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DEVELOPMENT OF A SAMPLING FRAMEWORK FOR THE AUSTRALIAN ALPS STREAM HEALTH MONITORING PROJECT

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CONTENTS

EXECUTIVE SUMMARY

1 **Predictive models** for the assessment of river health have been successfully implemented in Britain (RIVPACS), the United States (the BEAST), Australia and Indonesia (AUSRIVAS). These models match test sites to a set of reference sites using habitat and environmental features of the site. Taxa likely to occur at test sites are predicted using the reference data and compared to those collected, the differences providing an assessment of damage. This provides an independent method of comparison, avoiding problems of upstream/downstream controls and comparisons to predetermined thresholds that may be unrealistic to expect for many sites.

2 **Reference sites** are used to characterize the region based on their physical, chemical and biotic attributes. The condition at a test sites will be described in the reference data so that accurate site comparisons can be made

3 **Selection of reference sites** involved choosing more than 100 sites from relatively unmodified regions of the Alps. These sites were chosen to describe the range of altitudes (>1000m), vegetation types, slope and conditions experienced within the national Parks of the Australian Alps.

4 **Test sites** were chosen to determine if the AUSRIVAS model for the Alps will be able to detect degradation in biological condition.

5 **Physical and chemical water quality variables** will be measured at all sites to relate to the biota and assist in identifying if any biological impairment at a site results from water quality issues or land use or habitat degradation.

6 **Habitat variables** will be measured at all sites and will be related to biological data in model development. Ultimately the habitat and environmental data will be used to determine the macroinvertebrate community that should occur at a site in the absence of the effects of human activities.

7 **The predictive technique** involves classifying a large number of reference sites into groups using the biological attributes. A discriminant function analysis is used to determine how well the groups describe the structure in the environmental/habitat data. The habitat features at a site are then used to determine into which reference group a test site should belong and ultimately the taxa that should occur (EXPECTED) at that site in the absence of environmental stress. These EXPECTED taxa are then compared to what was found at a sites (OBSERVED) to provide an assessment of the sites (OBSERVED to EXPECTED ratio -O/E).

8 **Biological bands** are used to allocate a level of biological impairment to the O/E ratio for the purposes of management, for example Band A the biological condition ins equivalent to reference through to Band D that indicates that the biological condition of that sites is impoverished.

9 **Ongoing use of the model** only requires sampling of test sites to assess the condition of streams and rivers across the national parks of the Australian Alps.

1. INTRODUCTION

In Australia there has been increased pressure on water managers and the government to maintain ecological values (Norris and Norris 1995). As a consequence, the National River Health Program (NRHP) was formed by the Federal Government to provide a means of assessing the ecological condition of Australia's river systems. The NRHP involves the major environment agency in each State and Territory and is administered by Environment Australia and the Land and Water Resources Research and Development Corporation (LWRRDC). The development of predictive models in Australia, similar to the British **R**iver **I**nvertebrate **P**rediction **A**nd **C**lassification **S**ystem (RIVPACS) predictive models (Wright 1995), which predict the biological condition of a site in the absence of environmental stress was central to the NRHP.

The British RIVPACS models moved away from traditional monitoring that used before, after, impact, control study designs (BACI; Green 1979) or study designs that used upstream/downstream sites as controls. BACI designs can rarely be implemented because of the lack of baseline data while upstream/downstream controls suffer from "psuedoreplication" and are generally confounded in their study design (Norris 1994; Reynoldson *et al.* 1997). The RIVPACS models involve multi-site investigations that covering broad regions (Wright 1995; Norris 1994; Reynoldson *et al.* 1997). The development of predictive models for assessing the biological condition of sites across Australia was based on the methods used in the development of the British RIVPACS models. The Cooperative Research Centre for Freshwater Ecology (CRCFE) developed the predictive model software called the **Aus**tralian **Riv**er **As**sessment **S**ystem (AUSRIVAS). Currently, AUSRIVAS has been developed to a level where it can be accessed and run by authorised users via the Internet (Simpson *et al.* 1997). So far, there are >50 AUSRIVAS models available, covering all States and Territories. Regional models are also being developed in some states. In addition to model building and software development, there also has been comprehensive agency training in the use of AUSRIVAS.

The development of AUSRIVAS has required some innovative changes to the British RIVPACS predictive models. There are some fundamental differences in sampling methods, geographic coverage of models, taxa selected, model construction, model running, outputs and supply of supporting information. Some of these differences took advantage of advances in computing and statistical techniques while others were necessary because of Australia's unique environment. These differences have resulted in AUSRIVAS operating in a different way from RIVPACS.

AUSRIVAS is now being used in Australia's First National Assessment of River Health (FNARH) for which 4-6000 sites are being sampled over 3 years (LWRRDC 1997). Results from FNARH will provide valuable information for testing the effectiveness of the techniques chosen for AUSRIVAS in providing useful assessments of river condition for both managers and researchers alike.

1.1 Reference Condition

The development of a predictive model of this type requires a large number of *reference sites* to characterize the region based on their physical, chemical and biological attributes (Wright 1995; Parsons and Norris 1994; Reynoldson *et al.* 1997; Simpson and Norris 1999). Reference sites are chosen to have habitat and biological condition little affected by human activities (Norris 1994; Reynoldson *et al.* 1997). Within this approach, groups of similar reference sites are the replicates against which sites of unknown physical, chemical and biological condition (test sites) are compared (Reynoldson *et al.* 1997).

Reference sites have to be selected to cover the range of conditions experienced within that region (Norris 1994). This is essential so that the conditions at a test site will be described in the reference data allowing accurate comparisons to be made (Norris 1994). If conditions at test sites are not represented in the reference data set spurious comparisons and ultimately spurious site assessments may arise. Reference sites may be chosen by using ecoregions, altitude, stream order and vegetation type (Reynoldson *et al.* 1997). Ultimately reference sites will be grouped according to their macroinvertebrate assemblages to ensure a high level of within group homogeneity (Norris 1994). High within-group homogeneity is required to ensure that the power to detect differences between test and reference sites will be high and accurate site predictions will be made.

1.2 Selection of Reference Sites

A large number of reference sites have been chosen across the Australian Alpine area (Table 1). These sites were chosen from 1: 250 000 topographic maps. Currently, 114 reference sites have been proposed for sampling, however, the final sampling program will only sample 100 reference sites in the first stage. Extra sites have been included as backup for sites that may be inaccessible or unsuitable as reference sites when sampling takes place. In total, 56 sites were selected from the national parks of Victoria including each unit of Alpine National Park and 54 sites were selected from the national parks of NSW and four sites have been selected in Namadgi National Park in the ACT. These sites were chosen from relatively pristine areas that represent a variety of altitudes (generally above 1000m ASL), stream orders (small, medium and large if available) and land uses (eg. national park, state forest). Some sites were selected in areas that have been described by Meredith *et al.* (1989) as having good, pristine and modified catchment condition. Sites will also be located on rivers identified through the course of the review (Davies and Norris 1999) as being in need of further monitoring. Few sites were chosen in the mountainous area of Namadgi National Park in the ACT because the existing ACT AUSRIVAS models encompass sites from this area. The majority of sites were selected with some sort of access including roads, minor roads, vehicular tracks, fire trails and walking tracks. Some sites were initially proposed that were located below 950m ASL or had no access marked on the maps. Most of these sites have been reviewed and discarded. It was difficult to ascertain if a site may have been impacted, thus, some sites that may have a greater chance of being impacted have been highlighted and require review.

Table 1. Initial reference sites chosen for Australian Alps Stream Health Monitoring Project. Access may be more difficult at highlighted sites.

Site	River/Stream name	Location	Easting	Northing	Access	Land uses	Altitude	Stream Order	Other
1	Tributary of Kiewa River		0515650	5915500	Vehicular track	State Forest	1220	1	
2	Cobungra River	d/s confluence of Murphy Ck	0518550	5906450	Vehicular track	Dense vegetation	1210	2	Bogong National Park
5	Pheasant Ck.	Wet Gully Track	0501700	5908750	Vehicular track	Dense vegetation	1100	1	Bogong National Park
6	Kiewa West branch	Near blairs hut	0515300	5913800	Vehicular track	Dense vegetation	1130	3	Bogong National Park
8	Big River	near Bogong Ck saddle	0525050	5929700	Vehicular track	Dense Vegetation	1240	2	Bogong National Park
10	Pretty Valley Ck.		0520150	5920050	Vehicular track	Dense Vegetation	1130	3	Bogong National Park
11	Cope Ck		0522800	5915300	Vehicular track	Scattered Vegetation	1650	3	Alpine National Park?
15	Macalister R.		0468450	5880900	Minor Road	Medium Vegetation	1050	2	Wonnangatta Moroka Unit
19	Limestone Ck.		0592150	5917900	Minor Road	Scattered Vegetation	970	3 *	Cobberas-Tingaringy Unit
20	Buchan R.	Black Mountain Track	0597050	5915450	Minor Road	Scattered Vegetation	1150	2	Cobberas-Tingaringy Unit
21	Buckwong Ck	Buckwong Track	0589500	5933050	Vehicular track	Scattered Vegetation	1090	3	Cobberas-Tingaringy Unit
23	Pilot Ck.	Cowombat Flat	0604300	5927550	Vehicular track	Scattered Vegetation	1170	3	Cobberas-Tingaringy Unit
24	Plain Ck.	Mount Misery Trail	0600700	5943400	Vehicular track	Scattered Vegetation	1370	2	Cobberas-Tingaringy Unit
25	Ingeegoodbee R.	Ingeegoodbee Track	0613000	5933300	Vehicular track	Scattered Vegetation	1130	3	Kosciuszko National Park
26	Ingeegoodbee R.	Ingeegoodbee Track	0617650	5924700	Vehicular track	Scattered Vegetation	1030	3	Kosciuszko National Park
27	Wombargo Ck.	Black Mountain Track	0609400	5965700	Vehicular track	Scattered Vegetation	950	3	Cobberas-Tingaringy Unit
28	Unnamed Ck	Cascade Trail	0612200	5947450	Vehicular track	Scattered Vegetation	1370	2	Kosciuszko National Park
29	Cascade Ck.	Cascade Trail	0611900	5951200	Vehicular track	Scattered Vegetation	1460	3	Kosciuszko National Park
30	The Big Boggy Ck.	Dead Horse Gap	0613100	5956850	Vehicular track	Scattered Vegetation	1550	3	Kosciuszko National Park
31	Tin Mine Ck.	Tin Mine Track	0610400	5937100	Vehicular track	Scattered Vegetation	1290	3	Kosciuszko National Park
32	Meritts Ck.		0615800	5964300	Vehicular track	Scattered Vegetation	1930	3	Kosciuszko National Park
33	Twins Ck.		0614400	5979350	Vehicular track	Dense Vegetation	1060	3	Kosciuszko National Park
34	Bogong Ck.		0612800	5986800	Vehicular track	Dense Vegetation	1080	4	Kosciuszko National Park
36	Geehi Ck.	8km u/s of Geehi Dam	0620500	5986300	Vehicular track	Medium Vegetation	1290	4	Kosciuszko National Park
37	Valentine Ck.		0623200	5990000	Vehicular track		1670	3	Kosciuszko National Park
38	Back Flat Ck.		0621600	5990900	Vehicular track	Medium Vegetation	1450	3	Kosciuszko National Park
39	Back Flat Ck.		0620750	5992400	Vehicular track	Medium Vegetation	1570	3	Kosciuszko National Park
40	Tooma R.	u/s of confluence hell hole Ck	0616600	6002200	Vehicular track		1290	4	Kosciuszko National Park
41	Verandah Ck.		0615550	5976650	Vehicular track	Medium Vegetation	1080	2	Kosciuszko National Park
42	Doubtful Ck.		0628650	6003000	Vehicular track	Medium Vegetation	1533	3	Kosciuszko National Park
43	Bogong Ck.		0626600	6002950	Vehicular track	Medium Vegetation	1520	2	Kosciuszko National Park
44	Tumut R.		0625350	6009950	Vehicular track	Medium Vegetation	1310	3	Kosciuszko National Park
46	Reardons Ck.		0614500	6010400	Vehicular track	Dense Vegetation	1250	2	Kosciuszko National Park

Table 1. Continued

Site	River/Stream name	Location	Easting	Northing	Access	Land use	Altitude	Stream Order	Other
47	Munyana Ck.		0620650	5978800	Vehicular track	Scattered Vegetation	1490	2	Kosciuszko National Park
48	Middle Ck.		0616800	5981950	Vehicular track	Dense Vegetation	1160	1	Kosciuszko National Park
49	Stanley Ck.		0457850	5889400	Minor Road	Dense Vegetation	1100	2	Wonnangatta Moroka Unit
50	Zeka Ck.		0473300	5883500	Vehicular track	Dense Vegetation	970	2	Wonnangatta-Moroka Unit
51	Unnamed trib of 16 mile Ck.		0457750	5881650	Vehicular track	Dense Vegetation	1140	1	Wonnangatta-Moroka Unit
52	Unnamed Trib. of Catherine R.		0466990	5897850	Minor Road	Medium Vegetation	1120	1	Wonnangatta-Moroka Unit
53	Unnamed Trib. Of King R.		0457150	5894350	Minor Road	Medium Vegetation	970	2	Wonnangatta Moroka Unit
54	Shaw Ck.		0477400	5858800	Vehicular track	Medium Vegetation	1390	2	Wonnangatta-Moroka Unit
55	Shaw Ck.		0473800	5854200	Vehicular track	Medium Vegetation	1230	3	Wonnangatta Moroka Unit
56	Wet Plain Ck.		0473150	5856850	Vehicular track	Medium Vegetation	1280	1	Wonnangatta-Moroka Unit
57	Caledonia R.		0477550	5869450	Vehicular track	Medium Vegetation	1290	2	Wonnangatta-Moroka Unit
58	Moroka R.	Track off Moroka Rd	0498350	5852300	Vehicular track	Medium Vegetation	1000	3	Wonnangatta-Moroka Unit
59	Race Course Ck.	Valencia Rd.	0494000	5848000	Minor Road	Dense Vegetation	1080	3	Wonnangatta-Moroka Unit
65	Nigothoruk Ck.		0484200	5845750	Vehicular Track	Dense Vegetation	1380	1	Wonnangatta-Moroka Unit
66	Campbell Ck.	Mellick Munjie Ck Track	0596600	5891200	Vehicular Track	Medium Vegetation	990	3	Cobberas-Tingaringy Unit
67	Murphy Ck.		0592700	5886000	Vehicular Track	Medium Vegetation	1060	3	Cobberas-Tingaringy Unit
68	Mellick Munjie Ck.		0591700	5858650	Vehicular Track	Medium Vegetation	980	4	Cobberas-Tingaringy Unit
69	Seldom Seen Ck.		0507800	5893200	Vehicular Track	Medium Vegetation	980	2	Snowy River National Park
70	Trib. Of Gungarlin R.		0635400	5984600	Vehicular Track	Medium Vegetation	1330	3	Kosciuszko National Park
71	Gungarlin R.	Snowy Plains	0640300	5993050	Vehicular Track	Scattered Vegetation	1360	4	Kosciuszko National Park
72	Bulls Peak River		0636800	5996600	Vehicular Track	Scattered Vegetation	1400	3	Kosciuszko National Park
73	McKeahnies Ck.	Grey Mare Trail	0637050	6007050	Vehicular Track	Scattered Vegetation	1460	3	Kosciuszko National Park
74	Happy Jacks Ck.		0636500	6009050	Vehicular Track	Scattered Vegetation	1430	4	Kosciuszko National Park
75	Geehi R.		0622800	5991800	Vehicular Track	Scattered Vegetation	1530	3	Kosciuszko National Park
77	Bullocks Head Ck.		0635100	6029500	Major Road	Scattered Vegetation	1350	2	Kosciuszko National Park
78	Swamp Ck.		0642450	6018400	Vehicular Track	Dense Vegetation	1190	4	Kosciuszko National Park
79	Gang Gang Ck.		0644700	6022250	Highway 18	Dense Vegetation	1100	3	Kosciuszko National Park
80	Unnamed trib. Of Yarrangobilly R.		0636750	6059450	Fire trail	Dense Vegetation	1130	3	Kosciuszko National Park
81	Yarrangobilly R.	Jounama Fire Trail	0634400	6053000	Fire trail	Dense Vegetation	1060	4	Kosciuszko National Park
82	Eucumbene R	Four Mile Hut Fire Trail	0638900	6023800	Fire trail	Dense Vegetation	1280	3	Kosciuszko National Park
83	Brownleys Back Ck.	Jounama Fire Trail	0633250	6055950	Fire trail	Medium Vegetation	1080	3	Kosciuszko National Park
84	Big Ck.	Warogong Fire Trail	0627400	6064000	Fire trail	Medium Vegetation	1080	2	Kosciuszko National Park
85	Rings Ck.	Pethers Hut Fire Trail	0623550	6066300	Fire trail	Medium Vegetation	1050	3	Kosciuszko National Park
86	Landers Ck.	Cumberland Fire Trail	0622500	6055200	Fire trail	Medium Vegetation	1030	2	Kosciuszko National Park

Table 1. Continued.

Site	River/Stream name	Location	Easting	Northing	Access	Land use	Altitude	Stream Order	Other
87	Section Ck.	Goat Ridge Road	0627500	6026500	Minor Road	Medium Vegetation	1260	2	Kosciuszko National Park
88	Race Course Ck.	Snowy mountain Highway	0634500	6032500	Highway 18	Scattered Vegetation	1370	2	Kosciuszko National Park
89	Reedy Ck.	Victoria River Vehicle track ?	0634250	6098050	Vehicular Track	Medium Vegetation	1010	3	Bogong National Park
90	Wildhorse Ck.	Kelly Track	0535400	5919850	Vehicular Track	Medium Vegetation	1400	1	Bogong National Park
91	Tea-Tree Ck.		0536450	5909800	Vehicular Track	Medium Vegetation	1190	1	Alpine National Park
92	Unnamed Ck.		0526300	5917150	Vehicular Track	Dense Vegetation	1680	1	Bogong National Park
93	Watchbed Ck.		0528300	5919250	Vehicular Track	Scattered Vegetation	1620	2	Bogong National Park
94	Mountain Ck.		0527150	5938100	Vehicular Track	Dense Vegetation	980	2	Bogong National Park
95	Unnamed trib of Bogong Ck.		0522800	5933300	Vehicular Track	Dense Vegetation	1010	2	Bogong National Park
96	Unnamed trib of Tooma R.		0615050	6012050	Vehicular Track	Dense Vegetation	1260	3	Kosciuszko National Park
97	Snowy R.	The Long Corner	0633700	5980200	Vehicular Track	Dense Vegetation	1150	3	Kosciuszko National Park
98	Wollondibby Ck.		063300	5962900	Vehicular Track	Scattered Vegetation	1150	2	Kosciuszko National Park
99	No. One Creek	Off Alpine Way	0623800	5963600	Major Road	Dense Vegetation	1250	3	Kosciuszko National Park
100	Trib of Shibgle Ck.	Tooma Rd	0609650	6007250	Minor Road	Dense Vegetation	1130	3	Kosciuszko National Park
102	Swampy Plain R.		0610000	5961900		Scattered Vegetation	1700	2	Kosciuszko National Park
103	Sawpit Ck.	Tooma Rd	0608200	6006400	Minor Road	Dense Vegetation	1070	3	Kosciuszko National Park
104	Little R.	Black Mountain Track	0610200	5908050	Minor Road	Medium Vegetation	990	3	Cobberas-Tingaringy Unit
105	Native Dog Ck.	Cobberas Track	5999800	5916600	Vehicular Track	Medium Vegetation	1300	2	Cobberas-Tingaringy Unit
106	Moscow Ck.	McFarlane Flat Track	0608200	5923300	Vehicular Track	Scattered Vegetation	1000	3	Cobberas-Tingaringy Unit
107	Mowamba R.	Barry Trail	0624200	5955400	Vehicular Track	Scattered Vegetation	1280	3	Kosciuszko National Park
109	Spring Sugarmart Ck.	Diner Plain Track	0531200	5888800	Vehicular Track	Dense Vegetation	1110	3	Bogong National Park
111	Victoria River	Victoria River Vehicle track	0532200	5893800	Vehicular Track	Dense Vegetation	1010	4	Snowy River National Park
112	Goodwin Ck.		0608300	5903200	Vehicular Track	Medium Vegetation	1040	2	Cobberas-Tingaringy Unit
113	Bulley Ck.	Cowombat Track	0598750	5920600	Vehicular Track	Medium Vegetation	1270	3	Cobberas-Tingaringy Unit
120	Trib of Kiewa R. West branch		0515550	5924850	Vehicular Track	Dense Vegetation	1040	2	State forest / Bogong National Park
121	Trib of Tawonga Hut Ck.		0517700	5917550	Vehicular Track	Dense Vegetation	1640	1	Bogong National Park
123	Hollands Ck.	near Johnsons Hut	0531400	5921700	Vehicular Track	Dense Vegetation	1610	1	Bogong National Park
124	Spion Kopje Ck.		0524650	5925650	Vehicular Track	Dense Vegetation	1180	1	Bogong National Park
126	unnamed trib		0531100	5918150	Vehicular Track	Scattered Vegetation	1660	1	Bogong National Park
127	unnamed trib		0529700	5910000	Vehicular Track	Dense Vegetation	1480	1	Bogong National Park
129	High Plains Ck.		0520200	2913000		Dense Vegetation	1680	2	Bogong National Park
131	Black Ck	Dingo Hill Rd	0474050	5855000	Vehicular Track	Medium Vegetation	1260	1	Wonnangatta-Moroka Unit
134	Conglomerate Ck.		0476250	5874350	Walking Track	Medium Vegetation	1400	2	Wonnangatta-Moroka Unit
135	Moroka Ck.		0488900	5849100	Vehicular Track		1170	2	Wonnangatta-Moroka Unit

Table 1. Continued.

Site	River/Stream name	Location	Easting	Northing	Access	Land use	Altitude	Stream Order	Other
136	McFarlane Ck.		0484150	5851700	Vehicular Track	Medium Vegetation	1280	1	Wonnangatta-Moroka Unit
140	Wilkinson Ck.		0612300	5966050	Walking Track	Scattered Vegetation	1900		Kosciuszko National Park
141	Unnamed		0614900	5960900	Walking Track	Scattered Vegetation	1970	2	Kosciuszko National Park
142	Watchbed Ck.		0529600	5919900	Vehicular Track	Scattered Vegetation	1720	1	Bogong National Park
143	Unnamed Ck.		0624350	5983350	Vehicular Track	Scattered Vegetation	1800	1	Kosciuszko National Park
160	Snowy R.		0639400	5979400	Vehicular track	Medium Vegetation	960	5	Kosciuszko National Park
161	Snowy R.		0635700	5982700	Vehicular track	Medium Vegetation	1080	4	Kosciuszko National Park
162	Snowy R.		0621900	5971950	Vehicular track	Scattered Vegetation	1600	4	Kosciuszko National Park
163	Jack's Ck.	Yaouk Trail	0665800	6049700	Vehicular Track	Dense Vegetation	1070	3	Namadgi National Park
164	Pond Ck.	Yaouk Trail	0667900	6054900	Vehicular Track	Dense Vegetation	1100	2	Namadgi National Park
165	Tributary of the Naas Ck.	Sams' River Fire Trail	0672750	6036700	Vehicular Track	Dense Vegetation	1200	3	Namadgi National Park
166	Cotter River	Sams' River Fire Trai	0665700	6053000	Vehicular Track	Dense Vegetation	1030	4	Namadgi National Park

Table 2. Test sites that may be used to test the predictive model.

Site	River/Stream name	Location	Easting	Northing	Access	Land use	Altitude	Stream Order	Other
100*	Snowy R.		0618400	5967400	Walking Track	Scattered Vegetation	1720	3	Kosciuszko National Park
122*	Trib of Rocky Valley Storage		0523800	5917800	Vehicular Track	Dense Vegetation	1610	2	Not quite in National Park
125*	Big R.	d/s of aqueduct	0526900	5923950	Vehicular Track	Dense Vegetation	1750	2	Bogong National Park
60*	Deep Ck.	Besford Track	0570350	5926900	Vehicular track	Dense Vegetation	1000	3	Dartmouth Unit
61*	Cattleman Ck.		0558250	5947550	Vehicular track	Dense Vegetation	1170	1	Dartmouth Unit
62*	Buffalo Ck.		0479800	5930600	Sealed Road	Scattered Vegetation	1490	1	Buffalo National Park
63*	Eurobin Ck.		0482450	5934200	Sealed Road	Scattered Vegetation	1310	2	Buffalo National Park
64*	Crystal Brook	The Gap	0482600	5935800	Sealed Road	Scattered Vegetation	1310	2	Buffalo National Park
160	Snowy R.		0639400	5979400	Vehicular track	Medium Vegetation	960	5	Kosciuszko National Park
T1	Spencers Ck.		0621800	5967400	Road	Scattered Vegetation	1730	3	Kosciuszko National Park

Sites will be sampled in summer, which differs slightly from current AUSRIVAS sampling regimes. The discharges associated with spring snowmelt and recovery of streams following such disturbance preclude the employment of the normal spring sampling regime. Otherwise, standardized National River Health Program methods will be employed for field, laboratory and data analysis procedures (Davies 1994; Williams and Norris 1997).

1.3 Test Site Selection

Initially 10 sites with known impacts (test sites) will be selected and sampled to determine if the AUSRIVAS model for the Australian Alps can detect degradation. Some of these sites will be sites for which monitoring has been undertaken for a number of years in NSW ski resort areas. Some new test sites identified in the reference site selection process were identified and have been listed in Table 2. The final list of test sites will probably include some previously sampled and some new test sites. A large number of test sites may be sampled in future to test and assess land use activities within the Alps.

1.4 Physical and chemical water quality variables

Water temperature, electrical conductivity, pH, dissolved oxygen and turbidity will be measured at each site using a multi-probe meter (Hydrolab model Scout 2). Total alkalinity will be measured in the field by titration to pH 4.5 (APHA 1992). A 250ml-water sample will be collected at each site in low-density polyethylene bottles and stored on ice until return to the laboratory to be frozen for later nutrient analysis. Water samples will be analyzed for total nitrogen (TN), total phosphorus (TP) and nitrate/nitrite (NOx) using flow injection analysis (APHA 1992). A Hydrological Services pygmy flow meter will be used to measure water velocity in the riffle and the edge (3 measurements in each habitat).

1.5 Selection of habitat variables

A large number of habitat variables including physical, chemical and map measurements will be measured to characterize each site (Simpson *et al.* http://ausrivas.canberra.edu.au/ausrivas/; Simpson and Norris 1999). These variables include measurements of altitude, stream order, distance from source and a variety of site specific habitat variables (Table 3). Habitat variables are recorded using standardized National River Health Program (NRHP) methods (Davies 1994; Parsons and Norris 1994; Table 3). The habitat survey used (Appendix I) was originally based on United States Environmental Protection Agency (US EPA) protocol (Plafkin *et al.* 1989).

1.6 Invertebrate Sampling and Laboratory Procedures

At each site, invertebrates will be collected from the riffle habitat. D-framed kick-nets with a 350 mm base and 250 μm mesh are used to sample a 10 m transect of each habitat. Riffle samples will be taken by disturbing the substratum upstream of the net using a kicking action for 10m. The nets will be washed thoroughly between collections. Samples will be placed in labelled containers and preserved in 10% formalin buffered with calcium carbonate (Ca CO_3) and Rose Bengal stain ($100gL^{-1}$) will be added to assist with sorting (Mason and Yevich 1976).

Table 3. Physical, chemical and habitat variables measured at the test and reference sites used in the construction of the AUSRIVAS predictive models.

Variable	Description	Variable	Description
Reach Characteristics		**Riffle Characteristics**	
STORDER	Stream order	RBEDROCK	% Bedrock
ALTITUDE	Altitude (m)	RBOULDER	% Boulder
DFS	Distance from source (km)	RCOBBLE	% Cobble
LATITUDE	Latitude (Degrees|Minutes eg. 3519)	RPEBBLE	% Pebble
LONGITUDE	Longitude (Degrees|Minutes eg. 14857)	RGRAVEL	% Gravel
CATCHAREA	Catchment Area upstream (km^2)	RSAND	% Sand
ALKALINITY	Alkalinity (mg l^{-1})	RMACRO	% Macrophytes
RIPWIDTH	Riparian width (m)		
TREES>10	% Trees >10 m		
TREES<10	% Trees < 10 m	**Edge Characteristics**	
SHRUBVINE	% Shrubs and vines	EBANKVEG	Edge bank vegetation (Category 1-4)
GFS	% Grasses ferns sedges	EBEBROCK	% Bedrock
SHADING	Shading of reach (Category 1-5)	EBOULDER	% Boulder
STREAMWIDTH	Stream width (m)	ECOBBLE	% Cobble
BANKWIDTH	Bank width (m)	EPEBBLE	% Pebble
BANKHEIGHT	Bank height (m)	EGRAVEL	% Gravel
RIFFAREA	% Riffle habitat	ESAND	% Sand
RDEPTH	Riffle depth (cm)	EMACRO	% Macrophytes (Category 0 -4)
RVELOCITY	Riffle flow (m s^{-1})		
EDGEAREA	% Edge habitat	Habitat Assessment Variables	
EDEPTH	Edge depth (cm)	SUBSTRATE	Substrate (Category 0 –20)
EVELOCITY	Edge flow (m s^{-1})	EMBEDNESS	Embeddedness (Category 0 -20)
		VELDEP	Velocity/depth category (Category 0 - 15)
Reach Specific Characteristics		SCOURING	Scouring (Category 0 -15)
REBEDROCK	% Bedrock	PRRBRATO	Pool/riffle run/bend ratio (Cat. 0 –15)
REBOULDER	% Boulder	BANKSTAB	Bank stability (Category 0 -10)
RECOBBLE	% Cobble	VEGSTAB	Vegetation stability (Category 0 –10)
REPEBBLE	% Pebble	VEGCOVER	Vegetation cover (Category 0 –10)
REGRAVEL	% Gravel	HABSCORE	Habitat score (Total of habitat assessment Variables)
RESAND	% Sand		
REMACRO	% Macrophytes		

Samples will be thoroughly rinsed using a 250µm mesh sieve to remove fine sediment and preservative. The samples will be placed in a sub-sampling box and agitated until the sample was evenly distributed throughout all cells. The sub-sampling box is divided into 100 cells (3cmx3cmx2.5cm deep) and was based on a design by Marchant (1989). Cells are selected randomly and a vacuum pump was used to remove their contents. Cells are extracted, sorted and identified until 200 animals are collected. Once a cell is removed, all macroinvertebrates are counted from that cell even after 200 animals are obtained. A stereo microscope (x10 magnification) is used to sort samples. Macroinvertebrates are identified to the family level with the exception of Oligochaeta (class), Turbellaria (class), Hydracarina (order) and Chironomidae (sub-family) using keys recommended by Hawking (1994).

Invertebrate data are also converted to presence/absence form before analysis because the AUSRIVAS model only predicts the occurrence of taxa and not their expected abundance. A nationally adopted coding system was used to assign a specific code to each taxon (Trueman *et al*. 1996). These codes facilitated sorting and other data management that are required for building and running the AUSRIVAS models.

1.7 Macroinvertebrate Quality Control/Quality Assurance Procedures

Quality control/quality assurance procedures are designed to establish an acceptable taxonomic standard of macroinvertebrate sorting and identifications. The quality control component is to determine the variation in the level of identifications, and quality assurance provides potential users with the assurance that the accuracy of results is within controlled and acceptable limits. The following internal quality control procedures were implemented for the identification of macroinvertebrate samples.

- All samples will be separated into Orders and placed in separate vials to eliminate any high level discrepancies. This is also required for future curatorial preservation and storage.

- When an identification problem is encountered a decision tree for will be followed. The decision tree is provided in the ACT program for the Monitoring River Health Initiative Sampling Manual (Williams and Norris 1997). Very small, damaged, immature animals or pupae that are unable to be identified with confidence will be noted as such and will not included in the identification for that sample. These animals will be counted and placed in separate vials. The counts for unidentified animals will not included in the 200 organism sub-sample.

- Damaged animals will be identified if possible, with both head and tails counted and the highest number recorded and placed in the appropriate vials. If a specimen can not be identified it will be noted as such (e.g. Ephemeropteran damaged) and placed in the appropriate vial.

- Quality control staff will check the first five samples identified by each person.

- A miss-identification error of < 10 % of the total number of animals is deemed acceptable at Family level. This is the error rate used by the Murray Darling Freshwater Research Centre who conducted quality control checks of all state agencies during previous NRHP contracts. If the error is ≥ 10 %, miss-identifications are corrected under the guidance of quality control staff. All miss-identifications will be shown to the person and suitable instruction given to rectify the miss-identification. Other samples containing taxa that were found to be miss-identified will be randomly checked by the original identifier for miss-identification errors.

- Following the initial five samples checked a random selection of two samples in the following ten, two samples in the following 30 and two samples in the following 50 will be checked.

- Persons checking samples will be those with adequate experience in identification. Where possible, different samples will be checked by more than one person to avoid bias and increased workloads.

1.8 Data Entry and Storage

Data from field data sheets will be entered into a Microsoft Access database that matches the layout of the field data sheets to minimize transcription errors. Invertebrate data will also entered into a Microsoft Excel database with national codes for all taxa. All data will be checked for transcription errors using standard two person checking procedures. A backup of files will be carried out daily.

1.9 Analyses

Many Australian taxa have sparse distributions, occurring at few sites (Faith and Norris 1989; Marchant *et al.* 1997). Such taxa will be removed from further analyses to reduce unexplained variability caused by their patchy occurrence (Gauch 1982; Norris and Georges 1993). In the development of AUSRIVAS, rare taxa were defined as those that occurred at less than 10% of sites for datasets up to 100 sites or that occurred at less than 10 sites for datasets of more than 100 sites. All taxa collected will be used when constructing RIVPACS models (Wright *et al.* 1984).

<u>1.9.1 Classification Analysis.</u>

The first step in building an AUSRIVAS model is to classify the reference sites based on invertebrate composition using the agglomerative clustering technique, flexible Unweighted Pair-Group arithMetic Averaging (UPGMA), as recommended by Belbin and McDonald (1993). The Bray-Curtis association measure will be used on the recommendation of Faith *et al.* (1987) as a robust measure of association for cluster analysis. Classifications will then be visually inspected as dendrograms to identify groupings of sites.

Wright *et al.* (1993) recommended that classification groups should contain not less than five sites. Groups containing less than five sites can result from poor representation of a particular habitat type, problems with the initial sampling, or degradation of sites in some manner resulting in loss of taxa indicative of reference conditions. Small classification groups will either be deleted from further analysis, or those sites are amalgamated with another group of appropriate reference sites after review (Simpson *et al.*, 1997).

1.9.2 Discriminant function Analysis.

Like RIVPACS, AUSRIVAS models use habitat features that are little affected by human activities to predict which taxa should occur at a site in the absence of environmental stress (Wright *et al*. 1984; Moss *et al*. 1987). Stepwise Multiple Discriminant Function Analysis (MDFA) will be used to select the predictor variables best able to discriminate among the invertebrate classification groups.

Subsets of habitat variables from the Stepwise MDFA will be tested in a MDFA to predict the probabilities of group membership for each reference site. Biased discriminations will be avoided by using the cross-validation option that predicts group membership of each site separately (SAS Institute 1995). A subset of habitat variables that produced the lowest error in predicting the membership of reference sites to the invertebrate classification groups will be obtained from this procedure. The invertebrate and habitat data from the reference sites will then be used to construct the AUSRIVAS models following methods described by Wright *et al.* (1984) and Moss *et al.* (1987).

Unlike the RIVPACS models, which use all the taxa predicted to occur (Moss *et al.* 1987), the AUSRIVAS models only consider families that were calculated to have a probability of 50 % or greater of occurring at a test site (Simpson *et al*., 1997). The sum of the probabilities of occurrence for taxa predicted with a ≥50% chance of occurrence gives the number of taxa 'expected' (E) to be found at a test site. The observed (O) number of taxa will be obtained by summing the number of taxa with ≥ 50% chance of occurrence found at a site.

In addition to calculating the expected number of taxa at a test site, AUSRIVAS will also calculates the expected SIGNAL (Stream Invertebrate Grade Number Average Level) score for a site. The SIGNAL index (Appendix II; Chessman 1995) is similar to the British ASPT (Average Score Per Taxon) (Wright *et al.* 1993), summing the scores for each taxon occurring at a site and then dividing by the number of scoring families. As with ASPT (Wright *et al.* 1993), SIGNAL allocates pollution-sensitive taxa high grades and pollution-tolerant taxa low grades on a scale from 1 to 10 (Chessman 1995). Expected SIGNAL scores will be calculated by multiplying a taxon's SIGNAL grade by the probability of occurrence for that taxon, if it is ≥ 0.5, summing all grades and dividing by the number of predicted taxa. Observed SIGNAL scores are the sum of the SIGNAL grades for the predicted taxa (≥50% chance of occurrence) that were found at the site, divided by the number of scoring families. AUSRIVAS will then compare both the expected (E) number of taxa and the expected SIGNAL score against what taxa were actually observed (O) at a test site. This will provide two O/E ratios (O/E Taxa and O/E SIGNAL) that provide a measure of biological impairment at a test site.

1.10 Internal/external testing

Initially a number of reference sites (usually 10% of the total) will be set aside when the AUSRIVAS model is built and then run through the completed models to ensure the model will correctly assess them as reference sites. The models will then be rebuilt including these sites. A number of sites with known impacts will also be sampled in conjunction with the reference sites. These will also be run through the models to test for predictive accuracy.

As an internal check of predictive ability and also as a validation of reference site condition the reference sites used to build an AUSRIVAS model will be run through that model. Sites that produced O/E ratios below 0.75, i.e. 25% of their expected taxa were missing, will be reviewed and discarded if it is deemed they were unsuitable to use as reference sites. Under-sampling, unusual habitat conditions, extreme flow events before sampling and unexpected pollution impacts are some factors that will be investigated when reviewing failed reference sites. Some reference sites may appear to fail if the habitat type found at those sites is under-represented, a problem that can only be rectified when additional reference sites from future sampling occasions are added to the models.

1.11 Outputs

To simplify interpretation and to aid management decisions, AUSRIVAS will present both O/E Taxa and O/E SIGNAL as bands representing different levels of biological condition (Table 1). The width of the AUSRIVAS bands will be based on the distribution of the O/E values for the reference sites in a particular model. Sites that fall within the central 80% of reference O/E values about the mean (i.e., 10^{th} to 90^{th} percentiles) will be considered equivalent to reference (band A). The next two bands (B and C) will have the same width as band A but the width of band D will vary depending on the variability of the reference O/E values (Table 4). A site with O/E values below the lower boundary of band A (i.e., the index value is smaller than the 10th percentile of the reference sites) will be judged to have fewer families or a lower SIGNAL score than expected and will be allocated to one of the lower bands according to its value. A test site O/E value that exceeds the upper bounds of band A (i.e., the O/E value is greater than the 90th percentile of the reference sites) will be judged to be richer than the reference condition and is allocated to band X (Table 4).

1.12 Site Assessments

The outputs from the AUSRIVAS models and the bands will be used to determine the biological condition at a site. The physical, chemical and habitat data collected at the time of sampling will also be used in interpretation of the assessment of a site. These data will be used to determine if physical/chemical water quality or habitat features such as catchment erosion and surrounding land use are influencing the biological condition at a site. The AUSRIVAS assessments and the habitat data will enable the identification of sites with impaired biological condition and thus the identification of management goals.

Table 4 Division of the indices into bands or categories for reporting. The names of the bands refer to the relationship of the index value to the reference condition (Band A). Under comments, for each index, an explanation of the Band is stated first, followed by possible interpretations.

		Interpretations	
Band	Label	O/E Families	O/E SIGNAL
X	**Richer than reference** O/E greater than 90th percentile of reference sites	More families found than expected. Potential biodiversity "hot-spot" Mild organic enrichment Continuous irrigation flow in a normally intermittent stream	Greater SIGNAL value than expected. Potential biodiversity "hot-spot" Differential loss of pollution-tolerant taxa (potential impact unrelated to water quality)
A	**Reference** O/E within range of central 80% of reference sites	Expected number of families within the range found at 80% of the reference sites	Index value within range of central 80% of reference sites
B	**Below reference** O/E below 10th percentile of reference sites. Same width as Band A	Fewer families than expected Potential impact either on water and/or habitat resulting in a loss of families	Lower SIGNAL value than expected Differential loss of pollution-sensitive families Potential impact on water quality
C	**Well below reference** O/E below Band B. Same width as Band A	Many fewer families than expected Loss of families from substantial impairment of expected biota caused by water and/or habitat quality	Much lower SIGNAL value than expected Most expected families that are sensitive to pollution have been lost Substantial impact on water quality
D	**Impoverished** O/E below Band C to 0	Few of the expected families remain Severe impairment	Very low SIGNAL value Only hardy, pollution-tolerant families remain

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APENDIX 1

FIELD SAMPLING SHEET (Version 1.6 April 1997))

DATE .... **TIME** .... **LOCATION CODE** ....

RIVER .... **LOCATION** ....

RECORDERS NAME .... **PHOTOGRAPH NUMBER (S)** ....

WEATHER .... **AIR TEMPERATURE** ....°C

CLOUD COVER ....% **RAIN IN LAST WEEK ?** Y [ ] N [ ]

RIPARIAN VEGETATION

Width of riparian zone[1]: estimated / measured left bank[2] ....m
estimated / measured right bank[2] ....m

Vegetation type:	% Cover of riparian zone[3]	Description
trees (>10m)	....	....
trees (<10m)	....	....
shrubs	....	....
grasses / ferns / sedges	....	....

Vegetation cover of river[4]: <5% [ ] 6-25% [ ] 26-50% [ ] 51-75% [ ] >76% [

Native vegetation[5] ....%

Exotic vegetation[5] ....%

[1] Area where waterway interacts with vegetation. [2] Facing downstream. [3] From 'Plan' view, estimation of outline cover; may total >100%.

[4] Estimate as at midday. [5] Total 100%.

MEASUREMENTS:

Stream Widths[6] (m) 1............ 2............ 3............ bank width[7] ....m bank height[8]............m
Mean Stream Width (m) ....

		Instrument		
Water Temperature[9] (°C)	....	....	**Barometric Pressure (millibars)**	....
Conductivity[9] ($\mu S\ cm^{-1}$)	....	....	**Alk. H_2SO_4 (ml)/H_2O (ml)**	........./........
pH[9]	....	....	**Alkalinity ($mg\ l^{-1}$)**	....
Dissolved Oxygen[9] ($mg\ l^{-1}$)	....	....		
% Sat. Dissolved Oxygen	....	....	**Total Phosphorus ($mg\ l^{-1}$)**	....
Turbidity[9] (FNU)	....	....	**Total Nitrogen ($mg\ l^{-1}$)**	....

	% in Reach[10]	Depth[11] (cm) 1 2 3	mean	Flow[11,12] (revs/30sec) / (metres/seconds) U / L	U / L	U / L	mean
Riffle	....	....	....	......./.......	......./......	......./.......	....
Edge[13]	....	....	....	......./.......	......./......	......./.......	....
Pool	....						
M'phyt	....						
Run	....						

Flow meter fan no. .... **Water sample(s) taken? yes [ ] number**................ **no [ ]**

[6] From edges of water. [7] From tops of banks. [8] From water surface vertical to top of bank. [9] Measured/sampled from riffle area. [10] Within 'Reach' ie. 5 times mean water width either side of riffle sampling site. [11] U = Upper, at 4/5 depth; L = Lower, at 1/5 depth; if <30cm, measure at 1/2 depth only. [12] Measurements at 1/4, 1/2, 3/4 width along mean width transect. [13] Length of both banks as % of reach length which can be effectively sampled with sweep net.

RIVER.. DATE............................. LOCATION CODE...

OBSERVATIONS (Indicate appropriate number in box)

WATER ODOURS: **1. normal** **2. sewage** **3. petroleum** **4. chemical** **5. none** [ ]
WATER OILS: **1. slick** **2. sheen** **3. globs** **4. flecks** **5. none** [ ]
TURBIDITY: **1. clear** **2. slight** **3. turbid** **4. opaque** [ ]

PLUME: **1. little** **2. some** **3. lots** [ ]
(amount of fine sediment generated when kick-sampling)
SEDIMENT OILS: **1. absent** **2. light** **3. moderate** **4. profuse** [ ]

SEDIMENT ODOURS: **1. normal** **2. sewage** **3. petroleum** **4. chemical** **5. anaerobic** **6. none** **7. other**..................................... [ ]

FLOW LEVEL: (relative to "water mark" ie. normal inundation level shown by limit of terrestrial grasses, or by eroded area, or boundary in bank sediment types).
1. No flow (dry / isolated) **2. Low** (<water mark) **3. Moderate** (–) **4. High** **5. Flood** (>water mark) [ ]

Bare ground above watermark: area in riparian zone expected to be vegetated but bare. **Left bank................%** **Right bank...............%**
Are the undersides of stones, which are not deeply embedded, black? **1. yes** **2. No** [ ]
SEDIMENT DEPOSITS: 1. none 2. sludge 3. sawdust 4 paper fibre 5. sand 6. relict shells 7. other...................................... [ ]
LOCAL CATCHMENT EROSION: 1. none 2. some 3. moderate 4. heavy [ ]
LOCAL NPS POLLUTION: 1. no evidence 2. potential.................... 3. obvious.......... [ ]
DAMS / BARRIERS: 1. present upstream / downstream 2. absent [ ]
RIVER BRAIDING: 1. yes no. of braids .... 2. no [ ]

SITE CLASSIFICATION (of the reach): 1. steep valley 2. broad valley 3. wetland/bog 4 heath
(indicate >1 if required) 5. levees present 6. stream bars 7. natural riparian meadow [ ]

LANDUSE: 1. Native forest 2. Forestry 3. Native pasture 4. Grazing 5. Cropped
Left Bank[2] 6. Residential 7. Commercial 8. Industrial 9. Recreational [ ]

LANDUSE: 1. Native forest 2. Forestry 3. Native pasture 4. Grazing 5. Cropped
Right Bank[2] 6. Residential 7. Commercial 8. Industrial 9. Recreational [ ]

BARS: (bed surface protruding from normal water level & forming a bar) ....%

HABITAT SAMPLING SHEET

RIVER.. DATE.............................. LOCATION CODE.............................

REACH[10]

Length of Reach[10]........................metres.

SUBSTRATUM DESCRIPTION (% cover): **ORGANIC SUBSTRATUM** (% cover of inorganic substrate)

			PHI
Bedrock		[................]	-9.5
Boulder	(>256mm)	[................]	-9.0
Cobble	(64-256mm)	[................]	-6.5
Pebble	(16-64mm)	[................]	4.5
Gravel	(2-16mm)	[................]	-2.0
Sand	(0.06-2mm)	[................]	2.0
Silt	(0.004-0.06mm)	[................]	6.5
Clay	(<0.004mm)	[................]	9.5

Detritus (sticks, wood, CPOM[14]) [.................]

Muck/Mud (black, very fine organics) [.................]

Periphyton 0 1 2 3 4 **(percent of reach covered by)**
Moss 0 1 2 3 4 **(percent of reach covered by)**
Filamentous algae 0 1 2 3 4 **(percent of reach covered by)**
Macrophytes 0 1 2 3 4 **(percent of reach covered by)**

0= <10% 1=10-35% 2=35-65% 3=65-90% 4=>90%

[10] 'Reach' :ie. 5 times mean water width either side of riffle sampling site.

[14] Course Particulate Organic Material.

RIFFLE
Macroinvertebrates collected by ....
Macroinvertebrates picked/ sorted by ....

Method: Kicknet [ ] Other...
Length of riffle sampled 10 metres [ ] Other....................metres.
Sample preserved [ ]

SUBSTRATUM DESCRIPTION (% cover): **ORGANIC SUBSTRATUM** (% cover of inorganic substrate)

			PHI
Bedrock		[................]	-9.5
Boulder	(>256mm)	[................]	-9.0
Cobble	(64-256mm)	[................]	-6.5
Pebble	(16-64mm)	[................]	-4.5
Gravel	(2-16mm)	[................]	-2.0
Sand	(0.06-2mm)	[................]	2.0
Silt	(0.004-0.06mm)	[................]	6.5
Clay	(<0.004mm)	[................]	9.5

Detritus (sticks, wood, CPOM[14]) [.................]

Muck/Mud (black, very fine organics) [.................]

Periphyton 0 1 2 3 4 **(percent of riffle covered by)**
Moss 0 1 2 3 4 **(percent of riffle covered by)**
Filamentous algae 0 1 2 3 4 **(percent of riffle covered by)**
Macrophytes 0 1 2 3 4 **(percent of riffle covered by)**

0= <10% 1=10-35% 2=35-65% 3=65-90% 4=>90%

RIVER.. **DATE**............................ **LOCATION CODE**............................

EDGE / BACKWATER:
Macroinvertebrates collected by ....
Macroinvertebrates picked/ sorted by ....
Method: Sweep [ ] Other ....
Length of edge sampled 10 metres [ ] Other..................metres.
Sample preserved [ ]

SUBSTRATUM DESCRIPTION (% cover): **ORGANIC SUBSTRATUM** (% cover of inorganic substrate)

		PHI	
Bedrock	[................]	-9.5	**Detritus (sticks, wood, CPOM[14])** [..................]
Boulder (>256mm)	[................]	-9.0	**Muck/Mud (black, very fine organics)** [..................]
Cobble (64-256mm)	[................]	-6.5	
Pebble (16-64mm)	[................]	-4.5	
Gravel (2-16mm)	[................]	-2.0	Trailing bank Vegetation:
Sand (0.06-2mm)	[................]	2.0	nil [ ] slight [ ] moderate [ ] extensive [ ]
Silt (0.004-0.06mm)	[................]	6.5	Edge description
Clay (<0.004mm)	[................]	9.5	....

Periphyton 0 1 2 3 4 (percent of edge covered by)
Moss 0 1 2 3 4 (percent of edge covered by)
Filamentous algae 0 1 2 3 4 (percent of edge covered by)
Macrophytes 0 1 2 3 4 (percent of edge covered by)

0= <10% 1=10-35% 2=35-65% 3=65-90% 4=>90%

MACROPHYTES

Indicate whether the following common taxa are present in the reach:

SUBMERGED/ FLOATING	EMERGENT
Ceratophyllum (Hornwort)	*Callitriche* (Starwort)..............................
Chara (Stonewort)..	*Carex* (Tussock Sedge) ....
Elodea (Canadian Pondweed)	*Crassula* (Crassula) ....
Myriophyllum (Water Milfoil)	*Cyperus* (Sedge)...................................
Nitella (Stonewort)	*Eleocharis* (Spikerush)............................
Potamogeton (Pondweed)	*Juncus* (Rush)......................................
Triglochin (Water Ribbon)	*Paspalum* (Water Couch) ....
Vallisneria (Ribbonweed)	*Polygonum* (Smartweed) ....
Other	*Phragmites* (Common Reed).....................
....	*Ranunculus* (Buttercup) ....
....	*Scirpus* (Clubrush)................................
....	*Typha* (Cumbungi)..................................
....	Other ....
....	....

Vegetation samples collected: Yes [ ] No [ ]

Epiphyte cover on macrophytes Nil [ ] Slight [ ] Moderate [ ] Extensive [ ]

Notes:
....
....
....
....

HABITAT ASSESSMENT FIELD DATA SHEET

Date:.. **River:**.. **Location Code:**...

Name of recorder...

	CATEGORY			
Habitat Variable	**Excellent**	**Good**	**Fair**	**Poor**
1. Bottom substrate/available cover	Greater than 50% rubble, gravel submerged logs, undercut banks or other stable habitat 20, 19, 18, 17, 16	30-50% rubble, gravel or other stable habitat. Adequate habitat 15, 14, 13, 12, 11	10-30% rubble, gravel or other stable habitat. Habitat avail-ability less than desirable 10, 9, 8, 7, 6	Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious 5, 4, 3, 2, 1, 0
2. Embeddedness	Gravel, cobble and boulder particles are between 0 & 25% surrounded by fine sediment 20, 19, 18, 17, 16	Gravel, cobble and boulder particles are between 25 & 50% surrounded by fine sediment 15, 14, 13, 12, 11	Gravel, cobble and boulder particles are between 50 & 75% surrounded by fine sediment 10, 9, 8, 7, 6	Gravel, cobble and boulder particles are over 75% surrounded by fine sediment 5, 4, 3, 2, 1, 0
3. Velocity/depth category	Slow deep (<0.3 m/s & >0.5m); Slow shallow; Fast deep; Fast shallow; habitats all present 20, 19, 18, 17, 16	Only 3 of the four habitat categories present (missing riffles or runs receive lower score than missing pools) 15, 14, 13, 12, 11	Only 2 of the four habitat categories present (missing riffles/ runs receive lower score) 10, 9, 8, 7, 6	Dominating by one velocity/depth category (usually pool) 5, 4, 3, 2, 1, 0
4. Channel alteration	Little or no enlargement of islands or point bars and/or no channelisation 15, 14, 13, 12	Some new increase in bar formation, mostly from coarse gravel; and/or some channelisation present 11, 10, 9, 8	Moderate deposition of new gravel, coarse sand, on old and new bars; pools partly filled w/silt; and/or embankments on both banks 7, 6, 5, 4	Heavy deposits of fine materials, increased bar development; most pools filled with silt; and/or extensive channelisation 3, 2, 1, 0
5. Bottom scouring and deposition	Less than 5% of the bottom affected by scouring and deposition 15, 14, 13, 12	5-30% affected. Scours at constrictions and where grades steepen, some deposition in pools 11, 10, 9, 8	30-50% affected. Deposits and scours at obstruction and bends. Some deposition in pools. 7, 6, 5, 4	More than 50% of the bottom changing nearly yearlong. Pools almost absent due to deposition. Only large rocks in riffle exposed 3, 2, 1, 0

HABITAT ASSESSMENT FIELD DATA SHEET (Continued)

Date:.. **River:**.. **Location Code:**..

	CATEGORY			
Habitat Variable	**Excellent**	**Good**	**Fair**	**Poor**
6. Pool/riffle, run/bend ratio. *(Distance between riffles divided by stream width)*	0-7 Variety of habitat. Deep riffles and pools 15, 14, 13, 12	7-15 Adequate depth in pools and riffles. Bends provide habitat 11, 10, 9, 8	15-25 Occasional riffle or bend. Bottom contours provide some habitat. 7, 6, 5, 4	>25 Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 3, 2, 1, 0
7. Bank stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%. Little potential for future problem. 10, 9	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods 8, 7, 6	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme/high flows 5, 4, 3	Unstable. Many eroded areas. Side slopes > 60% common. "Raw" areas frequent along straight sections and bends. 2, 1, 0
8. Bank vegetative stability	Over 80% of the stream bank surfaces covered by vegetation or boulders and cobble 10, 9	50-79% of the stream bank surfaces covered by vegetation, gravel or larger material 8, 7, 6	25-49% of the stream bank surfaces covered by vegetation, gravel or larger material 5, 4, 3	Less than 25% of the stream bank surfaces covered by vegetation, gravel or larger material 2, 1, 0
9. Streamside cover	Dominant vegetation is of tree form 10, 9	Dominant vegetation shrub 8, 7, 6	Dominant vegetation is grass, sedge, ferns 5, 4, 3	Over 50% of the stream bank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings 2, 1, 0

Column Totals				
Score				

From US EPA RBA Protocols 1989

APPENDIX II

Pollution sensitivity (SIGNAL) grades for macroinvertebrate taxa predicted to occur at test and reference sites (Chessman pers. comm.).

Taxa	Grade	Taxa	Grade
Acarina	5	Helicophidae	9
Aeshnidae	7	Helicopsychidae	10
Amphipoda	7	Hydrobiidae	3
Ancylidae	5	Hydrobiosidae	9
Aphroteniinae	8	Hydrophilidae	4
Athericidae	7	Hydropsychidae	6
Atriplectididae	8	Hydroptilidae	5
Atyidae	4	Leptoceridae	8
Austroperlidae	10	Leptophlebiidae	10
Baetidae	7	Lymnaeidae	3
Caenidae	4	Notonectidae	3
Calamoceratidae	8	Notonemouridae	9
Calocidae	9	Odontoceridae	8
Ceratopogonidae	5	OLIGOCHAETA	3
Chironominae	2	Orthocladiinae	3
Coenagrionidae	2	Philopotamidae	9
Coloburiscidae	10	Physidae	3
Conoesucidae	9	Planorbidae	3
Corbiculidae	3	Podonominae	9
Corduliidae	6	Polycentropodidae	8
Corixidae	3	Psephenidae	6
Corydalidae	7	Pyralidae	6
Dixidae	8	Scirtidae	9
Dytiscidae	2	Simuliidae	5
Ecnomidae	5	Sphaeriidae	4
Elmidae	8	Stratiomyidae	2
Empididae	6	Synlestidae	7
Glossosomatidae	8	Tanypodinae	5
Gomphidae	6	Tipulidae	6
Gripopterygidae	9	TURBELLARIA	3