & Bruton, 1988).

In the study site only the downstream section of the river has a population of *M. dolomieui* that is so well established that no small indigenous species occur (*P. burchelli* and *S. capensis*). Five *B. andrewi* were observed in this section of the river. Studies on *M. dolomieui* show that their preferred prey is small fish (Skelton, 1993). *M. dolomieui* have had a very detrimental effect on the indigenous fish fauna of the upper Hex River (Figure 6).

6.3 Discussing hypotheses and results:

6.3.1 **Accept hypothesis one:** The population of B. andrewi downstream of the causeway is smaller than that upstream of the causeway.

This is most definitely the case. Upstream there were 345 *B. andrewi* (average of three snorkel surveys), while downstream there were only five. *P. burchelli* and *S. capensis* are abundant upstream of the causeway (Figure 5). They are however not found downstream of the causeway. *M. dolomieui* do not coexist with *P. burchelli* or *S. capensis.* Both the upstream and downstream sections are approximately 4.5 km long, they are comparable in area and habitat. Both sections of the river are suitable habitat for the indigenous fish of the Hex River. It is thought that predation by *M.dolomieui* has resulted in the current distribution and numbers of indigenous fish in the upper Hex River. Low numbers of indigenous fish are correlated with high numbers of *M. dolomieui.*

6.3.2 **Accept hypothesis two:** There are fewer size classes of B. andrewi downstream of the causeway than upstream of the causeway.

There is only one size class of *B. andrewi* downstream of the causeway while upstream there are nine size classes (Figure 7), ranging from 10 cm to 90 cm in length. *B. andrewi* occurring downstream are between 20 and 30cm in length. This must just be big enough to escape predation by *M.dolomieui.*

6.3.3 **Reject hypothesis three:** Only large B. andrewi are found downstream of the causeway.

Initially it was thought that large *B. andrewi* would be able to occur in the same pools as *M. dolomieui*. This is because they would escape predation due to their size. However this is not the case. Two explanations are put forward to explain the lack of large *B. andrewi* downstream of the causeway. Firstly *M. dolomieui* might have outcompeted them for their food supply. There are 190 *M. dolomieui* (Figure 6) in five pools downstream of the causeway. Averaging out, there are 38 *M. dolomieui* per pool. The Hex is a small river, with such large numbers of *M. dolomieui* in small pools (40 – 150m long), there must be fierce competition for food. Secondly, *B. andrewi* do not reach a large size as they are eliminated by *M. dolomieui* before they have had a chance to grow by predation.

6.3.4 **Accept hypothesis four:** *M. dolomieui* competes for habitat with *B. andrewi.*

Downstream of the causeway, *M. dolomieui* prefer habitat types one (48% of observations; 10% of area; Figure 8) and three (27% of observations; 16% of area; Figure 8). *M. dolomieui* hide in cover in the form of submerged trees, plants, roots and bushes. They prefer the deeper areas (+100cm) of the pool where the flow types are BPF or NF. Rankin (1986) found that *M. dolomieui* consistently avoided the shallowest areas (< 45 cm) of the stream. In the Hex River *M. dolomieui* generally occurred over a rocky substratum. Rankin (1986) also noticed that *M. dolomieui* were associated with habitats that have rocky substrata.

Upstream of the causeway, *B. andrewi* favoured habitat is habitat type three (71% of observations; 22% of area; Figure 9). *B. andrewi* would have to compete with *M. dolomieui* for this habitat type. The results of such competition is clearly demonstrated downstream of the causeway where *B. andrewi* were once plentiful (Harrison, *cited by* Impson, 2001). Another important habitat type for *B. andrewi* upstream of the causeway is type one. However it consisted of only 5% of the area and only 4% of the observations. How can it be important if it consisted of such a small percentage of observations? Observations were made between 9am and 5pm. During the pilot study an important discovery was made. Pool B1 (see map) was entered at 7am but no *B. andrewi* were seen. It was only later around 9am that fish were observed. *B. andrewi* had been hiding in the bankside vegetation. An explanation has been proposed for this behaviour. This is *B. andrewi* seek refuge in bankside vegetation over periods of darkness. The proposed explanation for this behaviour provides an area for further study in the future.

Thus although habitat type one was not used as much as habitat three during daylight hours, it is probable that it is used exclusively overnight. This could make it an important habitat for *B. andrewi*. Also to be noted is that habitat type one was always near to where *B. andrewi* were seen, providing shelter if it were needed. In pools B1, B4 and B5 *B. andrewi* were observed to make use of habitat type one after being disturbed by the snorkellers. Habitat type one is a refuge for *B. andrewi* during periods of inactivity or alarm. *M. dolomieui* and *B. andrewi* prefer habitat types one and three.

B. andrewi were also found in habitat type six. This habitat type was not used as frequently as it consisted of 27% of the area, but only 4 % of the observations. It is thought that *B. andrewi* might move into this habitat type in search of food.

B. andrewi may often bask in the sun in very shallow water (< 25 cm). This behaviour was observed during the pilot study. A possible explanation might be that warming in the sun provides them with more energy, especially when water temperatures drop below 20 °C (Impson, *pers com*, 2002).

Chi-squared tests were done to see whether there are significant differences in habitat variables between *M. dolomieui* and *B. andrewi* (Table 8). The only significant result was for a Pearson Chi square test where water temperature downstream of the causeway was significantly different to water temperature upstream of the causeway. This could be explained by the time of day at which sampling was conducted. Pools sampled in the afternoon were warmer (4°C) than pools sampled early in the morning. However a M-L Chi square test on the same data provided no significant difference. All other results obtained were not significant. *M. dolomieui* and *B. andrewi* habitat are the same with regards to shade, cover, leaves, branches, substratum type, water depth, focal point depth and flow. If *M. dolomieui* and *B. andrewi* were to be present in the same environment then they would have to compete as they both prefer the same habitat types. The competitive exclusion principle

(Barnes, 1991) predicts that if two species compete for the same resource in a homogenous and constant environment, one will become extinct.

Three of the four hypotheses put forward in the introduction have been proven. The population number of *B. andrewi* downstream of the causeway is smaller (five fish) than that upstream of the causeway (345 fish). There are fewer size classes of *B. andrewi* downstream of the causeway (one) than upstream of the causeway (nine). Only medium sized *B. andrewi* are found downstream of the causeway (20-25cm length; hypothesis three). Although these are not the largest fish found in the upper Hex River, they can be considered large enough to be safe from bass predation. It has been shown (Figure 6) that *M. dolomieui* occurs in the same habitat as *B. andrewi* (hypothesis four). It has also been shown that *M. dolomieui* does not coexist with *P. burchelli, S. capensis* or juvenile *B. andrewi*.

It is recognized that predation by *M. dolomieui* is not the sole reason for the absence of indigenous fishes in the upper Hex River. Other factors have also added to the pressure on the indigenous fish. However both the upper and lower sections of the Hex are subject to the same disturbances. In light of this, the results from this snorkelling survey strongly suggest that *M. dolomieui* is the main factor in explaining why there are so few *B. andrewi* below the causeway and why there are no *P. burchelli* or *S. capensis* below the causeway.

It must be noted that although this study has carefully examined the habitat of *B. andrewi*, it has only done so in five pools in which *B. andrewi* are trapped at present. Under different flow conditions, *B. andrewi* might utilise different habitats that were not available to them under the low flow conditions that were present during the study period. *B. andrewi* occurred in the five pools as there was no other habitat available to them. This presents an area for further research. What habitat types do *B. andrewi* prefer during periods of higher flow when they are not restricted to pool environments?

6.4 Management options for conserving *B. andrewi*.

Impson (2001) remarked that the long-term key in conserving *B. andrewi* remains effective habitat conservation and rehabilitation, including preventing the further spread of invasive alien fishes. He identifies the education and co-operation of anglers and farmers as being an essential component of the conservation management of *B.andrewi.*

Moyle and Sato (1991, *cited by* Impson *et al.*, *in press*) have identified three guidelines for designing aquatic protected areas. These areas should:

- encompass the entire catchment if possible, or alternatively be higher up in the catchment where protection and management is more effective;
- maintain natural hydrological cycles to secure the water quantity and quality requirements of the aquatic biota;
- eradicate high impact alien predators such as *M. dolomieui.*

The Roode-Elsburg dam is situated upstream of the section of river still containing *B. andrewi.* By releasing more water out of the dam daily and preventing farmers from using this water, the river's flow could be supplemented, the average water depth would increase and *B. andrewi* would no longer be restricted to a few pools.

It is vital that the farmers in the vicinity of the Upper Hex River are educated about the Critically Endangered state of *B. andrewi* (Skelton, 1998). They can then practice farming methods more sensitive to the needs of *B. andrewi.*

Even if farmers do not bulldoze the riverbed anymore and more water is released from Roode-Elseburg dam, there would still only be 4.5 km of habitat for *B. andrewi* as they are restricted to being above the causeway by *M. dolomieui.* This 4.5 km stretch supports some of the last riverine *B. andrewi.* The only way to increase the number of *B. andrewi* would be to increase the length of river available to them, by including invaded downstream areas. Lintermans (2000) examined the use of barriers and targeted eradication programs for the management of threatened fish species. The study demonstrated that treatment of small streams with Rotenone is a rapid and cost effective technique for removing invasive exotic fish species. It was also shown that relatively small, cost effective structures like weirs are an effective long-term barrier to the movements of invasive exotic fish species. Barriers and eradication programs provide a useful management tool for conserving threatened endemic fish. The incorporation of instream barriers to exclude invasive alien fishes is a key guideline in the design of aquatic reserves (Moyle & Sato, 1991, *cited by* Impson *et al*., *in press*). Downstream of pool A3 is a weir (Figure 4). *M. dolomieui* are upstream and downstream of this weir. If this weir were increased in size so that it provided an obstacle to the movement of *M. dolomieui* then it would be possible to double the length of river available to *B. andrewi*. This would be accomplished by using Rotenone to remove all the *M.dolomieui* between the causeway and the weir. Rotenone is a viable means of removing *M. dolomieui* from the Upper Hex River as it can only effectively be used in small rivers. The five *B.andrewi* present in this stretch of river could be netted and moved upstream before Rotenone is applied. If *M. dolomieui* are removed and prevented from re-entering by the weir *B.andrewi* can be reintroduced into the section of river. *B. andrewi* will also reintroduce themselves as, after spawning huge numbers of fry spill over the causeway and are washed downstream (Impson, *pers com* 2002). *andrewi*. If the weir is enlarged and *M. dolomieui* are removed, regular monitoring by snorkelling surveys could provide information regarding the progress of *B. andrewi*.

Bok and Immelman (1989) describe natural and induced spawning of *B. andrewi*. They have shown that it is possible to artificially breed *B. andrewi* using aquaculture techniques. Bred *B. andrewi* could be used to restock the upper Hex River.

Local farmers could be urged to stock their local farm dams with *B. andrewi*. The more dams that are stocked with *B. andrewi*, the greater chance *B. andrewi* has of survival.

6.5 Limitations of the study:

Due to the limited time available to complete this project, data were collected over a period of five days in late summer (26th &27th March; 2nd, 3rd & 4th May). The habitat types used by *B. andrewi* and *M. dolomieui* are only indicative of late summer. To obtain information concerning habitat preference over different seasons, water temperatures and flow conditions information would need to be collected over at least one year.

6.6 Conclusion:

B. andrewi need urgent conservation attention as they are now confined to five pools in a 4.5 km stretch of in the Upper Hex River. The Breede River population is Critically Endangered (Skelton, 1998). The primary causes for their threatened status are as follows:

- effects of the predatory alien fish, *M. dolomieui;*
- fragmentation and alteration of their environment by agriculture;
- bulldozing of the riverbed;
- water abstraction for irrigation;
- siltation;
- pesticides.

A large conservation effort will be required to reduce the factors resulting in the Critically Endangered state of *B. andrewi.*

6.7 Summary of areas identified for future research:

(1) What habitat types do *B. andrewi* utilise under periods of different flow when they are not restricted to pool habitats?

(2) Are bankside vegetation and instream vegetation important refuges for *B. andrewi* during periods of darkness and when water temperatures are below 17°C?

(3) Do pesticides and fertilizers in the Hex River have an effect on the growth, survival and population size of *B. andrewi*?

(4) Collecting data that proves *M. dolomieui* feed on *B. andrewi* juveniles and that few, if any survive.

6.8 Acknowledgements:

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8. APPENDICES

8.1 APPENDIX 1 – Maps of pools

Pool A1

THALWEG — TREES & BUSHES

• 26-03-02 ■ 2-04-02 ▲ 3-04-02

Figure 10: Habitat types (numbers in circles, Table 4) & markers (squares, triangles & circles)

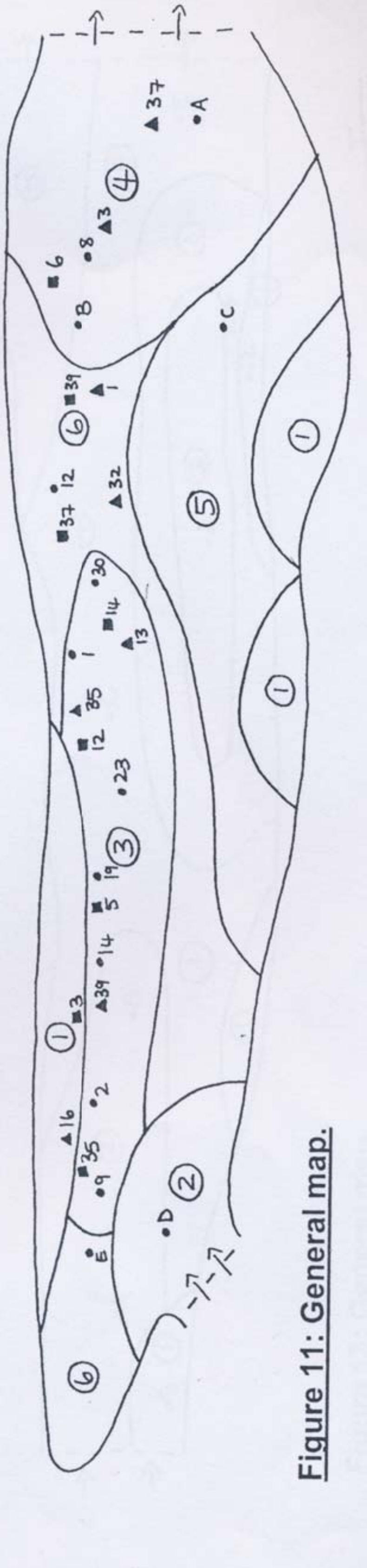
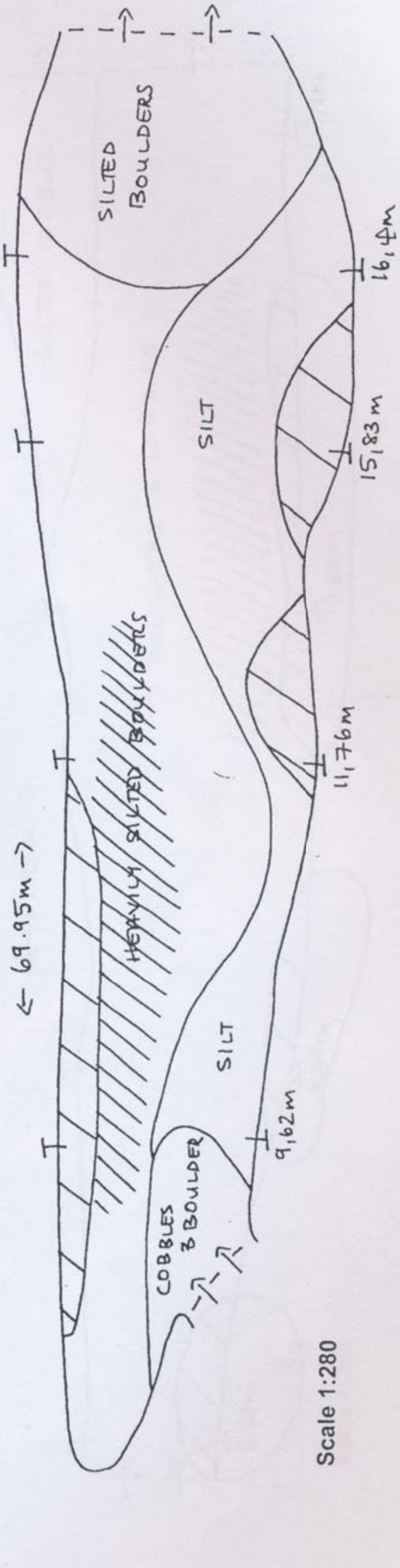


Figure 11: General map.



Scale 1:280

Pool A2

Figure 12: Habitat types and markers.

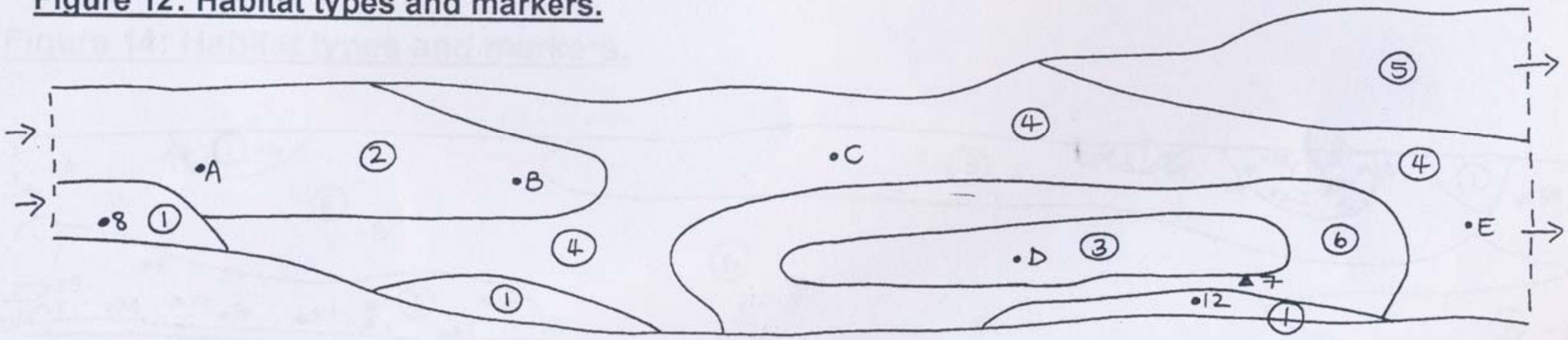
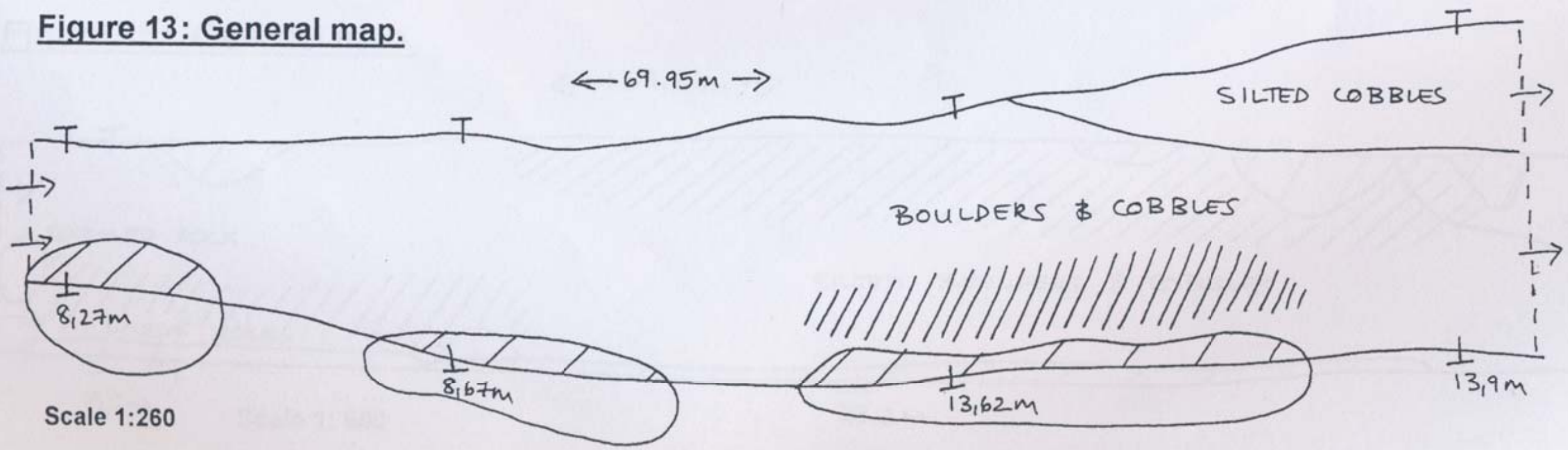


Figure 13: General map.



Scale 1:260

Pool A3

Figure 14: Habitat types and markers.

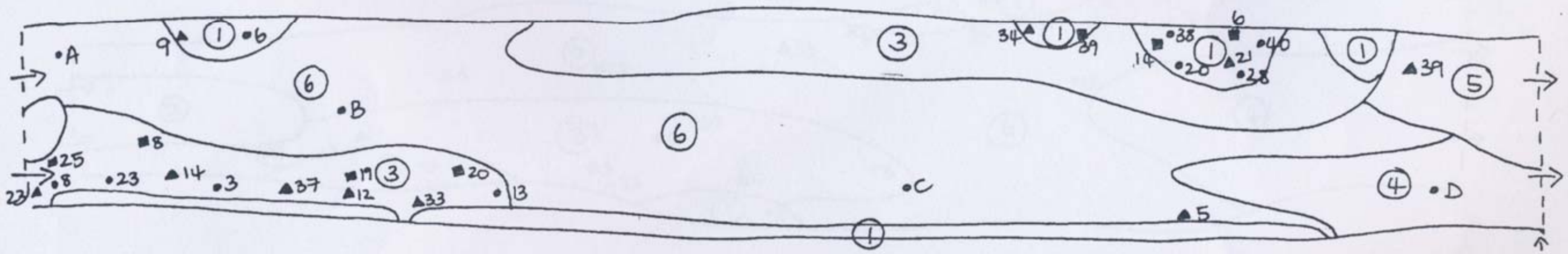
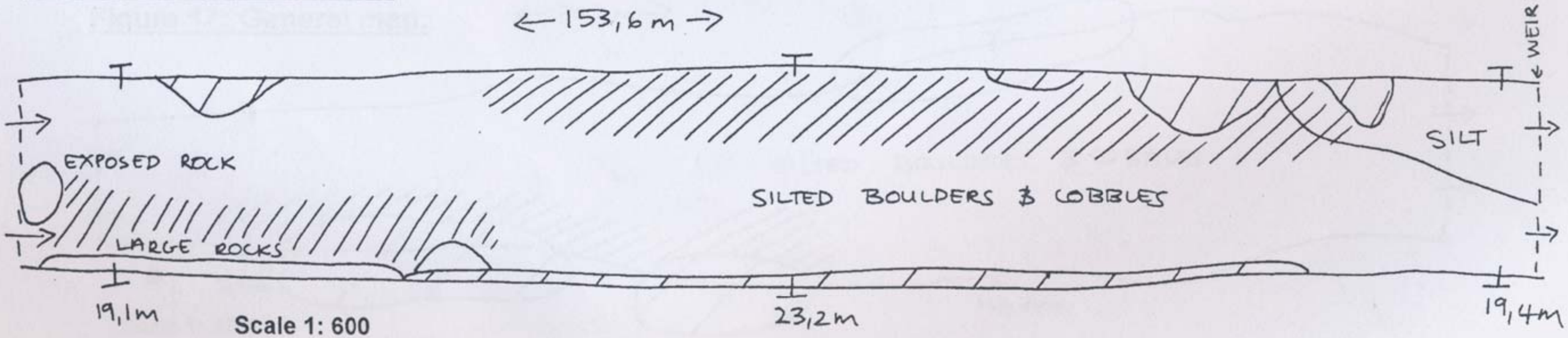


Figure 15: General map.



Scale 1: 600

Pool A4

Figure 16: Habitat types and markers.

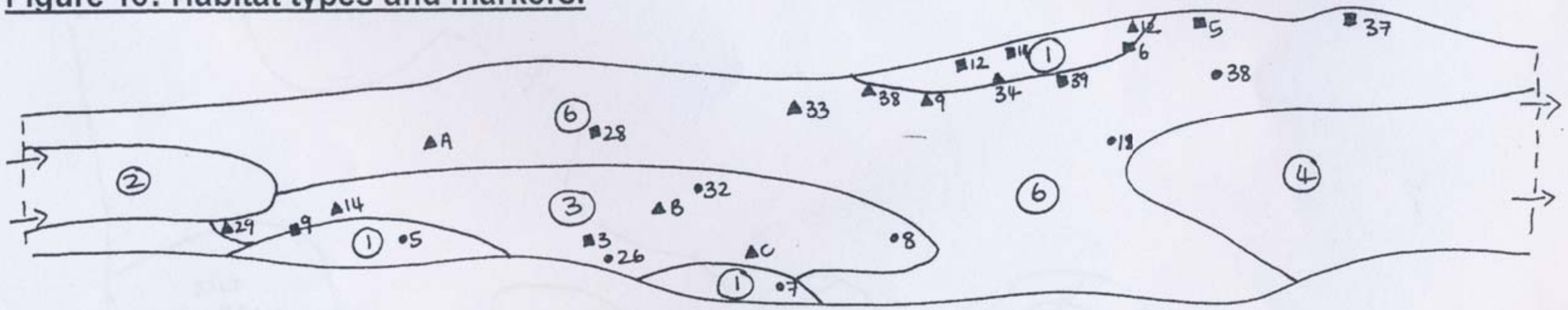
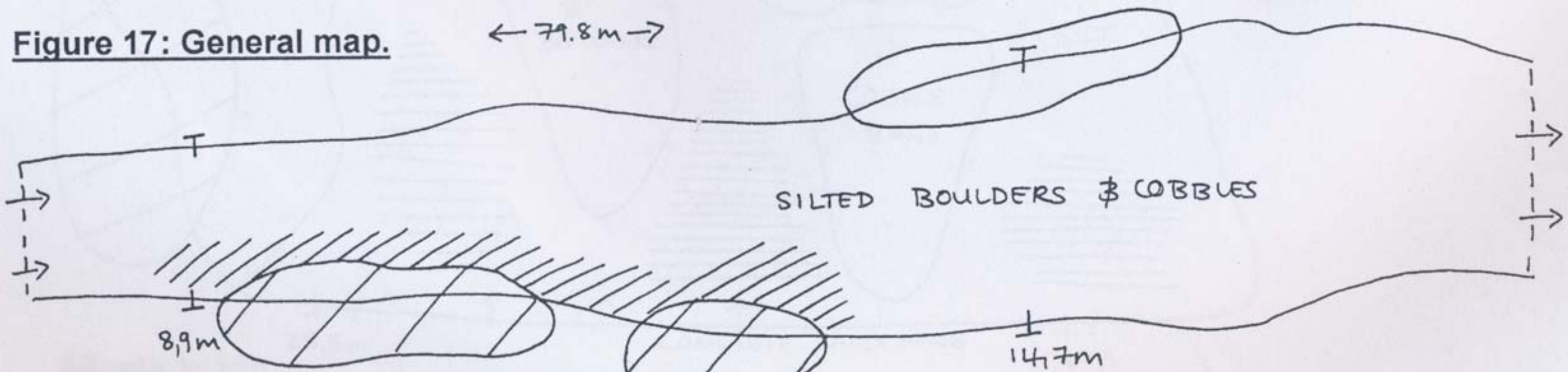


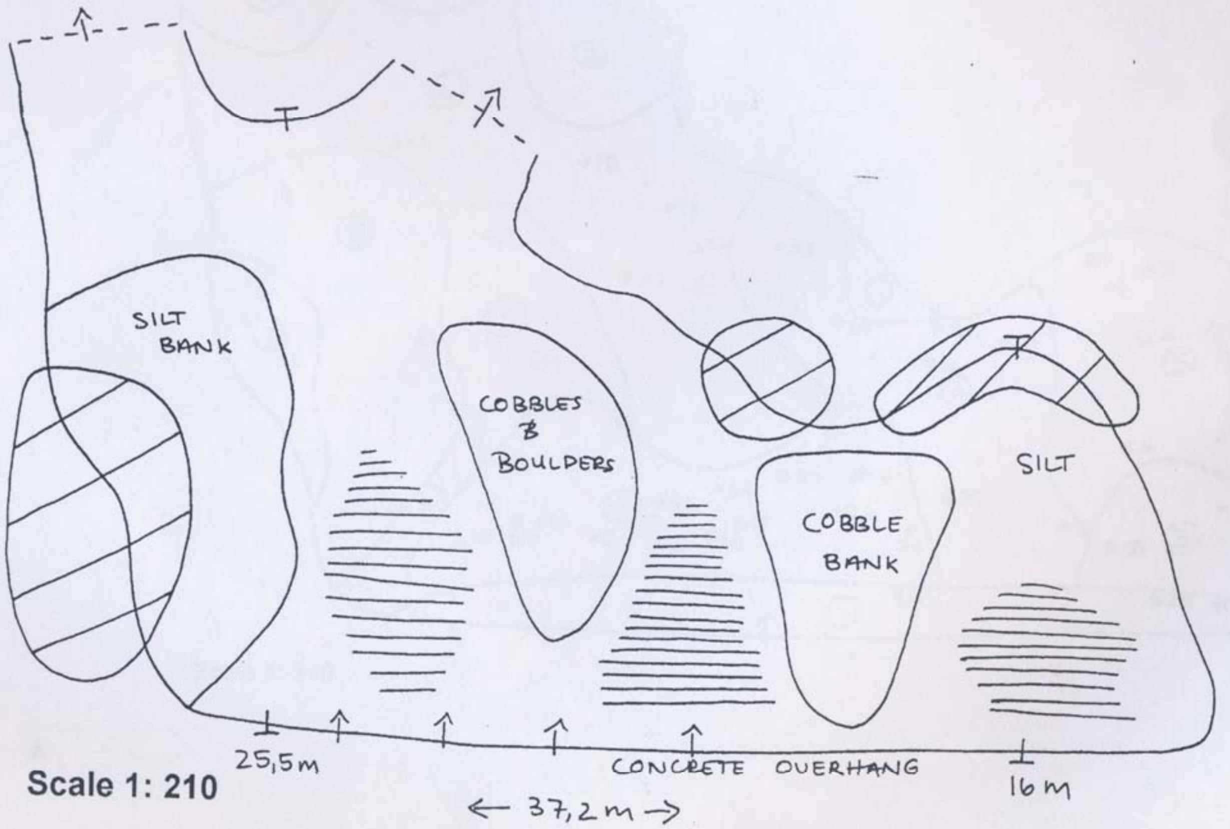
Figure 17: General map.



Scale 1: 320

Pool A5

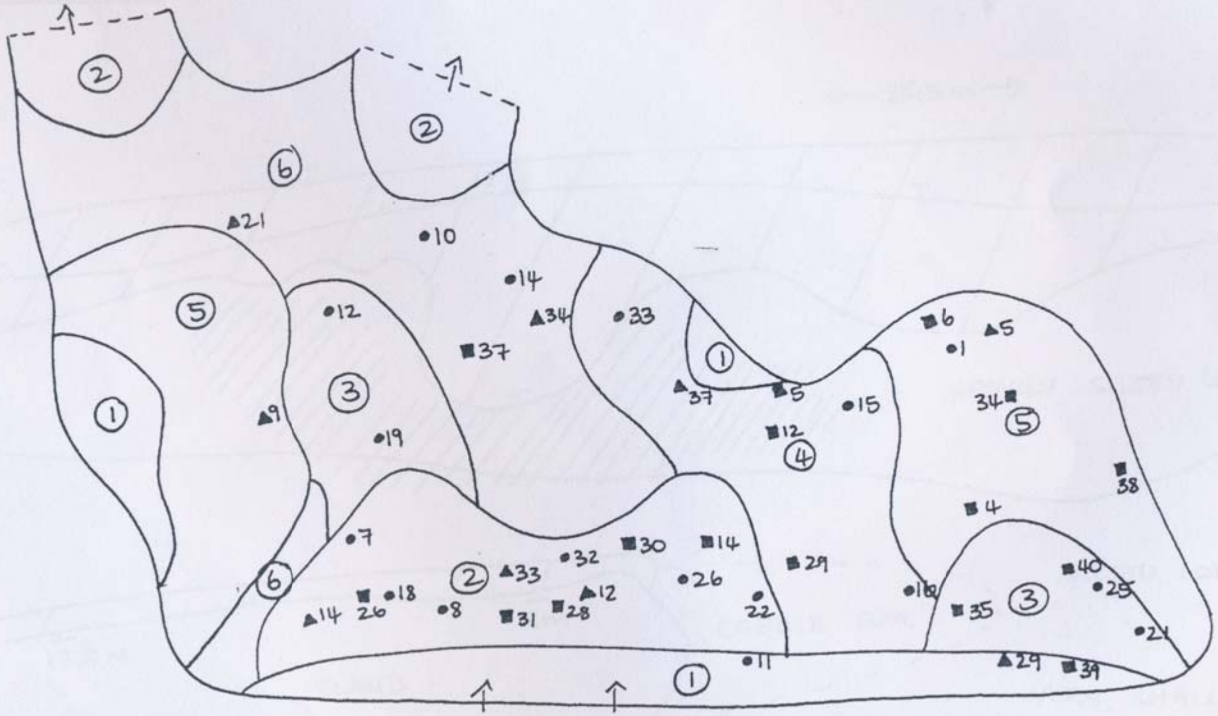
Figure 18: General map



Scale 1: 210

Pool A5

Figure 19: Habitat types and markers.

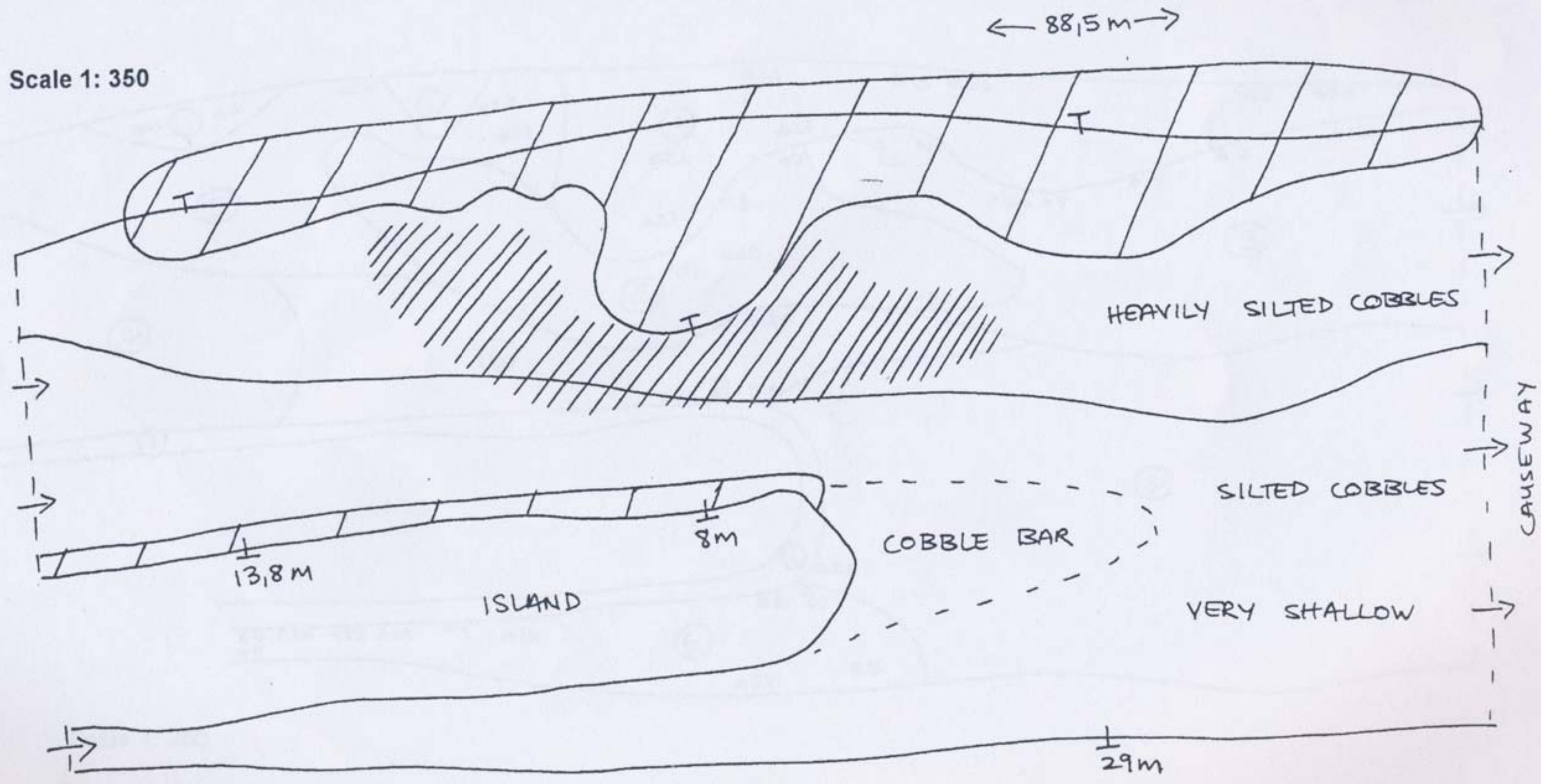


Scale 1: 210

Pool B1

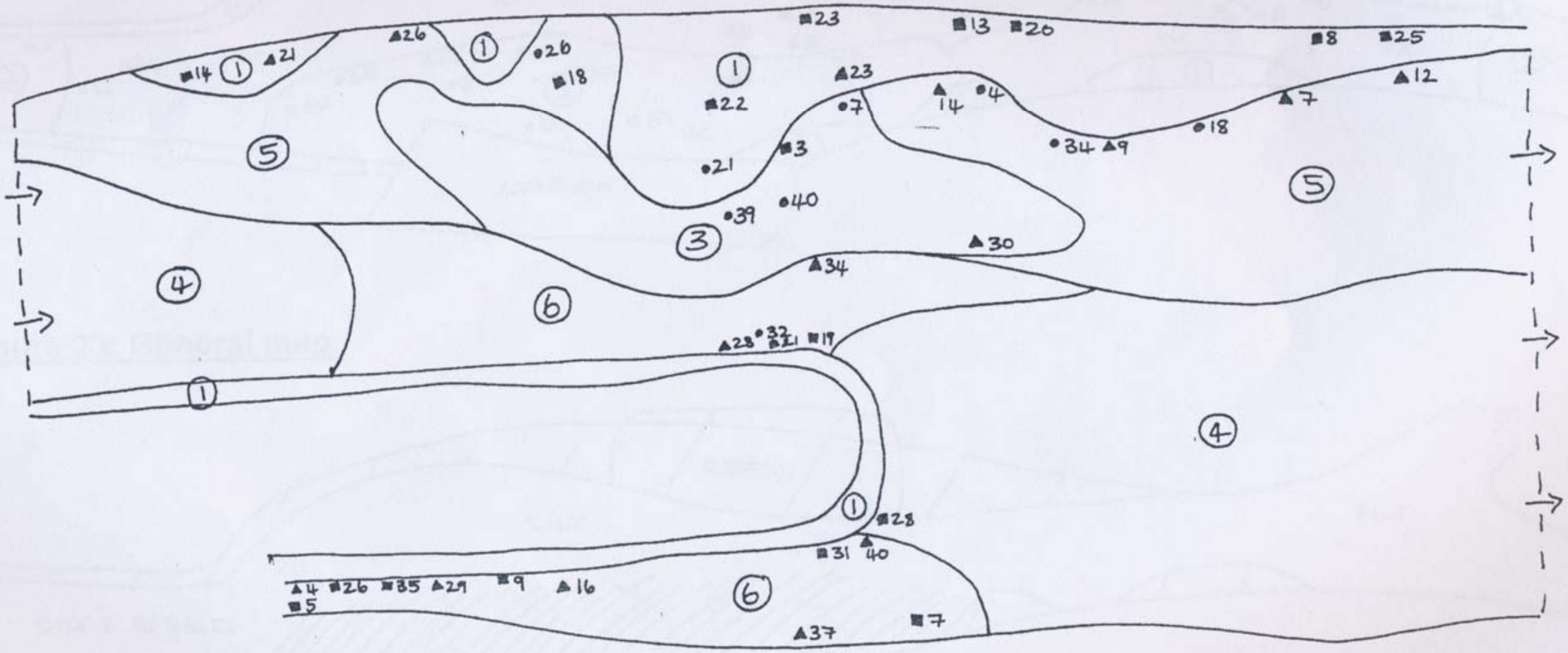
Figure 20 : General map

Scale 1: 350



Pool B1

Figure 21: Habitat type and markers



Scale 1: 350

Pool B2

Figure 22: Habitat types and markers.

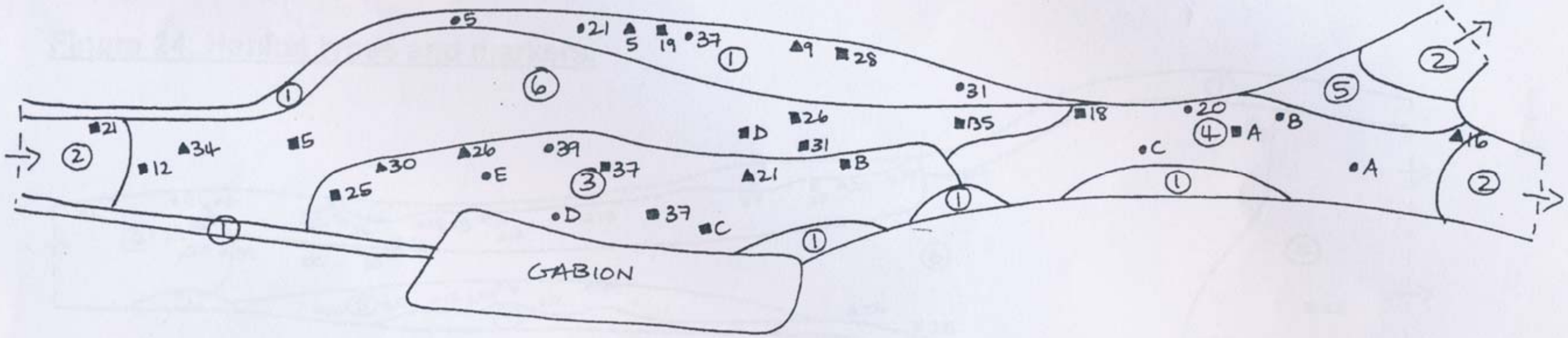
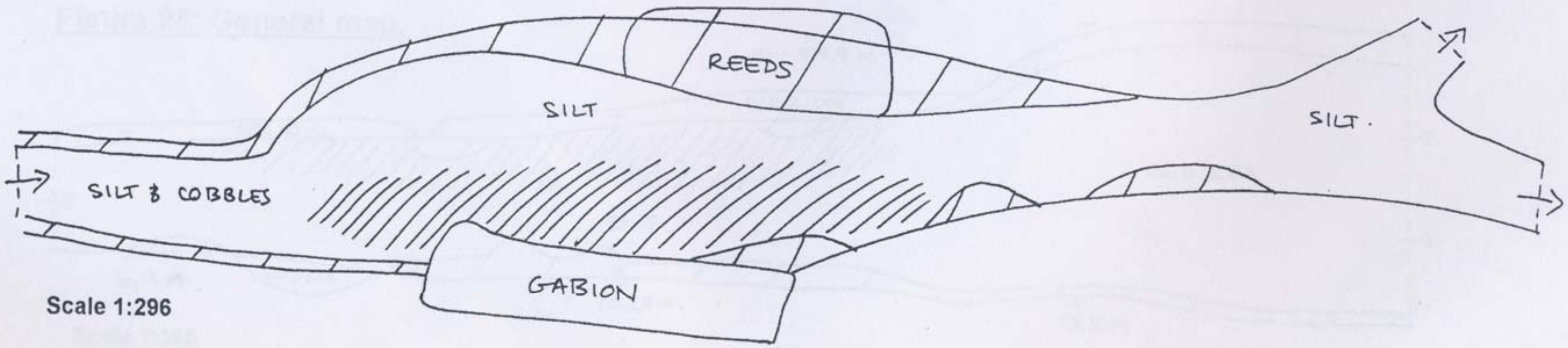


Figure 23: General map.



Scale 1:296

Pool B3

Figure 24: Habitat types and markers.

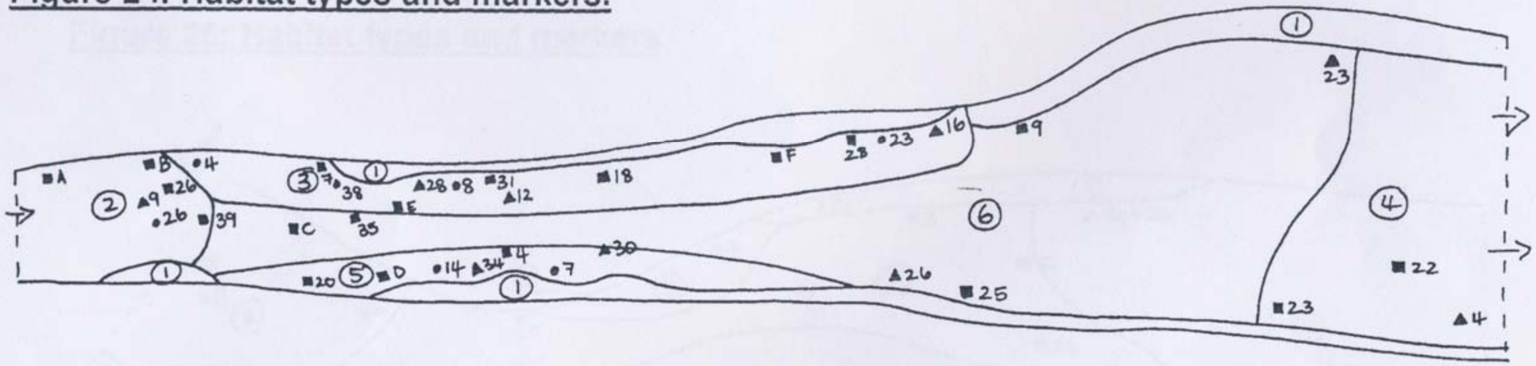
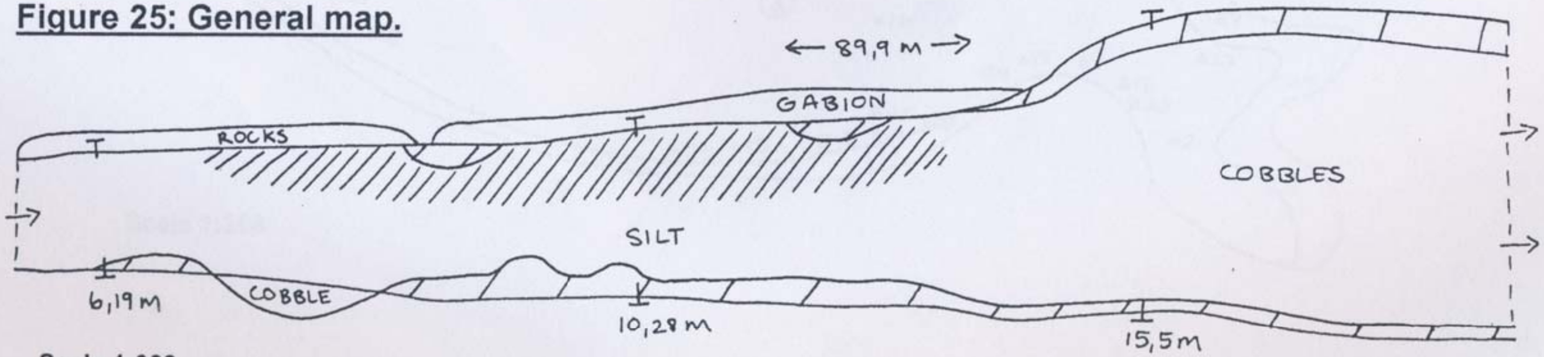


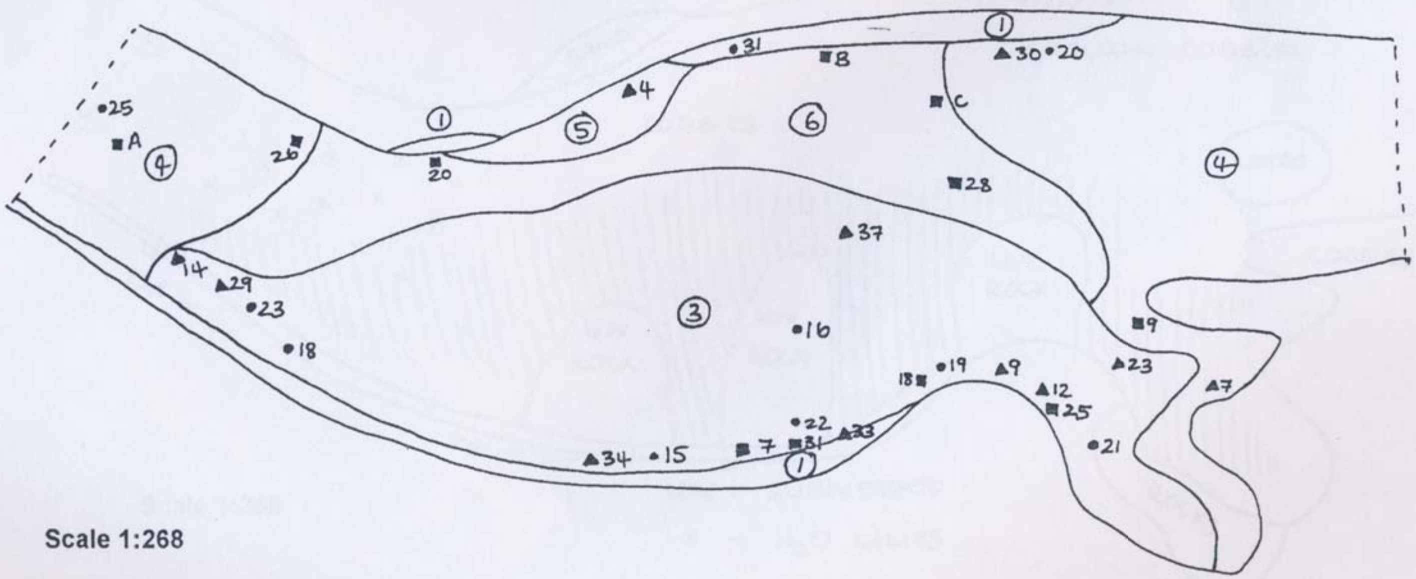
Figure 25: General map.



Scale 1:360

Pool B4

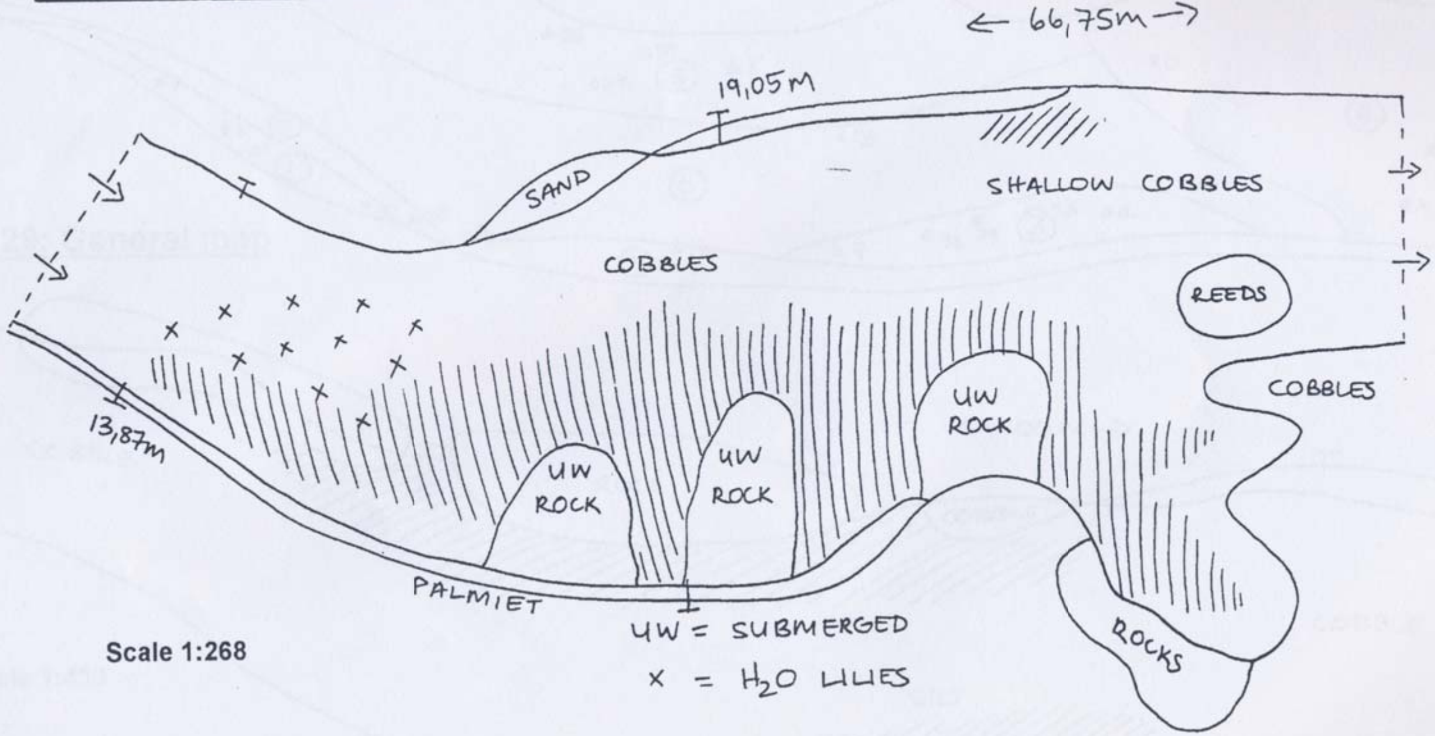
Figure 26: Habitat types and markers



Scale 1:268

Pool B4

Figure 27: General map



Scale 1:268

Pool B5

Figure 28: Habitat types and markers.

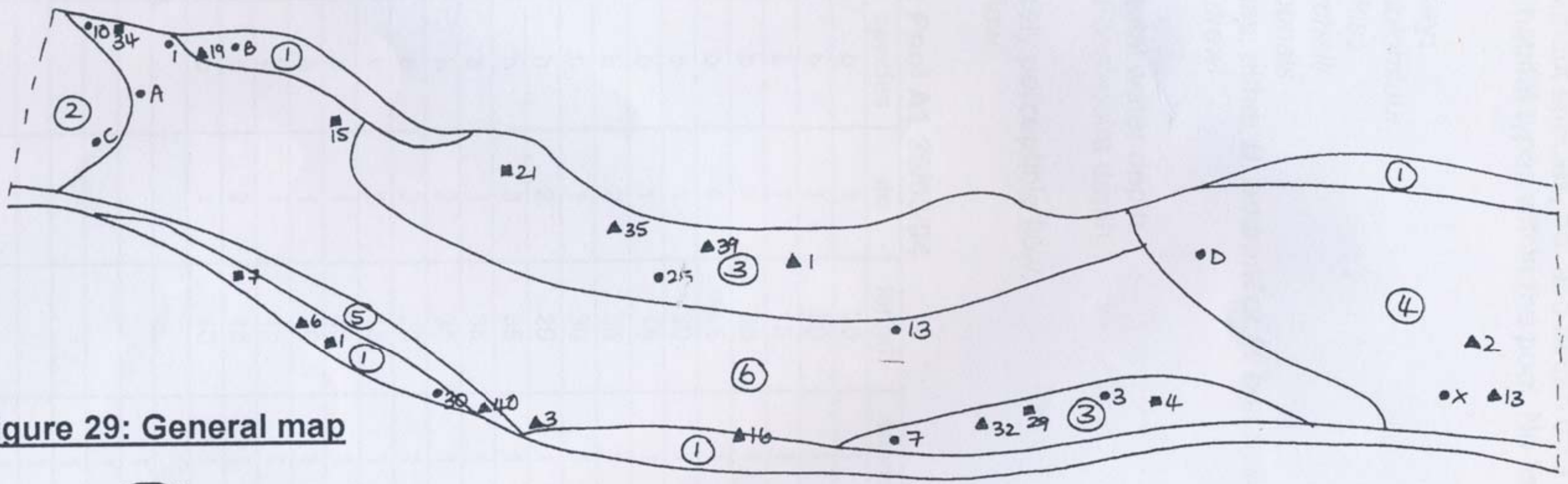
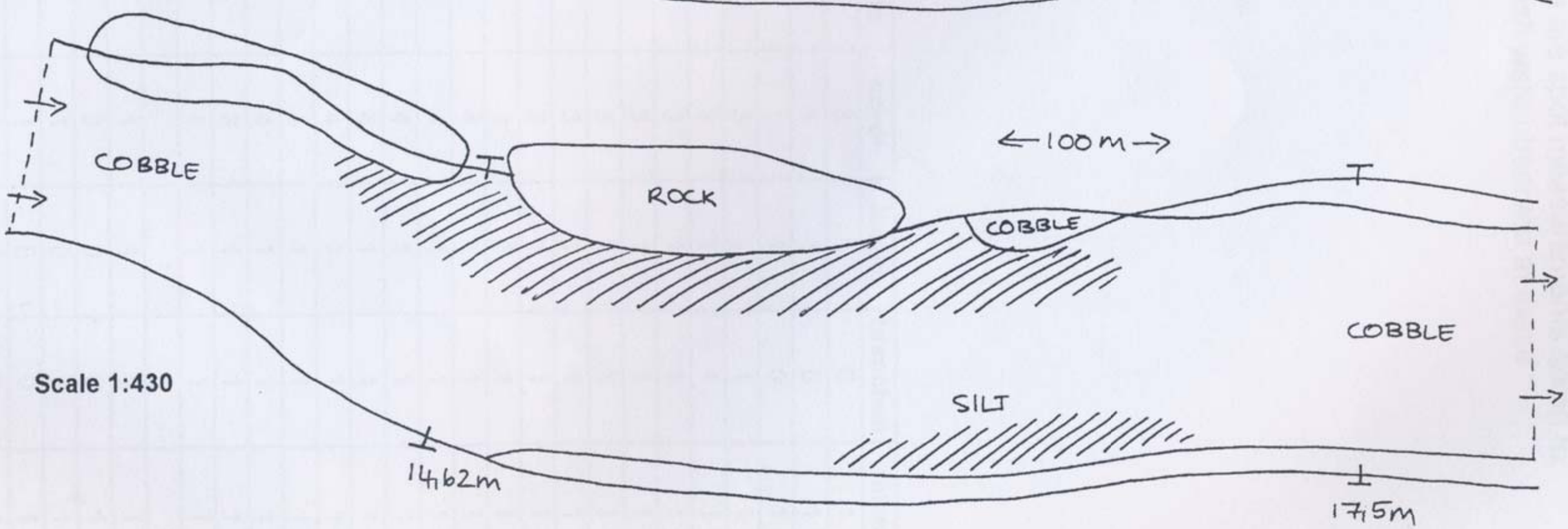


Figure 29: General map



8.3 APPENDIX 3- Raw data tables

Markers without species, no. and length data are spot measurements taken to include all habitat types within the pool. No fish were observed at these markers.

Species key:
B/b – *M. dolomieui*
T – *O. mykiss*
R – *P. burchelli*
K – *S. capensis*
J – juveniles, either *B. andrewi* or *P. burchelli*
W – *B. andrewi*

Deptht – total water depth.
Depthf – Focal-point depth.

BPF – barely perceptible flow.
NF – No flow.

Table 11: Pool A1 26/03/04

marker	species	no	length	shade	cover	leaves	branches	fines 1
8	b	1	20	1	3	1	0	1
12	b	1	30	1	4	1	0	1
30	b	1	15	1	1	1	0	1
1	b	1	35	1	3	1	1	1
1	b	4	15	1	3	1	1	1
23	b	1	30	1	3	1	1	1
23	b	1	15	1	3	1	1	1
19	b	2	35	1	3	1	1	1
19	b	1	30	1	3	1	1	1
19	b	2	20	1	3	1	1	1
19	b	3	35	1	3	1	1	1
26	b	1	35	1	4	1	1	1
26	b	2	30	1	4	1	1	1
26	b	2	20	1	4	1	1	1
26	b	2	15	1	4	1	1	1
14	b	1	25	1	4	1	1	1
14	b	1	20	1	4	1	1	1
14	b	1	15	1	4	1	1	1
2	b	2	15	1	3	1	1	1
9	b	1	40	1	4	1	1	1
A				1	1	1	0	1
B				1	3	0	0	1
C				1	1	0	0	1
D				1	1	0	0	1
E				1	1	1	0	1

Gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	1	1	0	92	10	18.7	BPF
0	0	1	0	142	20	18.7	BPF
0	0	1	0	143	50	18.7	BPF

0	1	0	0	149	20	18.7	BPF
0	1	0	0	149	20	18.7	BPF
0	1	1	0	161	53	18.7	BPF
0	1	1	0	161	53	18.7	BPF
0	1	1	0	60	20	18.7	BPF
0	1	1	0	60	20	18.7	BPF
0	1	1	0	60	20	18.7	BPF
0	1	1	0	60	20	18.7	BPF
0	1	1	0	139	46	19	BPF
0	1	1	0	139	46	19	BPF
0	1	1	0	139	46	19	BPF
0	1	1	0	139	46	19	BPF
1	1	1	0	131	30	19	BPF
1	1	1	0	131	30	19	BPF
1	1	1	0	131	30	19	BPF
1	1	0	0	112	20	19	BPF
0	1	1	0	107	10	19	BPF
0	0	1	0	39	0	19	BPF
1	1	1	0	47	0	19	BPF
0	0	0	0	47	0	19	BPF
1	1	0	0	25	0	19	SBT

Table 12: Pool A1 02/04/02

marker	species	no	length	shade	cover	leaves	branches	fines 1
6	B	1	25	3	3	1	1	1
6	B	1	20	3	3	1	1	1
39	B	1	15	3	3	0	1	1
39	B	1	20	3	3	0	1	1
32	B	2	30	1	3	0	1	1
32	B	1	35	1	3	0	1	1
14	B	1	15	1	3	0	1	1
5	B	1	15	1	3	0	1	1
5	B	2	20	1	3	0	1	1
5	B	1	25	1	3	0	1	1
5	B	2	10	1	3	0	1	1
5	B	1	40	1	3	0	1	1
12	B	2	30	1	3	0	1	1
12	B	2	20	1	3	0	1	1
12	B	1	5	1	3	0	1	1
3	B	1	30	1	3	0	1	1
3	B	1	25	1	3	0	1	1
3	B	4	10	1	3	0	1	1
35	B	4	10	3	3	0	1	1

Gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	1	0	0	138	20	20	BPF
0	1	0	0	138	20	20	BPF
0	0	0	0	130	20	20	BPF
0	0	0	0	130	20	20	BPF
1	1	0	0	163	20	20	BPF
1	1	0	0	163	20	20	BPF
1	1	0	0	167	20	20	BPF
0	1	0	0	136	20	20	BPF
0	1	0	0	136	20	20	BPF

0	1	0	0	136	20	20	BPF
0	1	0	0	136	20	20	BPF
0	1	0	0	136	20	20	BPF
0	1	0	0	158	20	20	BPF
0	1	0	0	158	20	20	BPF
0	1	0	0	158	20	20	BPF
0	1	0	0	138	20	20	BPF
0	1	0	0	138	20	20	BPF
0	1	0	0	138	20	20	BPF
1	1	0	0	104	20	20	BPF

Table 13: Pool A1 03/04/02

marker	species	no	length	shade	cover	leaves	branches	fines 1
37	B	3	15	2	3	0	0	1
3	B	3	15-20	2	3	1	0	1
1	B	1	30	3	3	1	0	1
1	B	1	15	3	3	1	0	1
32	B	2	15	3	3	1	1	1
13	B	2	15	3	3	1	1	1
13	B	1	25	3	3	1	1	1
35	B	3	15	3	3	1	1	1
35	B	1	30	3	3	1	1	1
35	B	1	25	3	3	1	1	1
22	B	1	30	3	3	1	1	1
22	B	1	20	3	3	1	1	1
22	B	1	15	3	3	1	1	1
22	B	3	30	3	3	1	1	1
22	B	2	40	3	3	1	1	1
22	B	1	25	3	3	1	1	1
39	B	4	15	2	3	0	1	1
39	B	1	30	2	3	0	1	1
16	B	2	15	3	4	0	1	1
16	B	1	30	3	4	0	1	1

Gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
1	1	1	0	59	20	25	BPF
0	1	1	0	90	30	25	BPF
0	0	1	0	125	40	25	BPF
0	0	1	0	125	40	25	BPF
0	0	1	0	147	50	25	BPF
0	1	0	0	156	55	25	BPF
0	1	0	0	156	55	25	BPF
0	1	0	0	163	30	25	BPF
0	1	0	0	163	30	25	BPF
0	1	0	0	163	30	25	BPF
0	1	0	0	139	25	25	BPF
0	1	0	0	139	25	25	BPF
0	1	0	0	139	25	25	BPF
0	1	0	0	139	25	25	BPF
0	1	0	0	139	25	25	BPF
0	1	0	0	139	25	25	BPF
1	1	0	0	130	30	25	BPF
1	1	0	0	130	30	25	BPF
0	1	0	0	108	20	25	BPF
0	1	0	0	108	20	25	BPF

Table 14: Pool A2 26/03/04

Marker	species	no	length	shade	cover	leaves	branches	fines 1
12	B	1	20	3	4	1	1	1
8	B	2	30	1	4	1	1	1
A				2	3	0	0	1
B				2	3	0	0	1
C				2	3	1	0	1
D				2	1	0	0	1

Gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
1	1	1	0	57	10	20	BPF
0	1	1	0	31	10	20	BPF
1	1	1	0	33	0	20	SRF
1	1	0	0	45	0	20	BPF
0	1	1	0	100	0	20	BPF
0	0	1	0	33	0	20	BPF

Pool A2 02/04/02 – No fish seen, cold overcast conditions

Table 15: Pool A2 03/04/02

marker	species	no	length	shade	cover	leaves	branches	fines 1
17	B	2	30	1	4	0	1	0
17	B	1	35	1	4	0	1	0
17	B	5	20	1	4	0	1	0
17	B	4	15	1	4	0	1	0
17	B	1	10	1	4	0	1	0
17	B	1	15	1	4	0	1	0

Gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	1	1	0	98	30	24	BPF
0	1	1	0	98	30	24	BPF
0	1	1	0	98	30	24	BPF
0	1	1	0	98	30	24	BPF
0	1	1	0	98	30	24	BPF
0	1	1	0	98	30	24	BPF

Table 16: Pool A3 26/03/02

marker	species	no	length	shade	cover	leaves	branches	fines 1
28	B	3	30	1	2	1	1	1
28	B	1	25	1	2	1	1	1
40	B	1	30	1	4	1	1	1
38	B	1	40	1	4	1	1	1
38	B	1	30	1	4	1	1	1
20	B	1	30	1	4	1	1	1
20	B	1	20	1	4	1	1	1
20	B	1	25	1	4	1	1	1
6	B	1	30	1	4	1	1	1
35	B	1	30	2	3	1	0	1
13	B	2	30	1	4	1	1	1

13	B	1	25	1	4	1	1	1
3	B	3	25	1	4	0	1	1
3	B	2	30	1	4	0	1	1
3	B	1	40	1	4	0	1	1
23	B	4	25	1	4	1	1	1
23	B	3	30	1	4	1	1	1
23	B	1	40	1	4	1	1	1
8	B	1	20	1	4	1	1	1
A				2	3	0	0	1
B				2	1	0	0	1
C				1	1	0	0	1
D				2	3	0	0	1

Gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	0	1	0	89	30	21	BPF
0	0	1	0	89	30	21	BPF
0	0	1	0	89	30	21	BPF
1	1	1	0	93	30	21	BPF
1	1	1	0	93	30	21	BPF
1	1	0	0	76	25	21	BPF
1	1	0	0	76	25	21	BPF
1	1	0	0	76	25	21	BPF
0	1	1	0	88	10	21.5	BPF
1	1	0	0	67	10	22	BPF
0	1	0	0	87	30	21	BPF
0	1	0	0	87	30	21	BPF
0	0	1	0	115	40	21.5	BPF
0	0	1	0	115	40	21.5	BPF
0	0	1	0	115	40	21.5	BPF
0	0	0	0	90	30	21.5	BPF
0	0	0	0	90	30	21.5	BPF
0	0	0	0	90	30	21.5	BPF
0	1	1	0	80	40	22	BPF
0	1	1	0	112	0	22	BPF
0	0	0	0	78	0	22	BPF
0	1	0	0	55	0	22	BPF
0	1	1	0	98	0	21.5	BPF

Table 17: Pool A3 02/04/02

Marker	species	no	length	shade	cover	leaves	branches	fines 1
6	B	1	25	1	4	0	1	1
14	B	5	40	1	4	1	1	1
14	B	4	30	1	4	1	1	1
14	B	4	25	1	4	1	1	1
14	B	4	20	1	4	1	1	1
14	B	1	45	1	4	1	1	1
14	W	1	30	1	4	1	1	1
39	T	1	50	1	4	0	1	1
39	B	3	30	1	4	0	1	1
20	B	1	25	1	4	1	1	1
20	B	1	35	1	4	1	1	1
19	B	1	40	3	3	0	0	1
19	B	2	30	3	3	0	0	1
19	B	1	25	3	3	0	0	1
8	B	1	20	3	3	0	0	1

25	B	1	20	1	4	1	1	1
25	B	2	30	1	4	1	1	1

gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	1	0	0	92	20	20	NF
1	1	0	0	98	20	20	NF
1	1	0	0	98	20	20	NF
1	1	0	0	98	20	20	NF
1	1	0	0	98	20	20	NF
1	1	0	0	98	20	20	NF
1	1	0	0	98	20	20	NF
0	0	0	0	86	20	20	NF
0	0	0	0	86	20	20	NF
0	1	0	0	90	20	20	NF
0	1	0	0	90	20	20	NF
0	1	0	0	127	20	20	BPF
0	1	0	0	127	20	20	BPF
0	1	0	0	127	20	20	BPF
0	1	0	0	146	20	20	BPF
0	1	0	0	98	20	20	NF
0	1	0	0	98	20	20	NF

Table 18: Pool A3 03/04/02

marker	species	no	length	shade	cover	leaves	branches	fines 1
5	B	1	35	1	4	0	1	1
33	B	1	12	1	4	0	1	1
33	B	2	30	1	4	0	1	1
33	B	1	35	1	4	0	1	1
12	B	1	30	2	3	0	0	1
12	B	2	20	2	3	0	0	1
12	B	1	40	2	3	0	0	1
37	B	3	25	3	3	0	0	1
37	B	1	30	3	3	0	0	1
14	B	1	40	1	3	0	0	1
14	B	2	30	1	3	0	0	1
14	B	11	25	1	3	0	0	1
23	B	1	30	1	4	0	1	1
29	B	1	22	2	3	0	0	1
21	B	1	40	1	4	0	1	1
21	B	4	30	1	4	0	1	1
21	B	3	25	1	4	0	1	1
21	B	2	18	1	4	0	1	1
34	B	1	30	1	4	0	1	1
34	B	1	10	1	4	0	1	1
34	B	2	20	1	4	0	1	1
9	B	1	30	1	4	0	1	1
9	B	2	20	1	4	0	1	1
21	W	1	40	1	4	0	1	1

gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	1	1	0	72	20	22.5	NF
0	0	1	0	89	30	22.5	NF
0	0	1	0	89	30	22.5	NF
0	0	1	0	89	30	22.5	NF
0	0	1	0	96	30	22.5	NF

0	0	1	0	96	30	22.5	NF
0	0	1	0	96	30	22.5	NF
0	0	1	0	121	40	22.5	NF
0	0	1	0	121	40	22.5	NF
0	1	0	0	98	20	22.5	BPF
0	1	0	0	98	20	22.5	BPF
0	1	0	0	98	20	22.5	BPF
0	1	1	0	106	30	22.5	NF
0	1	0	0	129	40	22.5	BPF
0	0	1	0	88	30	22.5	BPF
0	0	1	0	88	30	22.5	BPF
0	0	1	0	88	30	22.5	BPF
0	0	1	0	88	30	22.5	BPF
0	0	0	0	86	20	22.5	NF
0	0	0	0	86	20	22.5	NF
0	0	0	0	86	20	22.5	NF
0	0	0	0	126	40	22.5	NF
0	0	0	0	126	40	22.5	NF
0	0	1	0	88	30	22.5	BPF

Table 19: Pool A4 26/03/02

marker	species	no	length	shade	cover	leaves	branches	fines 1
5	B	1	25	1	4	1	1	1
26	B	1	25	1	3	1	0	1
26	B	1	40	1	3	1	0	1
26	B	3	30	1	3	1	0	1
26	B	1	15	1	3	1	0	1
26	B	1	35	1	3	1	0	1
32	B	2	30	1	3	0	0	1
7	B	2	30	1	4	1	1	1
7	B	1	45	1	4	1	1	1
7	B	1	25	1	4	1	1	1
8	B	1	30	1	3	0	0	1
8	B	1	25	1	3	0	0	1
18	B	1	35	1	3	0	0	1
38	B	3	15	1	1	0	0	1
18	T	1	40	1	3	0	0	1
8	W	4	20-25	1	3	0	0	1

gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	1	1	0	74	25	22	BPF
0	0	1	0	95	30	22	BPF
0	0	1	0	95	30	22	BPF
0	0	1	0	95	30	22	BPF
0	0	1	0	95	30	22	BPF
0	0	1	0	95	30	22	BPF
0	1	1	0	109	35	22	BPF
0	1	1	0	124	40	23	BPF
0	1	1	0	124	40	23	BPF
0	1	1	0	124	40	23	BPF
0	1	1	0	142	70	23.5	BPF
0	1	1	0	142	70	23.5	BPF
0	1	1	0	102	30	23.5	BPF
1	1	1	0	79	25	22.5	BPF
0	1	1	0	102	30	23.5	BPF

0	1	1	0	142	70	23.5	BPF

Table 20: Pool A4 02/04/02

marker	species	no	length	shade	cover	leaves	branches	fines 1
3	B	2	10	1	4	1	1	1
5	B	1	25	3	4	0	1	1
6	B	2	30	3	3	0	1	1
7	B	2	10	1	4	1	1	1
12	B	2	25	1	4	0	1	1
12	B	3	30	1	4	0	1	1
12	B	1	35	1	4	0	1	1
14	B	3	20	1	4	0	1	1
28	B	1	30	2	3	0	0	1
28	B	1	40	2	3	0	0	1
37	B	1	25	3	4	0	1	1
38	B	3	30	3	3	1	0	1
39	B	2	25	3	3	0	1	1
39	B	1	35	3	3	0	1	1

gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	0	0	0	81	20	19	BPF
0	1	1	0	101	20	19	BPF
0	1	1	0	95	20	19	BPF
0	0	1	0	57	20	19	BPF
0	1	1	0	118	20	19	BPF
0	1	1	0	118	20	19	BPF
0	1	1	0	118	20	19	BPF
0	1	1	0	125	20	19.5	BPF
0	1	1	0	99	20	19	BPF
0	1	1	0	99	20	19	BPF
0	1	1	0	89	20	19	BPF
0	1	1	0	144	20	19	BPF
0	1	1	0	100	20	19	BPF
0	1	1	0	100	20	19	BPF

Table 21: Pool A4 03/04/02

Marker	species	no	length	shade	cover	leaves	branches	fines 1
22	B	1	15	1	3	0	0	1
22	B	1	25	1	3	0	0	1
12	B	2	10	1	4	0	1	1
12	B	2	25	1	4	0	1	1
34	B	1	20	1	3	0	1	1
34	B	2	10	1	3	0	1	1
34	B	2	30	1	3	0	1	1
9	B	1	25	1	4	0	1	1
9	B	2	30	1	4	0	1	1
9	B	1	115	1	4	0	1	1
9	B	1	25	1	4	0	1	1
9	B	1	30	1	4	0	1	1
38	B	2	20	1	3	0	0	1
38	B	2	8	1	3	0	0	1
33	B	1	35	1	3	0	0	1

33	B	1	30	1	3	0	0	1
29	B	2	8	1	3	0	1	1
29	B	2	10	1	3	0	1	1
15	B	1	25	1	1	0	0	1
15	B	1	20	1	1	0	0	1
38	W	4	15	1	3	0	0	1
A				1	1	0	0	1
B				1	1	0	0	1
C				1	4	0	1	1

gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
1	1	0	0	65	20	23	BPF
1	1	0	0	65	20	23	BPF
0	1	1	0	73	25	23	BPF
0	1	1	0	73	25	23	BPF
0	1	1	0	102	30	23	NF
0	1	1	0	102	30	23	NF
0	1	1	0	102	30	23	NF
0	0	1	0	121	40	23	NF
0	0	1	0	121	40	23	NF
0	0	1	0	121	40	23	NF
0	0	1	0	121	40	23	NF
0	0	1	0	121	40	23	NF
0	1	0	0	141	40	23	NF
0	1	0	0	141	40	23	NF
1	0	1	0	139	40	23	NF
1	0	1	0	139	40	23	NF
0	0	1	0	68	20	23	BPF
0	0	1	0	68	20	23	BPF
0	0	1	0	90	30	23	BPF
0	0	1	0	90	30	23	BPF
0	1	0	0	141	40	23	NF
0	0	1	0	99	0	23	BPF
0	0	0	0	61	0	23	BPF
0	0	0	0	79	0	23	BPF

Table 22: Pool A5 26/03/02

Marker	SPECIES	no	length	shade	cover	leaves	branches	fines 1
16	B	14	10 TO 15	3	2	0	0	1
16	B	3	20 -25	3	2	0	0	1
16	B	2	30	3	2	0	0	1
25	B	4	15	3	1	0	0	1
21	B	1	20	3	1	0	0	1
21	B	1	15	3	1	0	0	1
11	B	1	20	1	2	0	0	1
11	B	2	30	1	2	0	0	1
1	B	1	25	2	1	0	0	1
1	B	1	20	2	1	0	0	1
1	B	30	10	2	1	0	0	1
15	B	9	10	2	1	0	0	1
33	B	6	10	3	1	0	0	1
14	B	10	10	2	1	0	0	1
10	B	1	30	3	3	0	0	1
10	B	1	20	3	3	0	0	1
10	B	5	10	3	3	0	0	1

12	B	1	20	2	1	0	0	1
12	B	1	15	2	1	0	0	1
12	B	1	10	2	1	0	0	1
12	B	1	25	2	1	0	0	1
19	B	1	30	2	3	0	0	1
19	B	2	25	2	3	0	0	1
7	B	2	35	2	3	0	1	1
7	B	1	10	2	3	0	1	1
18	B	1	15	2	3	0	1	1
8	B	3	15	2	3	0	0	1
32	B	2	25	2	1	0	0	1
32	B	1	20	2	1	0	0	1
32	B	1	25	2	1	0	0	1
32	B	1	20	2	1	0	0	1
32	B	1	15	2	1	0	0	1
26	B	5	15-20	3	3	0	0	1
22	B	2	30	2	3	0	0	1
22	B	1	25	2	3	0	0	1
22	B	2	15	2	3	0	0	1
7	T	1	35	2	3	0	1	1

gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
1	1	0	0	122	40	22	NF
1	1	0	0	122	40	22	NF
1	1	0	0	122	40	22	NF
0	0	1	0	117	40	22	NF
0	0	1	0	90	30	22	NF
0	0	1	0	90	30	22	NF
0	0	0	0	75	25	22	NF
0	0	0	0	75	25	22	NF
0	0	0	0	99	35	22	NF
0	0	0	0	99	35	22	NF
0	0	0	0	99	35	22	NF
1	1	0	0	48	15	22	NF
1	1	0	0	88	30	22	NF
1	1	0	0	78	25	22	BPF
1	1	0	0	95	35	22	BPF
1	1	0	0	95	35	22	BPF
1	1	0	0	95	35	22	BPF
0	1	1	0	46	15	23	BPF
0	1	1	0	46	15	23	BPF
0	1	1	0	46	15	23	BPF
0	1	1	0	46	15	23	BPF
0	1	1	0	152	50	23	BPF
0	1	1	0	152	50	23	BPF
1	1	1	0	171	55	23.5	BPF
1	1	1	0	171	55	23.5	BPF
1	1	1	0	82	25	23	BPF
0	1	0	0	59	20	23	SBT
0	1	0	0	113	40	23	SBT
0	1	0	0	113	40	23	SBT
0	1	0	0	113	40	23	SBT
0	1	0	0	113	40	23	SBT
0	1	0	0	113	40	23	SBT
0	1	1	0	121	40	23	SBT

1	1	1	0	140	45	23	SBT
1	1	1	0	140	45	23	SBT
1	1	1	0	140	45	23	SBT
1	1	1	0	171	55	23.5	BPF

Table 23: Pool A5 02/04/02

Marker	species	no	length	shade	cover	leaves	branches	fines 1
35	B	1	20	1	2	0	0	1
35	B	1	25	1	2	0	0	1
9	B	2	6	2	3	0	0	1
11	B	3	30	1	3	0	1	1
11	B	1	15	1	3	0	1	1
39	B	1	20	1	2	0	0	1
38	B	2	20	1	2	0	1	1
34	B	6	10	2	1	0	0	1
6	B	2	10	2	3	0	0	1
6	B	1	6	2	3	0	0	1
5	B	1	6	2	3	0	0	1
12	B	12	10	2	3	0	0	1
37	B	2	6	2	3	0	0	1
37	B	1	8	2	3	0	0	1
31	B	1	20	2	1	0	0	1
26	B	1	35	1	2	0	0	1
28	B	2	13	2	1	0	0	1
30	B	1	35	1	2	0	0	1
30	B	2	25	1	2	0	0	1
30	B	2	20	1	2	0	0	1
30	B	4	12	1	2	0	0	1
40	B	1	10	2	2	0	0	1
29	B	2	10	2	3	0	0	0
14	B	4	12	1	2	0	0	1

Gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
1	0	0	0	92	20	19	NF
1	0	0	0	92	20	19	NF
1	1	0	0	71	20	19	BPF
0	1	1	0	145	20	19	BPF
0	1	1	0	145	20	19	BPF
1	0	0	0	74	20	19	NF
0	1	0	0	62	20	19	NF
0	0	0	0	105	20	19	NF
1	1	0	0	81	20	19	NF
1	1	0	0	81	20	19	NF
1	1	0	0	16	20	19	BPF
1	1	0	0	83	20	19	BPF
0	1	0	0	77	20	19	BPF
0	1	0	0	77	20	19	BPF
1	0	0	1	34	20	19	SRF
1	0	0	0	85	20	19	BPF
0	0	0	0	78	20	19	NF
1	1	0	0	138	20	19	NF
1	1	0	0	138	20	19	NF
1	1	0	0	138	20	19	NF
1	1	0	0	138	20	19	NF
0	1	1	0	90	20	19	NF

0	1	0	0	78	20	19	SRF
1	0	1	0	132	20	19	BPF

Table 24: Pool A5 03/04/02

Marker	species	no	length	shade	cover	leaves	branches	fines 1
29	B	1	30	1	4	0	1	1
29	B	2	25	1	4	0	1	1
29	B	4	1115	1	4	0	1	1
29	B	1	20	1	4	0	1	1
5	B	17	9	3	1	0	0	1
37	B	12	10	3	3	0	0	1
34	B	5	9	3	3	0	0	0
34	B	1	20	3	3	0	0	0
4	B	3	10	3	3	0	0	1
9	B	1	15	3	3	0	1	0
9	B	2	20	3	3	0	1	0
9	B	1	35	3	3	0	1	0
9	B	2	27	3	3	0	1	0
14	B	1	25	1	4	0	1	1
14	B	2	20	1	4	0	1	1
33	B	6	14	2	1	0	0	0
12	B	1	13	3	1	0	0	1
12	B	2	20	3	1	0	0	1
12	B	1	35	3	1	0	0	1
23	B	4	13	1	4	0	1	1
23	B	1	20	1	4	0	1	1
9	T	1	20	3	3	0	1	0
12	T	1	25	3	1	0	0	1

gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	0	0	0	106	30	23	NF
0	0	0	0	106	30	23	NF
0	0	0	0	106	30	23	NF
0	0	0	0	106	30	23	NF
0	0	0	0	92	25	23	NF
0	1	1	0	97	30	23	BPF
0	1	1	0	79	25	23	BPF
0	1	1	0	79	25	23	BPF
0	1	1	0	95	30	23	BPF
0	1	1	0	166	20	23	BPF
0	1	1	0	166	20	23	BPF
0	1	1	0	166	20	23	BPF
0	1	1	0	166	20	23	BPF
1	1	0	0	84	30	23	BPF
1	1	0	0	84	30	23	BPF
0	0	0	1	51	20	23	BPF
1	0	0	0	93	30	23	BPF
1	0	0	0	93	30	23	BPF
1	0	0	0	93	30	23	BPF
0	1	0	0	139	40	23	BPF
0	1	0	0	139	40	23	BPF
0	1	1	0	166	20	23	BPF

1	0	0	0	93	30	23	BPF

Table 25: Pool B1 27/03/02

Marker	species	no	length	shade	cover	leaves	branches	fines 1
18	J	1	3	1	4	0	1	1
34	J	2	2,5	1	2	0	1	1
4	J	30	2,5	1	2	0	0	1
7	J	3	3	1	2	0	1	1
26	J	60	2,5	1	2	0	1	1
18	K	1	4	1	4	0	1	1
7	K	7	5	1	2	0	1	1
40	K	1	70	1	2	0	1	1
32	R	20	6	1	4	0	1	1
40	T	1	30	1	2	0	1	1
40	W	5	70-80	1	2	0	1	1
40	W	100	20 -40	1	2	0	1	1
39	W	7	60 - 80	1	4	0	1	1
39	W	23	20-50	1	4	0	1	1
21	W	5	30	1	2	0	1	1

gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	0	0	0	87	10	17	BPF
0	0	0	0	58	5	17	BPF
0	0	0	0	98	5	17	BPF
0	0	0	0	52	10	17	BPF
0	0	0	0	56	5	17	BPF
0	0	0	0	87	10	17	BPF
0	0	0	0	52	10	17	BPF
0	0	0	0	129	40	17	BPF
0	1	1	0	28	10	17	BPF
0	0	0	0	129	40	17	BPF
0	0	0	0	129	40	17	BPF
0	0	0	0	129	40	17	BPF
0	1	1	0	124	50	17	BPF
0	1	1	0	124	50	17	BPF
0	0	0	0	107	20	17	BPF

Table 26: Pool B1 02/04/02

Marker	species	no	length	shade	cover	leaves	branches	fines 1
3	W	70	20-30	2	1	0	0	1
12	K	20	3 TO 6	1	2	0	0	1
34	K	30	3 TO 6	1	3	0	1	1
34	R	43	3 TO 6	1	3	0	1	1
37	R	43	3 TO 6	1	3	0	1	1
37	K	10	4 TO 6	1	3	0	1	1
7	K	12	04-Jan	3	3	0	1	1
5	R	30	4 TO 6	3	3	0	0	1
5	J	30	2 TO 3	3	3	0	0	1
26	K	30	4 TO 6	3	3	0	1	1
26	R	30	2 TO 3	3	3	0	1	1
35	K	2	4 TO 5	3	3	0	1	1
9	J	15	1 TO 2	3	3	0	1	1

9	K	4	3 TO 4	3	3	0	1	1
31	K	30	3 TO 5	3	3	0	1	1
28	K	10	3 TO 5	2	3	0	1	1
25	K	1	03-Jan	1	5	0	0	1
8	K	1	06-Jan	3	3	0	1	1
20	J	20	2 TO 4	3	3	0	1	1
13	K	1	10-Jan	1	3	0	1	1
23	K	20	6 TO 8	1	3	0	1	0
22	K	5	6 TO 10	1	4	0	1	1
18	K	5	06-Jan	3	4	0	1	1
14	K	30	5 TO 8	1	4	0	1	1
14	W	2	10-Jan	1	4	0	1	1
21	R	30	5 TO 6	3	3	0	1	1
19	R	50	6 TO 8	3	3	0	1	1

Gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	0	0	0	106	35	20	BPF
0	1	0	0	53	10	20	NF
0	0	0	0	47	10	20	NF
0	0	0	0	47	10	20	NF
1	1	0	0	60	10	20	NF
1	1	0	0	60	10	20	NF
1	1	1	0	63	10	20	BPF
1	1	0	0	41	10	20	BPF
1	1	0	0	41	10	20	BPF
1	1	0	0	57	10	20	NF
1	1	0	0	57	10	20	NF
0	0	0	0	52	10	20	NF
0	0	0	0	56	10	20	BPF
0	0	0	0	56	10	20	BPF
0	1	0	0	37	5	20	NF
0	1	0	0	44	10	20	NF
0	0	0	0	46	10	20	NF
0	0	0	0	56	10	20	NF
0	0	0	0	28	8	20	NF
0	0	0	0	40	10	20	NF
0	1	0	0	63	12	20	NF
0	0	0	0	104	20	20	NF
0	0	0	0	31	10	20	NF
0	0	0	0	61	15	20	NF
0	0	0	0	61	15	20	NF
1	1	0	0	31	10	20	NF
1	1	0	0	57	15	20	NF

Table 27: Pool B1 04/04/02

Marker	species	no	length	shade	cover	leaves	branches	fines 1
34	C	1	50	2	1	0	0	1
7	J	8	1 TO 3	3	3	0	1	1
9	J	10	1 TO 2	3	4	0	1	1
14	J	20	2 TO 4	2	3	0	1	1
4	J	80	3 TO 4	2	3	0	0	1
39	J	20	3	1	4	0	1	1
40	J	10	1 TO 2	3	3	0	1	1
12	K	1	6	2	4	0	1	1
23	K	6	6 TO 8	1	4	0	1	1

26	K	3	6	1	4	1	1	1
21	K	10	5 TO 8	1	4	1	1	1
29	K	2	4	2	3	1	0	1
16	K	10	4 TO 6	3	4	0	1	1
16	K	18	3 TO 4	3	4	0	1	1
39	K	1	6	1	4	0	1	1
28	R	20	5 TO 8	1	4	0	1	1
29	R	60	5 TO 6	2	3	1	0	1
30	W	3	50	2	1	0	0	1
34	W	40	30-40	2	1	0	0	1
34	W	40	20-30	2	1	0	0	1
34	W	40	15 TO 20	2	1	0	0	1
34	W	1	90	2	1	0	0	1
34	W	20	50- 70	2	1	0	0	1

gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	1	1	0	79	40	21	BPF
0	0	0	0	73	10	21	NF
0	0	0	0	53	15	21	NF
0	0	0	0	39	5	21	NF
1	1	1	0	47	15	21	NF
0	1	0	0	67	15	21	NF
0	0	0	0	41	5	21	NF
0	0	0	0	36	20	21	NF
0	0	0	0	56	25	21	NF
0	0	0	0	69	20	21	NF
0	0	0	0	60	30	21	NF
0	1	1	0	59	30	21	NF
0	0	0	0	71	15	21	NF
0	0	0	0	71	15	21	NF
0	1	0	0	67	15	21	NF
0	1	0	0	60	20	21	BPF
0	1	1	0	59	30	21	NF
0	1	1	0	61	10	21	NF
0	1	1	0	79	40	21	BPF
0	1	1	0	79	40	21	BPF
0	1	1	0	79	40	21	BPF
0	1	1	0	79	40	21	BPF
0	1	1	0	79	40	21	BPF

Table 28: Pool B2 27/03/02

Marker	species	no	length	shade	cover	leaves	branches	fines 1
39	W	200	20 -30	2	2	0	0	1
40	W	2	20	2	3	0	0	1
5	K	1	5	1	5	0	1	1
5	J	30	2 TO 3	1	5	0	1	1
21	J	15	2 TO 3	1	5	0	1	1
37	J	30	3 TO 4	1	5	0	1	1
31	K	2	5 TO 6	1	5	0	1	1
20	J	10	2 TO 3	3	5	0	0	1
A				2	1	0	0	1
B				2	1	0	0	1
C				1	3	0	0	1
D				2	3	0	1	1

E				2	1	0	0	1

gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	1	1	0	180	60	18	BPF
0	3	4	0	70	25	18	BPF
0	0	0	0	51	10	18	BPF
0	0	0	0	51	10	18	BPF
0	0	0	0	71	5	18	BPF
0	0	0	0	88	7	18	BPF
0	0	0	0	71	10	18	BPF
2	3	0	0	39	5	18	BPF
1	1	0	0	60	0	18	BPF
0	0	0	0	36	0	18	BPF
0	1	1	0	183	0	18	BPF
0	0	1	0	136	0	18	BPF
0	1	1	0	192	0	18	BPF

Table 29: Pool B2 02/04/02

Marker	species	no	length	shade	cover	leaves	branches	fines 1
9	K	5	4 TO 8	1	3	0	1	1
18	K	3	8	1	3	0	1	1
28	K	1	5	1	3	0	1	1
19	K	1	6	1	3	0	1	1
37	K	20	5	1	3	0	1	1
21	R	20	6TO 8	1	3	0	1	1
37	R	1	5	1	3	0	1	1
31	T	1	25	1	1	0	0	1
35	T	1	25	1	1	0	0	1
12	T	2	15 TO 20	1	3	0	0	1
35	W	20	10 TO 20	1	1	0	0	1
35	W	15	20 TO 30	1	1	0	0	1
26	W	30	10 TO 20	1	1	0	0	1
26	W	30	20 TO 30	1	1	0	0	1
5	W	1	50	1	3	0	0	1
5	W	10	30	1	3	0	0	1
5	W	10	20	1	3	0	0	1
12	W	1	50	1	3	0	0	1
12	W	3	20	1	3	0	0	1
A				1	1	0	0	1
B				1	3	0	0	1
C				1	3	0	1	1
D				1	3	0	0	1

gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	0	0	0	59	10	20	BPF
0	0	0	0	62	12	20	NF
0	0	0	0	70	15	20	NF
0	0	0	0	48	10	20	NF
0	1	0	0	177	15	20	NF
0	1	0	0	67	15	20	NF
0	1	0	0	177	15	20	NF
0	1	0	0	129	50	20	BPF

0	1	0	0	125	50	20	BPF
0	1	1	0	69	30	20	SBT
0	1	0	0	125	50	20	BPF
0	1	0	0	125	50	20	BPF
0	1	0	0	139	60	20	BPF
0	1	0	0	139	60	20	BPF
1	1	1	0	96	50	20	BPF
1	1	1	0	96	50	20	BPF
1	1	1	0	96	50	20	BPF
0	1	1	0	69	30	20	SBT
0	1	1	0	69	30	20	SBT
0	0	0	0	49	0	20	BPF
0	1	0	0	55	0	20	BPF
1	1	0	0	96	0	20	NF
0	1	1	0	205	0	20	BPF

Table 30: Pool B2 04/04/02

Marker	species	no	length	shade	cover	leaves	branches	fines 1
16	J	70	3 TO 4	2	3	0	1	1
4	J	2	2 TO 3	1	4	0	1	1
5	J	20	2 TO 3	3	4	0	1	1
26	K	3	6	3	3	0	1	1
26	R	1	6	3	3	0	1	1
34	T	1	20	2	1	0	0	1
21	W	100	20 -30	2	1	0	0	1
21	W	1	70	2	1	0	0	1
21	W	70	15 - 20	2	1	0	0	1
21	W	10	40	2	1	0	0	1
30	W	2	30	2	1	0	0	1

Gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	0	0	0	35	10	21.5	NF
0	0	0	0	67	10	21.5	BPF
0	0	0	0	62	30	21.5	NF
0	1	0	0	175	10	21.5	BPF
0	1	0	0	175	10	21.5	BPF
0	1	1	0	76	30	21.5	BPF
0	0	1	0	125	40	21.5	BPF
0	0	1	0	125	40	21.5	BPF
0	0	1	0	125	40	21.5	BPF
0	0	1	0	125	40	21.5	BPF
0	1	1	0	92	40	21.5	BPF

Table 31: Pool B3 27/03/02

Marker	species	no	length	shade	cover	leaves	branches	fines 1
23	J	6	1 TO 2	2	3	0	0	0
8	J	3	3 TO 4	2	3	0	0	1
4	J	5	3 TO 4	3	3	0	0	1
14	J	200	1 TO 2	2	1	0	0	1
7	J	20	1 TO 2	3	5	0	1	1
8	K	1	4	2	3	0	0	1
38	K	2	8	3	3	0	0	0
38	R	3	8	3	3	0	0	0
38	R	15	4 TO 6	3	3	0	0	0

26	T	2	20	2	1	0	0	1

gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	0	1	0	23	5	18	BPF
0	0	1	0	100	10	18	BPF
1	1	1	0	103	5	18	BPF
1	1	0	0	26	7	18	BPF
0	0	0	0	23	15	18	BPF
0	0	1	0	100	10	18	BPF
0	0	1	0	81	15	18	BPF
0	0	1	0	81	15	18	BPF
0	0	1	0	81	15	18	BPF
0	1	0	0	59	10	18	SBT

Table 32: Pool B3 03/04/02

Marker	species	no	length	shade	cover	leaves	branches	fines 1
9	J	60	1 TO 3	1	4	0	1	1
28	J	40	1 TO 3	1	4	0	1	1
18	J	15	1	1	3	0	1	1
31	J	20	1 TO 3	1	4	0	1	0
9	K	30	4 TO6	1	4	0	1	1
7	R	13	5 TO 7	3	3	0	1	0
22	R	10	3 TO 4	2	3	0	0	1
23	R	26	4 TO 7	2	3	0	1	1
25	R	50	4 TO 5	2	3	0	1	1
4	R	80	3 TO 4	3	3	0	1	1
20	R	20	3 TO 4	2	3	0	1	1
39	R	10	3 TO 4	3	3	0	0	1
35	T	1	35	2	3	0	0	1
26	T	1	20	2	3	0	0	1

Gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	0	0	0	51	10	19	NF
0	0	0	0	60	15	19	NF
0	1	1	0	98	15	19	NF
0	0	1	0	123	5	19	NF
0	0	0	0	51	10	19	NF
0	1	1	0	71	10	19	NF
0	1	0	0	49	10	19.5	NF
1	1	0	0	51	10	19	NF
0	1	0	0	54	10	19	NF
0	0	0	0	36	10	19	NF
1	1	0	0	45	10	19	NF
0	1	0	0	55	10	19.5	BPF
0	1	1	0	99	40	19	BPF
0	1	0	0	51	10	19	BPF

Table 33: Pool B3 04/04/02

marker	species	no	length	shade	cover	leaves	branches	fines 1
23	J	120	3 TO 4	2	1	0	0	1
16	J	20	1 TO 2	1	3	0	0	0
12	J	20	1 TO 2	3	3	0	0	1
4	J	20	3 TO 5	2	4	0	1	1
26	J	10	3 TO 4	1	3	0	1	1

30	J	80	2 TO 3	3	1	0	0	1
34	J	20	2 TO 4	3	3	0	1	1
5	J	20	2TO 4	3	3	0	0	0
23	K	5	5	2	1	0	0	1
4	K	1	5	2	4	0	1	1
12	R	1	6	3	3	0	0	1
28	R	10	6	3	3	0	0	1
28	R	1	7	3	3	0	0	1
9	T	1	20	2	1	0	0	1

gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
1	1	1	0	45	10	22	BPF
0	0	1	0	22	5	22	NF
0	0	1	0	99	10	22	BPF
0	0	0	0	52	20	22	BPF
0	0	0	0	37	5	22	NF
0	0	0	0	57	10	22	NF
0	1	0	0	43	5	22	NF
0	1	1	0	50	10	22	NF
1	1	1	0	45	10	22	BPF
0	0	0	0	52	20	22	BPF
0	0	1	0	99	10	22	BPF
0	0	1	0	98	15	22	BPF
0	0	1	0	98	15	22	BPF
0	1	1	0	63	30	22	SBT

Table 34: Pool B4 27/03/04

Marker	species	no	length	shade	cover	leaves	branches	fines 1
19	J	20	2 TO 3	1	2	0	0	1
22	J	60	2 TO 4	1	2	0	0	1
15	J	20	2	1	2	0	0	1
25	J	10	2 TO 5	1	4	0	0	1
31	J	50	2 TO 3	3	4	0	0	1
20	K	1	8	1	1	0	0	1
21	T	1	20	1	1	0	0	1
16	T	1	20	1	1	0	0	1
16	T	1	25	1	1	0	0	1
23	T	1	20	1	3	0	1	1
18	W	6	40 - 60	1	1	0	0	1

gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	0	0	1	244	234	19	NF
0	0	0	1	62	42	19	NF
0	0	1	1	182	162	19	NF
0	1	0	0	54	34	19	SBT
0	1	0	1	43	23	19	NF
0	0	0	1	91	81	19	NF
0	0	1	1	245	163	19	NF
0	3	0	1	548	538	19	NF
0	3	0	1	548	538	19	NF
0	1	1	0	175	90	19	NF
0	1	0	0	171	114	19	NF

Table 35: Pool B4 03/04/02

Marker	species	no	length	shade	cover	leaves	branches	fines 1
9	J	30	1 TO 3	2	3	0	0	0
25	J	5	2 TO 4	2	3	0	0	0
18	J	40	2 TO 4	3	4	0	1	0
7	J	90	2 TO 3	3	4	0	1	0
26	J	20	2 TO 4	2	3	0	0	0
20	J	20	2 TO 4	3	4	0	1	1
20	K	1	4	3	4	0	1	1
28	T	4	20	2	3	0	0	0
31	W	20	40 - 50	3	4	0	1	0
31	W	20	20 - 40	3	4	0	1	0
A				2	3	0	0	1
B				2	1	0	0	1
C				2	1	0	0	0

gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	1	0	0	61	3	21	BPF
0	0	0	1	127	120	20.5	NF
0	0	0	1	320	310	20.05	NF
0	0	0	1	119	110	20.7	NF
0	1	0	0	25	10	20.7	NF
1	1	0	0	68	15	20.5	NF
1	1	0	0	68	15	20.5	NF
0	1	0	0	236	115	20.5	BPF
0	0	0	1	322	260	20.7	NF
0	0	0	1	322	260	20.7	NF
0	1	0	0	96	0	21	BPF
0	0	0	0	68	0	21	NF
0	1	0	0	62	0	21	NF

Table 36: Pool B4 04/04/02

marker	species	no	length	shade	cover	leaves	branches	fines 1
12	J	10	2 TO 3	3	4	0	1	1
9	J	40	2 TO 4	3	4	0	1	1
33	J	10	1TO 2	2	1	0	0	1
34	J	10	1	1	4	0	1	1
14	J	20	1 TO 2	3	4	0	1	1
4	J	20	2 TO 4	3	4	0	1	1
30	J	30	3 TO 6	3	4	0	1	1
14	K	1	4	3	4	0	1	1
7	R	30	3 TO 6	2	3	0	0	0
23	T	1	25	2	1	0	0	1
23	T	1	10	2	1	0	0	1
29	T	1	25	3	3	0	0	1
37	W	10	30-40	3	1	0	0	1
37	W	15	20-25	3	1	0	0	1
37	W	3	60	3	1	0	0	1
22				1	2	0	0	1
15				1	2	0	0	1
16				1	1	0	0	1
18				1	1	0	0	1
23				1	3	0	0	1
25				1	4	0	0	1
32				3	4	0	0	1

20				1	1	0	0	1

gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	0	0	1	26	16	20	NF
0	0	0	1	310	300	20	NF
0	0	0	1	29	19	20	NF
0	0	0	1	107	97	20	NF
0	0	1	0	54	44	20	BPF
1	1	0	0	35	25	20	NF
0	1	0	1	98	88	20	NF
0	0	1	0	54	44	20	BPF
0	1	1	0	63	3	19.5	NF
0	1	1	0	242	80	19.5	NF
0	1	1	0	242	80	19.5	NF
0	1	0	0	104	35	20	BPF
1	1	1	0	500	300	20	BPF
1	1	1	0	500	300	20	BPF
1	1	1	0	500	300	20	BPF
0	0	0	1	62	0	19	BPF
0	0	1	1	182	0	19	BPF
0	1	0	1	548	0	19	BPF
0	1	0	0	171	0	19	BPF
0	1	1	0	175	0	19	BPF
0	1	0	0	54	0	19	SBT
0	1	0	1	43	0	19	NF
0	0	0	1	91	0	19	NF

Table 37: Pool B5 27/03/04

Marker	Species	no	length	shade	cover	leaves	branches	fines 1
7	J	MANY	1 TO 3	1	4	0	1	1
30	J	30	1 TO 2	3	5	0	0	
10	K	3	6	3	4	0	1	1
10	R	100	3 TO 6	3	4	0	1	1
1	R	30	3 TO 6	1	3	0	0	0
X	R	30	6	3	3	0	0	0
13	T	6	20-25	2	1	0	0	1
25	T	2	20-25	2	3	0	0	1
3	W	8	40-60	1	3	0	0	1
3	W	5	70-80	1	3	0	0	1
3	W	20 -25	20-40	1	3	0	0	1
7	W	4	30-40	1	5	1	1	1
7	W	1	20	1	5	1	1	1
25	W	5	20-30	2	3	0	0	1
A				2	1	0	0	1
B				3	4	0	1	1
C				2	1	0	0	0
D.				2	1	0	0	1

gravel 2	Cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	0	0	0	68	30	19.5	NF
1	0	1	0	23	5	20	NF
0	1	1	0	65	10	20	BPF
0	1	1	0	65	10	20	BPF
1	1	0	0	33	10	20	BPF
0	1	0	0	30	5	20	BPF

1	1	0	0	103	35	20	BPF
1	1	0	0	65	20	20	BPF
1	1	0	0	75	25	19	BPF
1	1	0	0	75	25	19	BPF
1	1	0	0	75	25	19	BPF
1	1	0	0	74	25	19.5	BPF
1	1	0	0	74	25	19.5	BPF
1	1	0	0	65	20	20	BPF
1	1	0	0	28	0	20	BPF
0	3	0	0	124	0	20	BPF
1	1	0	0	20	0	20	SBT
1	1	0	0	57	0	20	BPF

Table 38: Pool B5 03/04/02

Marker	species	no	length	shade	cover	leaves	branches	fines 1
7	J	60	2 TO 4	2	3	0	0	1
1	J	70	3 TO 5	3	4	0	1	1
34	K	10	6 TO 8	2	4	1	0	1
11	R	50	5 TO 6	3	3	0	0	0
34	R	400	2 TO 6	2	4	1	0	1
4	T	1	20	1	4	0	1	1
21	T	2	15	2	3	0	0	1
15	T	1	15	2	3	0	0	0
4	W	1	20	1	4	0	1	1
29	W	18	50 -70	1	4	0	1	1
29	W	12	20 TO 30	1	4	0	1	1

Gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	0	0	0	15	3	22	NF
0	0	0	0	42	10	22	NF
0	1	1	0	50	10	22	NF
0	1	0	0	49	3	22	BPF
0	1	1	0	50	10	22	NF
0	0	0	0	122	40	22	NF
0	1	1	0	83	5	22.2	BPF
1	1	0	0	90	15	22.5	BPF
0	0	0	0	122	40	22	NF
0	1	0	0	81	22	22	BPF
0	1	0	0	81	22	22	BPF

Table 39: Pool B5 04/04/02

Marker	species	no	length	shade	cover	leaves	branches	fines 1
40	J	40	1 TO 3	3	5	0	0	1
16	J	60	1 TO 3	3	4	0	1	1
6	J	30	1 TO 3	3	5	0	0	1
3	J	60	1 TO 3	3	5	0	0	1
6	K	1	6	3	5	0	0	1
13	R	30	5 TO 6	3	3	0	0	0
19	R	12	3 TO 5	1	4	1	1	0
2	R	30	4 TO 6	1	4	0	1	0
8	T	1	20	2	1	0	0	0
1	T	1	20	2	1	1	0	1
39	T	1	20	2	1	0	0	1
35	T	3	20	2	1	0	0	1

32	W	10	70-80	2	1	0	0	1
32	W	2	50	2	1	0	0	1
32	W	15	30-40	2	1	0	0	1

gravel 2	cobble 3	boulder4	bedrock5	deptht	depthf	temp	flow
0	1	1	0	26	3	19	BPF
0	0	0	0	30	5	19	NF
0	1	1	0	19	3	19	NF
1	1	0	0	25	5	19	NF
0	1	1	0	19	3	19	NF
0	1	1	0	48	3	18	BPF
0	1	1	0	49	10	19	NF
0	1	1	0	32	6	19	BPF
1	1	1	0	61	10	18.5	BPF
1	1	1	0	144	5	18.5	BPF
1	1	1	0	139	5	19	BPF
0	1	1	0	101	20	19	BPF
0	0	1	0	81	25	18.5	BPF
0	0	1	0	81	25	18.5	BPF
0	0	1	0	81	25	18.5	BPF

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