BASSLINK INTEGRATED IMPACT ASSESSMENT STATEMENT

POTENTIAL EFFECTS OF CHANGES TO HYDRO POWER GENERATION

APPENDIX 10:

GORDON RIVER CAVE FLORA AND FAUNA ASSESSMENT

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EXECUTIVE SUMMARY

This report discusses the results of survey work on the cave fauna and entrance zone flora of the Nicholls Range karst (Bill Neilson Cave NR-001 and Kayak Kavern NR-002) on the Gordon River. The work was constrained by a number of factors, and so the results are at best a preliminary interpretation of the status of these communities.

Prevailing water management conditions on the Gordon River have been in place for so long that any impacts on the flora and fauna of the cave(s) are no longer likely to be detectable. Instead, the distribution and abundance of any sensitive species will have adjusted to the current conditions, and are most at mercy of future changes to this regime (such as proposed under Basslink).

Cave flora surveys produced only one species of significance in Bill Neilson cave: the bryophyte *Thuidium laeviusculum*, which has only been found on one other occasion since 1912 and has not previously been found on the west coast. Lichens and bryophytes represent a very rich and specialised field separate to other flora, and may benefit from specialist collections and surveys in future. Although there may be some scope for further work on such specialised flora groups, most of the flora species present are common and impacts are most likely to be erosional/depositional.

There appears to be relatively little development of a true cave adapted (troglobitic) fauna in Bill Neilson Cave in comparison to other caves, most likely due to the structure of the cave and the abundance of entrances and daylight holes. While some cave adapted species of conservation significance are and may be present (including some rarer forms not collected in the limited time available for this survey), these are likely to occur beyond the areas directly affected by fluctuations in the stream. Food and environmental conditions for these species are also likely to be less affected by the stream, and so major issues are again likely to be erosional/hydrological issues affecting the stability of the siltbanks and groundwater inflows themselves. Similarly, Kayak Kavern is little more than an extended overhang or entrance zone, and is of little significance in terms of troglobitic cave fauna.

Although both Bill Neilson Cave and Kayak Kavern contain terrestrial troglophilic, trogloxenic and accidental fauna of global/evolutionary and ecological significance, as well as some (non-listed) species of conservation importance, these species are not restricted to the cave, and are instead found extending throughout the surrounding forest. Some also have wider distributions throughout surrounding regions. While some of these animals may be directly affected by stream level fluctuations, the impact on their populations is likely to be negligible. Stream fauna within the main cave channel is of surface character, and its management requirements will be the same as for stream invertebrates along the Gordon River itself.

Potential long term monitoring sites, strategies and baseline data have been identified and provided, to allow these conclusions to be tested under the development and implementation of the Basslink proposal. Such monitoring should be coupled with hydrological monitoring of sediment deposition and transfer, atypical peak waterflows, and sediment slumping and collapse.

Finally, it needs to be emphasized that the above conclusions are based on very limited field investigations and a very small literature base. Because of the nature of caves, with their difficult topography and very dispersed food supply, troglobitic animals are always rare, usually small and cryptic, and consequently hard to find. Direct collecting is only possible in passages to which humans can gain access, and these may only be a small proportion of the caverns in the rock. Further work would undoubtedly enhance these results in future.

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1 INTRODUCTION

1.1 Overview

Hydro Tasmania is undertaking investigations into the environmental implications of water flow management changes in the Gordon River predicted to occur if a Basslink cable were operational. These investigations form part of the Basslink Environmental Impact Assessment (EIA). An assessment of the possible implications of Basslink on the karst fauna in the Gordon River is a necessary and important component of the Basslink EIA.

This study is a complementary one to that presented in Appendix 5 of this report series – Gordon River Karst Assessment (Deakin *et al*. 2001), which aims to identify and assess the significance of landforms, cave contents and geo-hydrological processes in this region. This study focuses on the associated karst-dependent flora and fauna, which may be affected by Basslink modifications to the operation of the Gordon power station.

1.2 Cave ecosystems: background

To understand the ways in which cave ecosystems may be affected by external influences, it is important to understand the divisions that exist within cave environments and how these are reflected in the flora and fauna.

Caves can usually be divided into distinct environmental zones:

- an **entrance zone or mouth**, which is the point where the surface and underground environments meet and environmental conditions, including light, may be very variable;
- a **twilight zone**, where light steadily diminishes, but temperature and other environmental conditions remain variable;
- a **transition zone**, where darkness is complete, but external environmental conditions still have a reduced influence (mostly via stream and air currents); and
- a **deep cave/troglic region**, which is typically a long way from any entrance, relatively stable in temperature and high humidity, and where evaporation negligible (this region may also contain elevated carbon dioxide concentrations, particularly in tropical caves).

The location and extent of different cave zones vary between caves, based on the number and location of entrances, surrounding vegetation and other features, the presence and activity of streams, and the degree of difference between internal and external environmental conditions. The condition and extent of cave zones may also differ within a given cave depending on diurnal and seasonal cycles and airflow throughout the system.

Cave flora is limited by penetration of light, and so is usually restricted to the entrance zone of caves. In contrast, distinct types of cave fauna (cavernicoles) are attached to each of the above zones, each with different levels of dependence on subterranean conditions. Based on traditionally accepted classifications (Vandel 1965, Howarth 1983), these groups include:

- **Troglobites**, which are obligate cave species strictly adapted to subterranean habitats and unable to survive outside them. These animals are usually restricted to the deep cave;
- **Troglophiles**, which are facultative cavernicoles that commonly live and reproduce in caves, but are not totally confined to them. These animals may also be found in any similarly sheltered, cool, dark and humid surface habitats, and are usually found in the entrance and twilight zones of caves;
- **Trogloxenes**, or occasional cavernicoles that regularly inhabit caves, but need to return to the surface for part of their lifecycle (e.g. to feed or breed). These animals are usually found near the entrance of a cave, but may extend deeper to roost or lay eggs; and

- **Accidentals**, or surface animals that wander, fall or are washed into caves, but cannot survive there over the long term.

Troglobites often display a suite of unusual and distinctive morphological ("troglomorphies"), physiological and behavioural adaptations to their environment, often strongly contrasting to the adaptations of their above ground relatives. Troglobitic species are usually restricted to the karst body in which they are found, and for this reason they are often the focus of conservation efforts. However, although troglophiles and trogloxenes can be more widely spread and are usually less directly a conservation issue of themselves, these species can be vitally important to energy flow within a cave, on which troglobitic species may depend. Similarly, impacts on water flow and entrance zone soil and vegetation may greatly affect environmental conditions deeper within a cave. Troglophiles and trogloxenes may act as surrogate species in this regard, on which the effects of disturbances may be more readily detected than on the rarer troglobites themselves (Doran *et al.* 1999a).

Despite their apparent isolation and insulation from the surface, cave environments are directly dependent on surface events. As no light penetrates the deeper cave, autotrophic production within cave systems is minimal, and food availability (and consequently species biomass) declines away from entrances. Land-use and water management activities that impact on ground and surface water quality, levels, and flow patterns, as well as surrounding vegetation, soil, humidity, air movement, temperature, and the provision of food (stream borne detritus, entrance zone vegetation and infall, trogloxene and troglophile movement and population cycles, accessibility of substrate, and rootlet ingrowth), can all have immediate and devastating impacts on underground systems and ecosystems (Eberhard *et al.* 1991, Kiernan *et al.* 1993, Clarke 1997, Doran *et al.* 1997, Richardson *et al.* 1997, Slaney & Weinstein 1997, Doran *et al.* 1999a).

1.3 The importance of cave biology

Caves are often considered to be barren due to their lack of vegetation, slow rate of change, and the sparse distribution, small size and often highly cryptic nature of cave fauna. Vertebrate species are not commonly present in Tasmanian caves, and the invertebrate fauna more frequently occurs in the smaller cracks, crevices and inter-cave (meso-cavernous) voids to which human access is severely limited. Despite this, cave faunas can be remarkably diverse, and Tasmanian caves have been identified as containing the richest assemblages of cave obligate invertebrates in temperate Australia (Eberhard *et al.* 1991).

These high biodiversity values, combined with Tasmania's location in the Australian region at a climatic and geographic extreme, its preponderance of undisturbed cave sites, and high abundance of globally and locally significant relict fauna, make Tasmanian cave biology extremely valuable for the study of local and global biogeography and the evolutionary history of Australian cave fauna as a whole. Cave ecosystems offer unique opportunities to evolutionary biologists because of their often highly adapted and specialised fauna combined with their unusual and strictly defined environmental conditions (Doran *et al.* 1997).

Cave ecosystems also potentially offer sensitive indicators of surrounding catchment and groundwater health, as well as biological compounds of potentially high industrial and medicinal value (Doran *et al.* 1999b & 2001).

1.4 Reasons for investigating caves and cave fauna in relation to Basslink

Since the open public debate and subsequent protection of Exit Cave under World Heritage legislation in 1992, the Tasmanian community has better recognised the value of its karst resources. Increasing efforts to protect these environmental features have recently resulted in the declaration of the Mole Creek Karst National Park in the north of the state.

With increasing appreciation of the value of caves, awareness has been steadily increasing of the specialised fauna they contain. Cave invertebrate communities are recognised as being of high conservation significance in the operational handbook of the Forest Practices Board (Jackson & Munks 1998), and a threatened fauna manual produced by the then Parks and Wildlife Service (Bryant & Jackson 1999). Conditions in every cave are different, and where management mechanisms exist (such as the *Forest Practices Code*) they require that individual prescriptions be developed on a case by case basis.

Twelve cave-related species of restricted distribution are listed under the *Tasmanian Threatened Species Protection Act* 1995 (Table 1.1), and are therefore accorded conservation priority under that legislation. Other non-listed cave invertebrate species are considered to be of high conservation significance, and many elements of the Tasmanian cave fauna may qualify for future listing due to their rarity, restricted ranges, evolutionary isolation and endemicity (Bryant & Jackson 1999).

Table 1.1 Cave-related species of particular conservation significance (as per Bryant & Jackson 1999).

Species	Status (*Threatened Species Protection Act* 1995)
Echinodillo cavaticus (Flinders Island cave slater)	Rare
Goedetrechus mendumae (blind cave beetle)	Vulnerable
Goedetrechus parallelus (slender cave beetle)	Vulnerable
Hickmanoxyomma cavaticum (Ida Bay harvestman)	Rare
Hickmanoxyomma gibbergunyar (harvestman)	Rare
Idacarabus cordicollis (rough necked cave beetle)	Rare
Idacarabus troglodytes (Ida Bay cave beetle)	Rare
Micropathus kiernani (Kiernans cave cricket)	Rare
Olgania excavata (little six eyed spider)	Rare
Parvotettix rangaensis (Ranga cave cricket)	Rare
Pseudotyrannochthonius typhlus (cave false scorpion)	Rare
Tasmanotrechus cockerilli (Cockerills cave beetle)	Vulnerable

Non-listed species of conservation significance:

(all cave species to some degree)	*Idacarabus longicollis* (beetle)
Acanthodillo (new sp.) (slater)	*Lomanella troglodytes* (harvestman)
Arachnocampa tasmaniensis (glow-worm)	*Notoniscus* (new sp.) (slater)
Cavernotettix craggiensis (cricket)	*Parvotettix whinrayi* (cricket)
Cavernotettix flindersensis (cricket)	*Pseudotricula eberhardi* (freshwater snail)
Hickmanoxyomma clarkei (harvestman)	*Phrantela kutikina* (freshwater snail)
Hickmanoxyomma eberhardi (harvestman)	*Styloniscus* (new sp.) (slater)
Hickmanoxyomma goedei (harvestman)	*Tupua cavernicola* (spider)

Importantly, karst values were amongst those features listed as formal criteria for the declaration and extension of World Heritage status for the south-west Tasmanian wilderness in 1982 and 1989 (Australian Heritage Commission 2000), with the resultant obligation that these values be addressed in any proposals for the region. The formal criteria include the following relevant values.

- **Natural values representing outstanding examples of the major stages in the earth's evolutionary history.** Specific examples of these values not only include karst geomorphology and hydrology, but also relict flora and fauna showing links to ancient Gondwanan (and older) biota. These species include the Tasmanian cave spider (*Hickmania troglodytes*), a mysmenid spider (*Trogloneta* sp.) and crustaceans (such as the Anaspidacea, Parastacidae and Phreatoicidae), all of which may be found in caves.

- **Superlative natural phenomena, formations or features.** In the 1989 Nomination, cave fauna were specifically identified as being of "outstanding interest due to the unique adaptations that are necessary in this sunless ecosystem. Displays of glow-worms (*Arachnocampa tasmaniensis*) in several limestone chambers in the area are of spectacular beauty."

- **Important and significant natural habitats for threatened species.** All threatened cave fauna could be included under this criterion.

2 METHODOLOGY

2.1 Study site

The study area was identified as the middle Gordon River between the Gordon Dam and the Franklin River tributary. Investigations centred on the Nicholls Range karst (SW43 in Kiernan's 1995 *Atlas of Tasmanian Karst*; Grid Ref. 403400 5271300), where there are two known caves: Bill Neilson Cave (NR-001) and Kayak Kavern (NR-002).

The karst hydrology team (Deakin *et al*. 2001) also investigated a recently unidentified dolomite karst area between the Albert River/Gordon confluence and the Second Split, and a third area between the Olga River junction and the Franklin River junction to determine whether further work would be required. However, they determined that the only karst development of significance was at the Nicholls Range, in the form of Bill Neilson Cave and the nearby Kayak Kavern, as above.

Although the karst hydrology team also visited Rocky Sprent Cave, the water level was deemed too high for safe access (see Deakin *et al.* 2001). It was described as robust system (consisting of boulders and high energy sand and gravel), with the cave consisting of only 30m of true cave passage with the rest open canyon. Some smaller karst depressions approximately 1km upstream of Bill Neilson cave were also deemed insignificant and/or too open for the development of cave fauna. Bill Neilson Cave and the neighboring Kayak Kavern were therefore identified as the priority areas for cave fauna investigations.

Field surveys were conducted alongside, and following on from, the karst hydrology study (Deakin *et al*. 2001). Detailed geomorphic and hydrologic descriptions of Bill Neilson Cave and Kayak Kavern are included in Appendix 5 of this report series – Gordon River Karst Assessment (Deakin *et al*. 2001) and will not be repeated here.

2.2 Existing information

As these caves are in a remote area, there has been little access previously. However, some quite substantial fauna records do exist.

Middleton (1977) reports glow-worm (*Arachnocampa tasmaniensis*) colonies at 220m and 300m into Bill Neilson Cave. In a more detailed report (Middleton 1979), the locations of these colonies are marked on a map and the cave is referred to as containing "some decoration, glow-worms, wetas (*Micropathus montanus* - A.M. Richards) and a new species of carabid beetle of genus *Theprisa* - B.P. Moore." [*see note regarding Theprisa in Table 2.1*].

Eberhard *et al.* (1991) compiled a list of species records for different karst areas around the state, including the Nicholls Range (Bill Neilson Cave), the Franklin River (e.g. Kutikina Cave, Proina Cave, Gahnia Cave) and the Gordon-Sprent area. These records were included in, updated and expanded upon within a cave fauna database constructed during the Tasmanian Regional Forest Agreement process (Clarke 1997). A table of fauna known from the Nicholls Range karst (principally from Bill Neilson Cave) has been prepared from these two sources in Table 2.1.

Significant groups found in neighbouring karst areas in the Gordon region (including the listed species *Olgania excavata*) are discussed in Section 3.3.

Table 2.1 A list of cave fauna recorded in the Nicholls Range karst, as compiled from Eberhard *et al.* 1991 and Clarke 1997.

NB Middleton (1979) reports the presence of an unidentified species of the beetle genus *Theprisa* (Carabidae: Amblytelini), citing B.P. Moore. No subsequent information on this species could be found.

Phylum/Class	Order/Family	Genus/species	Status
Platyhelminthes	Turbellaria: Tricladida – Paludicola	Unidentified spp.	
Annelida			
Oligochaeta	Haplotaxida	Unidentified spp.	
	–	Unidentified spp.	
Mollusca			
Gastropoda	Hydrobiidae	*Phrantela* (*daveyensis* group)	
	Charopidae	Unidentified spp.	
Arthropoda			
Insecta	Collembola – Neanuridae: Neanurinae	*Australonura* sp. c.f. *wellingtonia*	
		Unidentified spp.	
	– Onychiuridae	*Tullbergia* spp.	
	Ephemeroptera – Leptophlebiidae	Unidentified spp.	
	Orthoptera – Rhaphidophoridae	*Micropathus montanus*	Trogloxene
	Hemiptera – Cicadelloidea	Unidentified spp.	
	Trichoptera	Unidentified spp.	
	Lepidoptera – Hepialidae	Unidentified spp.	
	– Unidentified	Unidentified spp.	
	Coleoptera – Carabidae: Zolini	*Pterocyrtus* sp. n.	Troglobite?
	– Staphylinidae: Oxytelinae	Unidentified sp.	
	– Staphylinidae: unidentified	Unidentified sp.	
	– Cerambycidae	Unidentified sp.	
	– Unidentified	Unidentified sp.	
	Diptera – Mycetophilidae	*Arachnocampa tasmaniensis*	Troglophile
	– Simulidae	sp. or spp. indeterminate	Accidental
	– Chironomidae	*Lopescladius* SRV sp. 39	
	– Unidentified	Unidentified spp.	
Crustacea	Anaspidacea – Anaspidididae	*Anaspides tasmaniae*	Stygophile
	Amphipoda – Paramelitidae	*Giniphargus* sp.	
		cf. *Hurleya* sp.	
		Antipodeus franklini	
	Isopoda – Janiridae	*Heterias* sp (near *petrensis*)	Stygobiont
		Heterias sp	
	– Styloniscidae	*Styloniscus* sp.	
Myriapoda	Diplopoda – Polydesmida: Dalodesmidae	Unidentified spp.	Accid. & ?
	– Unidentified	Unidentified spp.	
Arachnida	Acarina – Unidentified	Unidentified spp.	
	Opiliones – Laniatores: Triaenonychidae	*Hickmanoxyomma goedei*	Troglobite
		Lomanella troglophila	Troglophile
	Araneae – Austrochilidae	*Hickmania troglodytes*	Troglophile
	– Amaurobiidae	Gen et sp. nov, cf. *Milvinus* (2 spp?)	Troglobite
	– Stiphidiidae	Gen. et spp. n.	
	– Theridiidae	*Icona* spp (2 spp)	
	– Metidae: Metinae	*'Orsinome'* sp.	Troglophile
	– Theridiosomatidae	*Baalzebub* spp.	Troglophile
	– Unidentified	Unidentified spp.	

2.3 Field work: Bill Neilson Cave (NR-001)

2.3.1 Timing and constraints

Field investigations were conducted on:

- 30 July 2000 (full shutdown, short term)
- 19-20 August 2000 (full shutdown prior to Basslink simulation)
- 24-25 September 2000 (full shutdown, long term)

One of the authors (ND) accompanied the karst hydrology team for field work on the first date, while two (ND, SW) conducted field work for the remainder.

Access to the field site was limited to helicopter flights into the Gordon River, followed by boat transport to the mouth of the cave. Both were conducted in periods when the Gordon Power Station was shut down and river flow was reduced, to expose potential landing sites and lower the outflow levels of the river through the cave. Helicopter landings were only possible under conditions of low flow, and so field access, duration and continuity of work were dictated by the prevailing conditions, particularly visibility (mist and shorter daylength) and changing water levels.

Natural flooding and limits to the periods for which the power station could be shutdown meant that time within the cave was limited and dictated by the need for rapid evacuation as required. Helicopter access to the site was delayed on both 30 July and 24 September, with rising water levels further curtailing investigations on the earlier date. Logistical requirements of helicopter support for all teams of the Basslink EIA also limited access at some points. On two occasions (19 August and 24 September), the cave fauna team camped at the cave overnight to ensure early access the following day.

Restrictions in access to the cave meant that surveys of cave fauna were planned to be indicative rather than comprehensive, as insufficient time was available to ensure the capture or trapping of rarer cave species (which are usually small, cryptic, inaccessible within rock formations, and extremely sparsely distributed). Under partial and fluctuating shutdown conditions, such species were also less likely to emerge into the more open areas of the cave, where they could be readily trapped.

Given the above constraints, survey work therefore aimed to determine:

- preliminary/indicative flora and fauna species lists for the cave, according to specific cave habitats;
- a measure of population numbers and locations for the more common species, which could potentially act as a surrogate for monitoring cave flora and fauna in future.

Fauna species lists from this study were supplemented by the historical information already collated for the cave (e.g. Eberhard *et al.* 1991, Clarke 1997: see Section 2.2).

2.3.2 Cave entrance and daylight hole flora

A survey of cave entrance and daylight hole flora was conducted to produce a preliminary species list for the cave and determine whether any flora was likely to be directly affected by water level fluctuations.

Sampling of plant species was undertaken at the cave entrance on the Gordon River, and sampling and transects were subsequently run at 4 daylight holes throughout the cave, marked on the map (Figure 1) as D3, D4, D7, D11. Other daylight holes were not sampled due to inaccessibly steep and muddy slopes. These holes were noted to have relatively sporadic vegetation cover that was well above the high water mark.

Collections: Representative flora samples were collected and returned to the laboratory for identification in order to compile a species list of flora in the cave.

Transects: Two transects were conducted at each accessible daylight hole, running from water level up slope for as far as possible or a maximum of 15m (whichever came first). The lengths of the transects were often inhibited by the steep muddy and silty slopes. A 1 x 1 metre quadrat was placed at each 5m interval (5, 10, 15), where possible. Plant species were recorded within each quadrat and species cover was estimated using Braun-Blanquet scores (Table 2.2). Bare silt/mud, rocks and woody debris/litter were also recorded when present.

Table 2.2 Braun-Blanquet values.

Braun-Blanquet Score	0	1	2	3	4	5	6
Percentage Cover	0	<1	1-5	5-25	25-50	50-75	>75

The specific details of the sites where flora was sampled and transects undertaken are as follows.

Main Entrance: on the Gordon River, a very narrow entrance with vegetation only persisting a limited distance into the cave entrance. Due to the constricted nature and steep slopes, it was not possible to conduct transects or lay quadrats in this area.

D3: This site was poorly illuminated, with direct sunlight limited to less than 15 minutes or so per day. The slope ran at approximately a 20 degree incline. The substrate was very muddy and rocky underneath and littered with tree limbs and manfern trunks (*Dicksonia antarctica*).

- **Transect 1:** Indicator point – facing west, the large flat rock to the left about 2m before the beginning of the path up to the campsite. The transect ran uphill in the gully about 2m from and parallel to the rock wall to the right. Vegetation started at about 1m along the transect, with only mud and silt prior to this. Small low mosses and small ferns were present.
- **Transect 2:** Indicator point – the large pointed rock about 0.5m downstream from the flat rock indicator of transect 1. The transect ran on the rise or hill before the drop into the water about 3m from rock wall on the right. Parallel to the wall and transect 1. Vegetation started at 2m along the transect; ferns and mosses, becoming exclusively a thick carpet of moss by 3m.

D4: This site was very poorly illuminated with very limited time exposed to direct sunlight per day. The slope was estimated to be at a 45 degree incline, very steep and covered with a thick layer of wet silt and a few exposed boulders. The surface was littered with tree branches/logs and manfern trunks.

- **Transect 1:** Indicator point – at this site the Geomorphology survey team have erected stakes for the purpose of monitoring water levels. Transect 1 started from the lowest of these stakes which is inserted into a large flat rock. The transect ran west directly uphill from this stake, and perpendicular to the stream. There was no vegetation until 4m. The surface was very silty and slippery and it was not possible to run the transect beyond 5m at this site.
- **Transect 2:** Indicator point – this transect started from water level 5m upstream from the indicator point of transect 1 and ran parallel to transect 1. Vegetation began at 3m. Due to the steep slope it was again not possible to extend this transect beyond 5m.

D7: This site was also poorly illuminated. The slope was estimated to be at a 45 degree incline. This site was also very silty with few exposed boulders. The site was covered almost completely with woody debris, with the mosses and fern growing directly off the debris.

- **Transect 1:** Indicator point – the large flat rock located directly under a low section of the roof. The transect ran uphill perpendicular to the stream. Vegetation began at 3m. The steep nature of this daylight hole also made it impossible to extend this transect beyond 5m.
- **Transect 2:** Indicator point – this transect was run 2m upstream from the indicator point used in transect 1; almost in line with a large manfern at the top of the hill. This transect was also limited to 5m in length due to the severity of the slope, and was littered with woody debris.

D11: This daylight hole was relatively open and sunny. The vegetation at this site was comparatively more dense and taller than that of the previous daylight holes. The slope was steep with an estimated 45 degree incline. The site was not as silty as those previous and had numerous exposed boulders/rocks. The site was covered with woody debris and large logs.

- **Transect 1:** Indicator point – the large rock with two distinct ridges and a depression between. The transect ran directly uphill and perpendicular to the stream. Vegetation began at 1.5m. This transect was able to be extended to 10m.
- **Transect 2:** Indicator point – upstream end of the large submerged log under the low section of roof. Vegetation began at 1m. This transect was limited to 5m.

2.3.3 Cave fauna

Given the mobility of fauna, the aims outlined in Section 2.3.1 were met though a combination of techniques, including general stream sweeps, opportunistic observations and collections throughout the cave (Figure 2), and distinctly defined trapping, transect and census areas (Figure 3). Given the potential scarcity of cave fauna and the damage that scientific collections can have upon communities (Peck 1976, Slaney & Weinstein 1997), efforts were made to avoid repeat and unnecessary collections. Species were identified alive on-site where possible, and duplication in collections was avoided. Collected material was preserved direct into 70% alcohol, with the exception of some oligochaetes which were collected live for laboratory preparation and preservation.

2.3.3.1 Stream fauna

Observations of the stream habitat and fauna were made throughout the cave, in a general mapping exercise to gauge the number of different habitat types and primary trapping points along its length. Opportunistic observations and collections were recorded in this exercise. Particular attention was paid to groundwater inflows, still pools and other sites of potential significance for aquatic cave fauna.

Stream fauna collections were made at specific points along the streambed, disturbing the gravelly substrate as widely as possible above the mouth of an FPA net. Material from the net was settled in a white tray for sorting and collection by pipette and forceps. Some fauna (snails, amphipods) were collected directly by pooters and sieves. Sample sites targeted the lower entrance to the cave (just before outflow meets the Gordon River), groundwater and surface drip inflows, standing pools, and sections below the longer underground passages (both partway through and at the top of the cave). The streamway at the entrance of the cave was sampled on three separate occasions to provide three comparable samples, as this site was most at risk from inundation from the Gordon.

No specific quantitative counts were undertaken in the stream, given the variability of the gravel bed.

2.3.3.2 Terrestrial fauna - Stream passage and entrances

As with the stream fauna, observations of terrestrial species were made along the length of the stream to gauge the number of different habitat types and primary census points along its length. Opportunistic observations and collections were recorded in this exercise.

<u>*Species list*</u>

To compile a species list, representative samples were collected of the different fauna encountered within the cave, unless they could be identified *in situ*. The location and number of other specimens were recorded, with the exception of the common species: the Tasmanian cave spider (*Hickmania troglodytes*, cave crickets (*Micropathus* spp.), and glow-worms (*Arachnocampa tasmaniensis*). For these, the location of major colonies were mapped, along with census counts within specific areas.

Specific census areas were selected for the populations of animals that they contained, their location relative to the stream, and their repeatability (based on defined landmarks and boundaries, and the ability to describe these to future researchers). Census information was collected to provide base line population information of key populations and habitat types, should future monitoring be undertaken for this site.

General census area 1: lower entrance

The effect of changes to water levels and flow are not confined to – nor necessarily driven by – inundation itself. Changes to water levels and flow can have much broader effects on terrestrial cave fauna, and the longer term viability of the fauna may depend more on resultant changes to air flow patterns and the prevailing humidity, temperature and evaporation regimes (Vandel 1965, Barr 1967, Poulson & White 1969, Culver 1982, Howarth 1983). While flooding may directly impact individuals of a population, the above changes may instead impact upon the activity, distribution, reproduction, aestivation (warm weather dormancy), hibernation and simple survival of the whole population (Barr 1968). The movement of specific trogloxene and troglophile groups has been linked to changes in such conditions overseas (Barr 1964) and in Tasmania (our unpublished data), while consistent atmospheric conditions over the long term also appear crucial to the reproductive success of key troglophilic species such as *Hickmania troglodytes* (Doran *et al.* 1999a+b & 2001).

For the above reasons, the first area selected for census consisted of a small shaft to the west of the main passage at the lower entrance (Figure 3), where inundation levels from the Gordon River would be greatest. The shaft is above the potential level of inundation, and represents a greater abundance and diversity of cave related (troglophilic and trogloxenic) forms than the sediment banks below it. Irrespective of direct or indirect influences from the stream, the shaft represents a location in which the general stability and condition of the fauna can be monitored for broadscale change (Doran *et al.* 1999a).

The shaft is high above the stream and is naturally divided into three distinct sections:

1) an open and relatively exposed section, leading back to the first squeeze, including 2 domes/shafts into the roof (approximately 2m wide, by 3m deep and 1-1.2m high);
2) an open area beyond the first squeeze, with a high roof dome (approximately 2+m wide, by 2m deep and 6+m high); and
3) a wider area beyond second squeeze, with a high but thin roof shaft (3-4m high), extending approximately 4m back before the roof falls too low to allow human access (whole area approximately 4m wide, by 4m deep and, excluding the roof dome, 0.5m high falling to ground level at the rear of the shaft).

The census consisted of close examination of all surfaces within the shaft, and a simple count of the types and number of animals within each of the three defined sections. Additional information, consisting of the size classes and sex/status, was collected for the more common species (*Hickmania troglodytes*, *Micropathus* sp.), in keeping with similar surveys already being conducted for the long term monitoring of cave fauna (Eberhard 1990, Doran *et al.* 1997, 2001 & unpublished, Richardson *et al.* 1997, Eberhard 1999).

General census area 2: alcove at daylight hole D3

This census area (Figure 3) was selected for the same reasons as census area 1, approximately half-way towards the upper extent of the area that was expected to be effected by fluctuating water levels (as determined by Deakin *et al*. 2001). The census area consisted of the a single, well sheltered alcove/chamber in the rock (approximately 2.5m wide, 2m deep and 3m high), situated high above the stream between the two arms of the daylight hole on the bank leading up into the forest.

Methodology remained as per census area 1.

Glow-worm counts

The major glow-worm colonies reported by Middleton (1977 & 1979: see Section 2.2) are still intact. Sporadic glow-worms are now found closer to lower entrance, but may have simply escaped attention in the earlier reports. As outlined in the karst hydrology report (Deakin *et al*. 2001), glow-worm colonies were found in the roof of the cave 30–50, 90, 220 and 300m from the entrance. These were effectively above most of the inundation-affected areas. Single glow-worms and smaller clusters were found at other locations along the stream.

To provide baseline data on the glow-worm populations within the cave, glow-worm counts were conducted at four separate sites within the cave. As the major glow-worm colonies occur beyond the region of the cave most affected by human-induced water level fluctuations, these counts were designed to allow long-term monitoring of effects on these populations that may spread throughout the cave.

Glow-worms respond to artificial light by ceasing to glow (an energy saving response that stops them from glowing in daylight hours near entrances). Glow-worm counts therefore need to be conducted separately to other census counts as they (a) require total darkness, and (b) may be biased by other activity in the area preceding the count. Counts are conducted by identifying a predetermined area or rock structure (often outlined in the dark by glow-worms themselves) and counting the number of points of light seen within that area from a set vantage point. Counting is best conducted by not looking directly at the light itself, to take advantage of the greater perception of low light by the outer retina.

Counts were repeated five times, to minimise counting error and the intermittent glowing of some individual glow-worms. Counts were aborted if a large portion of the colonies being counted began to dim or switch off due to prior exposure to light. This methodology is in keeping with similar glow-worm surveys already being conducted for the long term monitoring of cave fauna (Eberhard 1999).

The glow-worm count sites are marked in Figure 3. Field sketches of these sites are retained by the senior author, and will be submitted for file at both DPIWE and Hydro Tasmania. The indicator points for each were as follows:

1. On the downstream side of the large overhanging rock face (approximately 3m wide) around the first main bend at the base of the main siltbank/upper levels. Viewing point standing on the siltbank at the upstream side of the steep corner, and counting all glow-worms on the rock formation.
2. On the upstream side of the large overhanging rock face (approximately 2m wide this side) around the first main bend, as above. Viewing point standing in the stream half way between the rock and the shelf on which the roof drip collects.
3. Sharp northern-cornered bend of stream with large glow-worm colony on the roof. Viewing point standing at sharp rock in streamway, facing into the corner and counting the whole roof (including the rock immediately above).
4. Sharp western-cornered bend of stream, with major glow-worm colony on the roof. Viewing point from sitting on exposed gravel bed in middle of stream (between the flow and the pooled backwater), half way under the low rock shelf. The count consisted of all glow-worms in the corner and on the roof in all directions.

2.3.3.3 Terrestrial fauna - Siltbanks

Siltbanks provide an important substrate for cavernicolous fauna, and usually support a diverse range of species. The upper level siltbank (Figure 1) was the most developed and expansive habitat of this type in the cave, as well as being relatively remote from any entrances. It was therefore subjected to a lot of attention and visual searching.

Because of the sensitivity of siltbank habitats to trampling and disturbance, and the impacts that this can have on the fauna that rely on them (Clarke 1997, Doran *et al.* 1997, Slaney & Weinstein 1997, Doran *et al.* 1999a), a single narrow path was established up and across the siltbank to the upper entrance passage, and movement was restricted to this path as far as possible. This measure was designed to minimise impacts, particularly as the siltbank was pristine and had not been surveyed before. Opportunistic observations and collections (by forceps or pooter into 70% alcohol) of terrestrial species were made across the siltbank path and extending to the upper cave entrance.

<u>Species list</u>

To compile a species list, representative samples were collected of the different fauna encountered on the siltbank, unless they could be identified *in situ* or had previously been collected elsewhere in the cave. In addition to opportunistic samples collected in traversing and examining the siltbank, pitfall traps were established at various intervals across the main siltbank and the one on the opposite side of the river (downstream, at Daylight Hole 4).

<u>Pitfall traps: main siltbank and siltbank at D4</u>

Pitfalls traps were set overnight on 24.9.00, from approximately 6pm to 10am the following morning. Traps were 72mm in diameter at the lip, 98mm deep (225ml volume), and used 70% alcohol as preservative and salami bait to lure rarer cave forms. Other species were observed at the time of setting these traps, and were either noted in the transect information (for the main siltbank) or as separate records (other siltbank). All baits and bait wires were gone at the time of collection (possibly due to bush rats or other vertebrates entering through the upper entrance – fresh scats were collected from near U6: see Attachment 3), but the traps, alcohol and preserved fauna remained intact in each case.

The general locations of pitfalls are marked in Figure 3, while more detailed descriptions are as follows. Field sketches of these sites are also retained by the senior author, and will be submitted for file at both DPIWE and Hydro Tasmania. All locations remain marked in the cave by yellow flagging tape.

U1-U6 (main siltbank):

- U1: in open silt, on the path leading up the siltbank, south-east from the first main bend in the streamway, approximately 3m below the upper wall;
- U2: in silt against the upper wall, just below a curtain of stalactites 3m directly south-east (upslope) from U1;
- U3: on limestone under a curtain of stalactites, approximately 2.5m south-south-east along the upper wall from U2 *[Note: due to the nature of the limestone substrate, no pitfall trap was inserted at U3, but this site was retained as a specific collection point due to the number of beetle remains in the vicinity]*.
- U4: in silt in a small rock alcove approximately 0.8m south-south-east along the upper wall from U3;
- U5: in silt in a rock alcove close to the start of the passage to the upper entrance, approximately 3m south-south-east along the upper wall from U4;
- U6: in silt halfway across the census alcove (as below), in the narrow passage leading to the upper entrance zone, approximately 3m south-east of U5.

N1-N2 (siltbank at D4):

- N1: in silt at the top of the siltbank, against the upper wall directly opposite the 0.5m water level recorder (see maps, Appendix 5 of this report series), near a round patch of subsidence in the silt surface;
- N2: in silt at the top of the siltbank, against the upper wall approximately 5m north of N1.

<u>Upper level transect</u>

To provide a measure of abundance for different groups, a set transect path was established on the siltbank (Figure 3). The location and number all fauna were recorded, with the exception of the

Micropathus crickets, which were extremely common and roamed widely across the silt. Cave crickets numbers were recorded in a specific census area along the transect, as below. Glow-worm and *H. troglodytes* numbers were recorded on the siltbank, as they were not as common here as along the stream; the former generally declining away from flowing water sources, and the latter more common closer to entrances.

The transect was examined three times in the course of the field work (19/8, 24/9, and 25/9/00). The transect path ran from the U1 pitfall site on the siltbank (approximately 3m below the upper wall, in line with the groundwater inflow below at stream level), past the sites for U2-U5, into the constricted passageway (including U6 and the below census area) until the point where it the passageways splits both east and west.

<u>Roof dome census, upper level</u>

The census area was demarcated by a roof dome/alcove next to the transect path, just after the siltbank constricts to a small passage leading to the upper entrance (Figure 3). The alcove runs for approximately 2m to the north-east of the path. The census area extended over all surfaces (ground, walls, roof) as far back as could be seen. The area also included the site for pitfall trap U6.

2.4 Field work: Kayak Kavern (NR-002)

Kayak Kavern consists of a large overhang in the rock of the riverbank, but does not extend beyond this cavern. As such, it is effectively only a large entrance zone, and this is reflected in terms of the flora and fauna it contains. Field work in Kayak Kavern was consequently restricted to a brief visit, with the main focus of work remaining on Bill Neilson Cave.

Much of the floor of Kayak Kavern consisted of thick silt. Vegetation was absent from the entrance and inside the cavern. Fauna was restricted to roof-dwelling species common in entrance zones (such as *Hickmania troglodytes* – including some discarded egg sacs – and *Micropathus* crickets). The cavern was clearly high enough for fauna to escape the direct effects of inundation, but would not be suitable for deep cave fauna in any case.

Notably, of the historical fauna records that have been compiled for the Nicholls Range karst (Middleton 1977 & 1979, Eberhard *et al.* 1991, Clarke 1997), nearly all have consisted of material from Bill Neilson Cave. Clarke (1997) records *Micropathus montanus*, *Arachnocampa tasmaniensis* and *Hickmania troglodytes* from Kayak Kavern, while Eberhard *et al.* (1991) record only one collembolan (Onychiuridae – *Tullbergia* spp) in NR-x1 (presumably an earlier code for Kayak Kavern). The latter authors also record *Micropathus montanus* from the surface.

2.5 Laboratory identifications

Time spent collecting material in the field was matched by time required in the laboratory for sample identification. Species lists were prepared from collections and field observations. In-field identifications were made by two of the authors (ND + SW). Laboratory identifications were made by the remaining author (AMMR), with the exception of spiders (ND) and plants (SW).

Collected material was identified as far as possible, using the following resources.

<u>Flora</u>: Ferns: Duncan and Isaac (1986), Garrett (1996);
Bryophytes: Jarman and Fuhrer (1995), with assistance from J. Jarman of the Tasmanian Herbarium and F. Duncan of the Forest Practices Board, Hobart;
Dicotyledons: Curtis (1967).

<u>Fauna</u>: Mollusca: Smith & Kershaw (1981);
Amphipoda, Crangonyctoidea: Williams & Barnard (1988), Bradbury & Williams (1999);

Decapoda, Parastacidae: Horwitz (1990)
Diplopoda: Harvey & Yen (1989);
Laniatores (Harvestmen): Hickman (1958), Hunt (1990, 1995), Hunt & Hickman (1993);
Araneae: Hickman (1963), Davies (1986), Raven (unpublished);
Insecta: CSIRO (1991);
Rhaphidophoridae: Richards (1964, 1968, 1971, 1974);
Coleoptera: Matthews (1980, 1982);
Ephemeroptera: Dean & Suter (1996);
Trichoptera: Dean *et al.* (1995);
Plecoptera: Hynes (1989).

The resultant species lists were examined for species listed under the *Threatened Species Protection Act* 1995 and the *Environment Protection and Biodiversity Conservation Act* 1999. These lists were also considered for other species likely to meet the criteria for listing. Assessment was made of the degree of cave adaptation and specialisation in the fauna, and of significance in global, regional, local or other terms.

The identified floral material has been pressed and preserved, with specimens of significance being lodged with the Tasmanian Herbarium. Faunal material has been labeled and stored for eventual deposit in the Tasmanian Museum & Art Gallery, Hobart.

3 RESULTS

3.1 Species lists: flora and fauna

Species lists compiled from the observations and collections of this study are presented in Table 3.1 (flora) and Table 3.2 (fauna). Major fauna communities/populations are marked in Figure 1, collection sites are marked in Figure 2, and census points and transects are marked in Figure 3. Flora per site and fauna per site tables are presented in Attachments 1 and 2, respectively.

Table 3.1 Flora list compiled for the Nicholls Range karst in this study.

	FAMILY	SPECIES
Dicotyledonae		
	Urticaceae	*Urtica incisa*
Pteridophyta		
	Blechnaceae	*Blechnum chambersii*
	Dryopteridaceae	*Polystichum proliferum*
	Hymenophyllaceae	*Hymenophyllum rarum*
	Pteridaceae	*Pteris comans*
Bryophyta		
Musci		
(moss)	Hypnodendraceae	*Hypnodendron sp.*
	Hypopterygiaceae	*Cyathophorum bulbosum*
	Hypopterygiaceae	*Lopidium concinnum*
	Thuidiaceae	*Thuidium laeviusculum*
Hepaticae		
(thallose liverworts)	Marchantiaceae	*Marchantia foliacea*
	Marchantiaceae	*Marchantia sp*
Hepaticae		
(leafy liverworts)	Lepidolaenaceae	*Lepidolaena sp.*
	Plagiochilaceae	*Plagiochila sp.*
	Schistochilaceae	*Schistochilia sp.*
	Trichocoleaceae	*Trichocolea mollissima*

Table 3.2 Fauna list compiled for the Nicholls Range karst in this study.

Note that many species are in common with the list compiled from previous records (Section 2.2), while some species were not recaptured and others still have been added to the list. Codes alongside each taxa relate to the codes used in Attachment 2.
A = aquatic fauna, E = terrestrial fauna: streamway and entrances/daylight holes, S = terrestrial fauna: siltbank.

Phylum/Class	Order/Family	Genera/species	A	E	S	Code
Nematomorpha	–	Unidentified spp.	–	–	S	Nemat
Annelida						
Oligochaeta	–	Unidentified spp.	A	E	S	Oligo
Mollusca						
Gastropoda	Hydrobiidae	*Phrantela* sp.?	A	–	–	Phran
	Caryodidae	*Caryodes dufresnii*	–	E	–	Caryd
Arthropoda						
Insecta	Ephemeroptera – Leptophlebiidae	*Nousia* sp.	A	–	–	Nousia
		Austrophlebioides sp	A	–	–	Austp
	Plecoptera – Notonemouridae	*Notonemoura lynchi*	A	–	–	Notoly
	– Eustheniidae	*Eusthenia costalis*	A	–	–	Eus_c
		Eusthenia sp.	A	–	–	Eus_sp
	– Plecoptera adult	Unidentified sp.	–	E	–	Plecop
	Orthoptera – Rhaphidophoridae	*Micropathus montanus*	–	E	S	Mmon
		Micropathus cavernicola	–	E	S	Mcav
	Hemiptera – (Terrestrial)	Unidentified sp.	–	–	S	Hemip
	Trichoptera -Calocidae/Helicophidae	Unidentified sp.	A	–	–	Caloci
	– Hydrobiosidae	Unidentified sp.	A	–	–	Hydro
	– Leptoceridae	Unidentified sp.	A	–	–	Lepto
	Coleoptera – Carabidae: Zolini	*Pterocyrtus* sp.	–	–	S	Prome
	Diptera – Mycetophilidae	*Arachnocampa tasmaniensis*	–	E	S	Glow
	– Tipulidae	Unidentified spp.	–	–	S	Tipul
Crustacea	Amphipoda – Paramelitidae	*Austrogammarus* sp.	A	–	–	Austg
	– Neoniphargidae	*Neoniphargus* sp.	A	–	–	Neonip
	Decapoda – Parastacidae	*Astacopsis tricornis*	A	–	–	Ast_tri
		Engaeus cisternarius	–	E	–	E_cist
Myriapoda	Diplopoda – Polydesmida	Unidentified spp.	–	E	–	Poly
Arachnida	Opiliones: Laniatores – Triaenonychidae	*Hickmanoxyomma goedei*				
		Pale form	–	E	S	Hg_pal
		Pigmented form	–	E	S	Hg_pg
	Araneae – Amaurobiidae	Gen et sp. nov? cf. *Milvinus*	–	E	S	Am
	– Austrochilidae	*Hickmania troglodytes*	–	E	S	Htrog
	– Cycloctenidae	Unidentified sp.	–	–	S	Cyclo
	– Metidae	?‘*Orsinome*’ sp.	–	E	–	Met
	– Stiphidiidae	Unidentified sp.	–	E	–	Stiph
	– Synotaxidae	*Tupua* sp.	–	E	S	Syno
	– Thomisidae	Unidentified sp.	–	E	–	Thom
	– Unidentified	Unidentified sp.	–	–	S	Aran

Voucher specimens of unidentified species will be sent to appropriate taxonomic specialists for further identification, conservation assessment, and/or description of previously undescribed species.

Additional fauna (but distinctly non-cavernicolous) included macropod skeletons (with one skull embedded in cave formations near the upper level entrance and four complete skeletons (including one joey) under daylight hole D5A, ‘rat’ scats, plus a variety of surface/accidental forms (forest snails, forest harvestmen) not included in the above table.

3.2 Populations/abundance: flora and fauna

Transect, pitfall, and census data were used to complete the above species lists for the cave. In addition, this information provides a baseline on entrance zone flora abundances and cave fauna populations that can be used for future monitoring in the cave. These data are presented in detail in Attachments 1-3, and their possible use in monitoring is discussed in Section 4.6.

3.3 Biological significance

3.3.1 In general

Species can be biologically significant at global, regional or local levels; through evolutionary or distributional characteristics; via ecological roles; or simply as components of the biodiversity in the area within which they are found (e.g. the WHA). Significance may be recognised through conservation classifications under legislation, but this may not always be required. For example, *Hickmania troglodytes* is of high phylogenetic and zoogeographic significance at a global scale, but is so widely distributed across Tasmania and throughout the areas in which it is found that the species is not under threat. In contrast, elements of the siltbank fauna, which may be more representative of a cave adapted fauna, may be more restricted in their distribution and more at risk from any single event or disturbance.

None of the flora or fauna species collected or observed within the cave are currently listed under either the *Threatened Species Protection Act* 1995 or the *Environment Protection and Biodiversity Conservation Act* 1999. However, some of these species may qualify for listing once they are known in greater detail, and there is the potential that listed species (or other candidates for listing) may also be present in the cave that were not collected or observed in the time available. The isolated nature of cave faunas means that their constituent species are often likely to meet the criteria for "Rare" under the *Threatened Species Protection Act* 1995.

It is possible that some of the more cave-adapted and as yet un-named fauna collected from the siltbank may be found to meet criteria for listing in future. However, no conclusive statements can be made on these species until they are described and better known. The same is true for other cave species that may have escaped detection or collection in the time available for this survey, and the significance of microbiological processes in caves is almost completely unknown.

Of the cave fauna listed under the *Threatened Species Protection Act* 1995, only the micropholcommatid spider *Olgania excavata* (a troglophile, discussed below) has previously been recorded from the Gordon River Valley (Hickman 1979, Bryant & Jackson 1999). This was collected from moss and not from a cave. An unidentified and unlisted troglobitic species from the same genus has also been recorded from the Franklin River (Eberhard *et al.* 1991). Although no *Olgania* species were observed or collected in Bill Neilson Cave, it is possible that they may be present.

Under the *Threatened Species Protection Act* 1995, the potential impacts of Basslink operations would need to be addressed for any such listed flora and fauna found within the cave in future.

3.3.2 Significance of the flora

All fern species found in the area are common and widespread in rainforest, wet sclerophyll forest and fern gullies (Garrett 1996).

Of the bryophyte species sampled, *Thuidium laeviusculum* is of particular significance. This is a rare species (J. Jarman, Tasmanian Herbarium, pers. comm.) with only one other specimen collected since

1912 (Table 3.3). Notably, *T. laeviusculum* was also found well outside its known range, with Tasmanian Herbarium records showing that it has only previously been found on the east coast.

Table 3.3 Specimens and records of *T. laeviusculum* held at the Tasmanian Herbarium, including the new record from this study.

(Note: records of specimens previously mistaken for this species have been removed).

Locality	Date
Bill Neilson Cave	2000
Plummers Creek	1998
Fern Tree	1912
Mt Dromedary	1899
Cascade Creek	1891
Prossers Plains	1887
Maria Island	1886

This specimen was found only at D11 (Figure 1), the daylight hole furthest from the river entrance and likely to be least affected by operational water level fluctuations.

All other bryophyte species collected are relatively common (J. Jarman, pers. comm.). However, Tasmanian riverine karst is proving to be rich in terms of lichens and bryophytes (J. Jarman, pers. comm.), and may benefit from specialist survey in Bill Neilson Cave in future. The identification of these groups is a very specialised field within Botany as no up-to-date, comprehensive resources are available. Indeed, the most recent account is over 75 years old (Jarman & Fuhrer 1995), and there is an increasing awareness of the need for more information on the distribution, ecology and management requirements of bryophytes within Tasmania (Brown *et al.* 1994).

This lack of systematic data makes it difficult to adequately assess the conservation status of Tasmanian bryophytes as it is difficult to determine whether species are genuinely rare or simply under-sampled (Moscal *et al.* 1996). It is therefore unknown whether the *T. laeviusculum* would qualify for listing under the *Threatened Species Protection Act* 1995 until the species is investigated in more detail.

Other lichens and bryophytes found on Tasmanian riverine karst do appear to meet the requirements for listing, however (G. Kantvilas, Tasmanian Herbarium, pers. comm.), but these were not collected or observed and so it is unknown whether they are present in the cave. The status of some species is complicated by the need to review their taxonomic placement, which may in turn effect their potential for future listing under the Acts.

3.3.3 Significance of the fauna

All invertebrate cave fauna in Tasmania is considered to be of high conservation significance due to long periods of evolutionary adaptation, high endemicity and often acutely restricted distributions (Bryant & Jackson 1999). This section discusses the significance of particular groups of the fauna, taken in taxonomic order.

Platyhelminthes, Annelida

Species from both these groups have been recorded from Bill Neilson Cave (Clarke 1997), but knowledge of these groups in Tasmania, and particularly from caves, is insufficient to allow any particular comment on their significance.

Mollusca

Hydrobiid aquatic snails have speciated extensively in Tasmania with very localised distributions (Ponder *et al.* 1993). The specimens collected from Bill Neilson Cave are likely to be a *Phrantela* sp. on the basis of published records (Ponder *et al.* 1993, Eberhard *et al.* 1991, Clarke 1997) and their shell morphology. Clarke (1997) records a *Phrantela* sp. of the daveyensis species group from Bill Neilson Cave. He also lists an unnamed charopid land snail which is likely to be an accidental.

None of the *Phrantela* spp. from the Gordon area have been listed on the Schedules of the Tasmanian *Threatened Species Protection Act* 1995, although at least one species is considered to be of high conservation significance (Bryant & Jackson 1999). Thirty nine other species of hydrobiid snails are listed in Schedule 5 of the TSP Act, and two further species in Schedule 4 (Vulnerable), reflecting the low dispersal capacity and local speciation patterns in this group. These lead to small populations that are highly vulnerable to local disturbance.

Collembola

Clarke (1997) lists a neanurid springtail, *Australonura* cf *wellingtonia*, from Bill Neilson Cave. The neanurid springtails include the world's largest species, but this is likely to be an accidental species in caves.

Ephemeroptera

The leptophlebiid mayfly larvae collected during the field survey, *Nousia* and *Austrophlebioides* are widespread genera in surface streams in Tasmania. Clarke (1997) also records unidentified leptophlebiids from the cave, but all records are likely to be accidentals.

Orthoptera

Cave crickets are numerous and conspicuous members of the Tasmanian cave fauna, though they are really trogloxenes and migrate out of the caves by night to feed. Two species from the genus *Micropathus* were collected during the field survey. The material on which Richards based the only recent taxonomic work came largely from the east of the state and it is likely that several other species await description (P.B. McQuillan, University of Tasmania, pers. comm.). Eberhard *et al.* (1991) recorded *M. cavernicola* and *M. montanus* from caves in the Gordon region, and Clarke (1997) lists *M. montanus* from Bill Neilson Cave and from Kayak Kavern.

Because their distributions are often centred on caves, local speciation in this group is possible. Two species, *Micropathus kiernani* and *Parvotettix rangaensis*, appear in Schedule 5 of the Tasmanian *Threatened Species Protection Act* 1995.

Coleoptera

Carabid beetles from the subfamilies Zolinae and Trechinae are widespread in Tasmanian caves and include strongly troglomorphic forms. A single carabid species was collected during the field survey, a member of either the sub-families Broscinae or Trechinae; it did not show any obvious troglomorphisms. Clarke (1997) lists *Pterocyrtus cavicola* from Bill Neilson Cave, and this may be the species collected here. *Pterocyrtus* is also listed by Clarke (1997) from the Franklin, Mt. Ronald Cross and Mt. Cripps karst areas, amongst others. The trechines *Goedetrechus mendumae* and *G. paralellus,* from caves in southern Tasmania, appear on Schedule 4 (Vulnerable) of the Tasmanian *Threatened Species Protection Act* 1995.

Clarke (1997) also lists staphylinids (including the genus *Oxytelus*) and cerambycid beetles from the cave; the staphylinids may be troglobitic.

Diptera

Larvae of the dipteran *Arachnocampa tasmaniensis* ("glow-worms") were locally abundant in Bill Neilson Cave, and are also listed in Kayak Kavern by Clarke (1997). This species is widespread in Tasmanian caves. Clarke (1997) also lists an unnamed simuliid, and a chironomid genus, *Lopesoladius*. The Tasmanian glow-worm has previously been recognised as a cave invertebrate of high conservation significance (Bryant & Jackson 1999).

Crustacea

Relict and primitive species in crustacean groups such as the Anaspidacea, Parastacidae and Phreatoicidae have been identified as outstanding representatives of stages in the earth's evolutionary history, and one of the reasons for which the south-west wilderness satisfies the formal criteria for World Heritage listing (Australian Heritage Commission 2000). Representatives of these groups have been collected from Bill Neilson Cave in this study (Table 3.2), in earlier studies (Table 2.1) and from karst in surrounding areas (Eberhard *et al.* 1991, Clarke 1997).

<u>Amphipoda</u>. The freshwater amphipods collected in Bill Neilson Cave during the field survey were from the genera *Austrogammarus* and *Neoniphargus,* both of which widespread in western Tasmania. They both occur in mainland Australia (Bradbury & Williams 1999). The genera are currently under review and species diversity within them appears to be high (J. Bradbury, University of Adelaide, pers. comm.). It is likely that many cave systems will have endemic species. When Bradbury's work is completed it is likely that it will reveal a number of restricted species of *Austrogammarus* and *Neoniphargus,* some of which are likely to qualify for Schedule 5 (Rare) under the Tasmanian *Threatened Species Protection Act* 1995*.*

Neither of the amphipods collected in the field survey were strongly troglomorphic, but both showed reduced pigmentation and reduced eyes. These features are also characteristic of amphipods from interstitial habitats. Neither genus is commonly found in caves; Clarke (1997) lists 12 cave collections of *Austrogammarus* spp. (mostly from the north west, but including caves in the Lower Maxwell and Franklin karst areas) and 17 of *Neoniphargus* spp. (mostly from the Mt Cripps karst area). This compares with more than double that number of records of *Antipodeus,* which is also known from many more karst areas.

Clarke (1997) lists three other paramelitid amphipod species that have been collected from Bill Neilson Cave: species of *Antipodeus, Giniphargus* and an unidentified genus with characteristics reminiscent of the West Australian genus *Hurleya.* Of these, *Giniphargus* is a strongly troglomorphic genus also found in Victoria. It is known from crayfish burrows and also from the Mt Cripps and Acheron River karst (Clarke 1997). The unidentified genus is also troglomorphic in that it is blind, and it has been recorded from a number of Tasmanian caves.

<u>Isopoda</u>. An unidentified species of *Styloniscus* was listed by Clarke (1997) in Bill Neilson Cave. Troglobitic slaters have been recorded in several Tasmanian caves (Eberhard *et al.* 1991). Two undescribed species of *Styloniscus* are strongly troglomorphic; one is known only from the Ida Bay area, but the other has been recorded from caves in 11 karst areas.

Two forms of aquatic heteriid isopods have been collected from the cave (Clarke 1997). The group is under revision (P.H.J. Horwitz & B. Knott, Edith Cowan University and University of Western Australia), and there is likely to be considerable species diversity. Heteriids are known from a number of Tasmanian caves (Eberhard *et al.* 1991, Clarke 1997).

<u>Syncarida</u>. The Anaspidacea are restricted to south east Australia, and Tasmania is the centre of diversity of the group; three families are present, the larger Anaspididae, the Psammaspididae and the Koonungidae, all of which have been recorded in caves. *Micraspides* spp. are found widely in the northern half of western Tasmania in fine sediments in seepages, springs, and crayfish burrows as well as caves. The taxonomy of the genus is in need of revision (Lake *et al.* 1978) and several undescribed species exist.

Koonungid syncarids are occasionally found in caves (Eberhard *et al.* 1991), but their presence may only be due to their general adaptations for life in ground water. Members of the genus

Eucrenonspides, in the related family the Psammaspididae, are more commonly found in caves in Tasmania, though not as yet in the north west of the state.

Anaspides spp. have been widely recorded from Tasmanian caves, though there is only one other record from the Gordon region, in Ballawine Cave in the Lower Maxwell karst. The genus is being revised (Jane Andrew, University of Tasmania), and it is likely that some cave forms will be described as new species. These cave records of *Anaspides* are outside the range of surface populations of the genus. This may mean that caves are a refuge from predation by introduced trout, or from climatic change.

Decapoda. Burrowing crayfish in the genus *Engaeus* are abundant in the rainforests of western Tasmania (Horwitz 1990). *E. fossor* and *E. cisternarius* partition habitats in creek gullies (Suter & Richardson 1977) and are both likely to be found around cave entrances, but usually no further into caves because of their requirement for soil to burrow in. The population of *E. cisternarius* in Bill Neilson Cave simply reflects the very open nature of the cave and the material that has collapsed into it from above through the daylight holes.

Astacopsis tricornis is the common river-dwelling crayfish in the west of Tasmania, growing to a large size (>1 kg). Although it has been noted as a species of conservation significance (Bryant & Jackson 1999), it is not listed under legislation and is widespread in the World Heritage Area. Further north it is replaced by *A. gouldi*. The latter species is listed on Schedule 4 (Vulnerable) of the Tasmanian *Threatened Species Protection Act* 1995 and has been recorded in caves (Eberhard *et al.* 1991) as an accidental, but no troglobitic crayfish are known from Australia despite the rich cave crayfish fauna in North and Central America (Hobbs *et al.* 1977).

Myriapoda

A single polydesmid millipede was collected during the field survey, and another specimen was reported by the karst hydrology team. The collected specimen will be sent to Dr. Bob Mesibov (Queen Victoria Museum, Launceston) for identification.

Troglobitic millipedes are widespread in Tasmanian caves, but all centipedes appear to be accidentals in caves. (Clarke 1997) lists a polydesmid (Dalodesmidae) and an unidentified millipede from Bill Neilson Cave.

Opiliones

Tasmania has a diverse fauna of harvestmen (Laniatores and Palpatores), several of which are troglobitic (Hickman 1958, Hunt, 1990, 1995, Hunt & Hickman 1993, Eberhard *et al.* 1991).

Troglobitic harvestmen are known in Tasmania from the genera *Hickmanoxyomma*, *Lomanella, Mestonia*, *Notonuncia* and *Glyptobunus.* Two cave harvestmen, *Hickmanoxyomma gibbergunya* and *H. cavaticum,* appear on Schedule 5 (Rare) of the Tasmanian *Threatened Species Protection Act* 1995, while *H. goedei* has been recognised as a cave invertebrate of high conservation significance due to its natural rarity and restricted distribution (Bryant & Jackson 1999).

Araneae

Tasmanian caves contain a diverse and interesting spider fauna (Eberhard *et al.* 1991). Amaurobiidae, Austrochilidae, Synotaxidae, and Micropholcommatidae all represent important cavernicolous groups, as discussed below. Cycloctenidae and Theridiosomatidae have also been found in Tasmanian caves, while Stiphidiidae and Metidae are a common entrance zone groups. Thomisidae are surface forms rarely found in caves.

Eight species of spider were collected or observed, representing eight different families and ranging from surface species to troglobites. Given the current gaps in taxonomic knowledge for this group, only one could be placed in a named species, and only two others assigned to genera. This is similar to the earlier attempts to identify spider material from this area (Eberhard *et al.* 1991, Clarke 1997).

Hickmania troglodytes, the Tasmanian cave spider, is the type and sole representative of its genus. This animal is not only of high ecological importance within caves, but is a phylogenetically and zoogeographically important species that is confined to Tasmania, with its closest relatives in Chile and Argentina (Eberhard *et al.* 1991, Doran *et al.* 1997, 1999a+b, 2001). The species has been recognised as a significant component of Australia's biodiversity (Mummery & Hardy 1996) and – as with the Crustacea – as an outstanding faunal example of the major stages in the earth's evolutionary history, as identified in the formal criteria for which the Tasmanian Wilderness is inscribed on the World Heritage List (Australian Heritage Commission 2000). Despite its significance on these counts, however, the species is a widespread troglophile common in cave and rainforest habitats throughout Tasmania, and is not restricted to the Gordon karst.

The Synotaxidae is a family of southern hemisphere distribution and has at least 4 species in Tasmania, all in the endemic genus *Tupua* (Eberhard *et al.* 1991). Three of these are found in caves and appear to be troglophiles, although at least one may be a troglobite (Forster *et al.* 1990, Eberhard *et al.* 1991). These spiders are superficially similar to *H. troglodytes* in appearance and habit, and build a similar (if finer woven) horizontal sheet web (R. Raven, Queensland Museum, pers. comm.). *Tupua troglodytes*, the potential troglobite, has previously been collected from the Franklin River (Gahnia Cave) but is depigmented (Eberhard *et al.* 1991). The specimens from Bill Neilson Cave are heavily pigmented, however, and are almost certainly troglophiles, given their proximity to cave entrances. This may identify the species as either *T. bisetosa* or *Tupua sp. (*near *bisetosa)* – which have a wide distribution from Hastings to Mole Creek – although other unidentified and undescribed material does exist and an indeterminate troglophilic species has previously been collected from the Franklin River (Kutikina Cave: Eberhard *et al.* 1991). At least one *Tupua* species (*cavernicola*) has previously been recognised as a cave invertebrate of high conservation significance (Bryant & Jackson 1999).

The Cycloctenidae are fast hunting spiders, closely related to wolf spiders. Four species have been recorded from Tasmania, but many more are likely to be present as the family is extremely common in the state. The species collected from Bill Neilson Cave represents a new spider family for this karst area, and may be quite cave-adapted given its location on the siltbank at some depth within the cave. Two genera (*Cycloctenus* and *Toxopsiella*) have been found in Tasmanian caves, but these include species that are yet to be described (Eberhard *et al.* 1991). Specimens are usually found near entrances, but can be found in the deep zone. *Cycloctenus cryptophilus* has previously been recorded from Kutikina Cave and Proina Cave on the Franklin River, while other species from the genus have been collected from caves interstate.

Tasmanian caves have a diverse troglobitic spider fauna, including several endemic genera (Eberhard *et al.* 1991), but it is hard to provide any commentary on the significance of these until they are known in greater detail. The Amaurobiidae are currently under revision, but represent a large group with many genera and species in Tasmania, including some significant troglobites. The amaurobiid species caught on the siltbank and above one of the groundwater inflows would appear to be a troglobite similar to other amaurobiids found throughout the state, and in keeping with the material already recorded for Bill Neilson Cave and caves on the Franklin River (Eberhard *et al.* 1991, Clarke 1997). These spiders are considered to be one of the dominant terrestrial predators in the deep cave zone. They are vagrant hunters covering a wide range of cave substrates, are not known to spin webs, and juveniles tend to be depigmented and to display some degree of eye reduction. Notably, the adult male collected in this study was found associated with a distinct web over one of the groundwater streams, and a preliminary examination of the collected material suggests that noticeable eye and pigment reduction may even be evident in the adults.

The crab spider (Thomisidae) caught at the lower entrance of the cave was an accidental/surface form. Various other surface and entrance zone spider groups (Metidae, Stiphidiidae) were also seen, but were not collected or recorded in detail. '*Orsinome*' sp. (Metidae) is a troglophilic/entrance zone species previously recorded from Bill Neilson Cave (Eberhard *et al.* 1991). Stiphidiidae are a common entrance zone/surface family around Tasmania, and have previously been recorded from Bill Neilson

Cave as well as from the caves on the Franklin River and the Gordon-Sprent area (Eberhard *et al.* 1991).

The small web-dwelling spider seen but not captured may have belonged to the theridiid genus *Icona* sp. previously recorded from Bill Neilson Cave (Eberhard *et al.* 1991). This genus is typically found in low abundance in a fine sheet web between formations in the transition zone or beyond. The genus includes both troglophiles and highly adapted troglobites. It is distributed in caves across southern Australia, but is otherwise only known from New Zealand's subantarctic islands. The only known surface populations occur in the Franklin valley (Eberhard *et al.* 1991).

Another small spider recorded from previous collections is a specimen from the theridiosomatid genus *Baalzebub*, a troglophile generally inhabiting entrance, twilight and transition zones, but showing little sign of troglomorphic modification (Eberhard *et al.* 1991).

Finally, spiders of the micropholcommatid genus *Olgania* have not been recorded from the Nicholls Range karst, although it is possible that they may be found in this area. This genus is represented by one rare surface/troglophilic species (*O. excavata*, listed on Schedule 5 (Rare) of the Tasmanian *Threatened Species Protection Act* 1995) and several undescribed and highly troglomorphic cave dwelling forms (Eberhard *et al.* 1991). The type locality for *O. excavata* is a surface site in the Gordon River Valley (Hickman 1979, Bryant & Jackson 1999), while an undescribed troglobite of the genus has been recorded from Kutikina Cave on the Franklin River (Eberhard *et al.* 1991).

4 IMPACTS AND MITIGATION

4.1 Potential impacts

Potential management issues in any cave are directly related to air and water flow (including levels, reversals and timing), temperature, humidity, food infall, riverbank and siltbank stability, organic and inorganic pollution (including sedimentation) and the effects of repeated draw-downs in karstic groundwater (Eberhard *et al.* 1991, Kiernan *et al.* 1993, Clarke 1997, Doran *et al.* 1997, Richardson *et al.* 1997, Slaney & Weinstein 1997, Doran *et al.* 1999a). The relevant issues will be discussed under each of the following sections.

4.2 Current conditions

Given that the prevailing operational and regulated flow conditions in the Gordon River have been in place for the past 25 years, assemblages of cave fauna and entrance zone flora have most likely adjusted to these conditions. Taxa less tolerant of the new conditions will have long since changed in distribution and abundance, with little evidence remaining of any major changes that may have occurred. Comparisons of current survey lists with those for comparable unimpacted caves would not provide an adequate surrogate, given the distinct and different assemblages that are found in different karst areas and types of cave.

Of the limited pre-regulation biological data available for Bill Neilson Cave itself (Middleton 1977, 1979), it would appear that the two major colonies of glow-worms, *Arachnocampa tasmaniensis,* remain in place, as do those of the cave cricket, *Micropathus montanus.* The karst hydrology report (Deakin *et al.* 2001) indicates that there has been increased deposition of sediments along the cave stream banks in this time, and this may have changed some of the character of the lower entrance flora and fauna, displacing some finer siltbank dwelling species, inundating some vegetation, and permitting the invasion of some predominantly surface dwelling species such as the burrowing crayfish, *Engaeus cisternarius.*

Baseline species lists, flora abundance and fauna census data compiled in this study are available in Tables 3.1 & 3.2 and Attachments 1-3. While these data are from a preliminary study only, and while some may vary according to daily and seasonal trends, as well as atypical environmental conditions, it is likely that the biological *status quo* within Bill Neilson Cave remains relatively constant.

While the layout of many caves can include multiple entrances (in turn complicating environmental conditions and the distribution of fauna), Bill Neilson Cave is atypical given the number of entrances and daylight holes present along its length. Because of these holes, the majority of the fauna appears to be restricted to surface, troglophilic and trogloxenic forms, with little development of full troglobitic fauna for much of the cave. Similarly Kayak Kavern is little more than a large overhang, and as such would appear to be entirely limited to entrance zone fauna.

A similar lack of terrestrial and aquatic troglobites has been found in surveys of other caves of limited size (Richardson & Doran 1998). It has also previously been noted that the western riverine karst is generally less species rich than the larger karst bodies with greater surface relief elsewhere in the State (Eberhard *et al.* 1991).

4.3 Potential changes due to Basslink

4.3.1 Overview

Potential changes due to Basslink operations will depend directly and indirectly on changes to hydrology within and around the cave system.

As outlined in the karst hydrology report (Deakin *et al*. 2001), Tasmanian Electricity Market Simulation Model (TEMSIM) predictions indicate that Basslink operations will produce a greater degree of fluctuation to flow levels in the Gordon River, with an increase in peak flow events. This will occur through:

- greater short-term variability in power station discharge levels;
- increased short-term power station (discharge) shutdowns;
- minor increases in the duration of peak flows per year (but not increases in peak levels); and
- distribution of increased flow over a longer period per year.

In terms of the Nicholls Range karst, Deakin *et al*. (2001) indicate that minimal direct hydrological impact will extend above the first major bend in Bill Neilson Cave (at the base of the main siltbank/upper levels). Below this, hydrological impacts are predicted to be streamway related only (through sediment deposition and erosion processes), with no damage to the higher-positioned siltbanks and formations within the cave. The primary Basslink hydrological issue in both Bill Neilson Cave and Kayak Kavern is identified as the potential increase in cave sediment disturbance to both caves, due to increased frequency in the systematic and repetitive cycle of saturation and dewatering of the sediments. This is predicted to lead to further deposition of fine sediment in both caves, and additional slumping and collapse of sediment in the Bill Neilson Cave in particular (see Deakin *et al*. 2001). The implications of these hydrological impacts to the flora and fauna are discussed below.

4.3.2 *Flora*

Cave flora is restricted to the entrance zones, and is also composed of species common throughout the surrounding forest. As previously mentioned, Tasmanian riverine karst is proving to be rich in terms of lichens and bryophytes, including species that are proposed for listing under the *Threatened Species Protection Act* 1995 (G. Kantvilas, Tasmanian Herbarium, pers. comm.). The identification of these species is a very specialised field and may benefit from specialist surveys in Bill Neilson Cave, although most of the areas that will be affected by water level fluctuations are covered by thick silt alone without any trace of vegetation. The majority of flora was instead observed to be growing well above the level which would be affected by water level fluctuations. The flora element of most significance, *T. laeviusculum*, was only collected from the daylight hole at the top end of the cave, well above the area that will be affected by Basslink operations.

The greatest impact on the flora is likely to be through depositional and erosional impacts on the substrate itself.

4.3.3 Stream fauna

Stream fauna will be directly affected by the fluctuating levels of the Gordon River.

Sources of impact include the level of increases in stream level and backflow produced by power station peaks, contrasted with enhanced outflow at power station lows, and atypical timing and frequency to flow peaks and throughs. True aquatic cave faunas would be especially prone to the effects of such disturbance due to:

- the direct physical conditions themselves (flow pattern and strength), as they are often strongly rheotactic to prevent accidental departure from a cave;
- the effect of altered flow on sites and rates of deposition for organic debris (a critical source of food);
- the effect of altered flow on reproductive cues (based on both physical abilities, triggers and non-photoperiod based cues); and
- alteration to water temperature (which is usually relatively constant within cave environments).

Such disruption to flow levels, whether they increase or decrease, can have devastating effects on aquatic cave fauna (Vandel 1965, Barr 1967 & 1968, Culver 1982). Although water levels may fluctuate enormously during the normal yearly cycle, these changes are generally much more predictable in subterranean streams than on the surface, and exceptionally severe conditions during the normal season are not as potentially catastrophic as relatively minor floods occurring at unusual time, or even the absence of floods at the expected time (Culver 1970, Howarth 1983).

Hydro Tasmania operations under the current regime and particularly under the proposed Basslink regime have the potential to affect aquatic cave fauna in these ways. However, due to the preponderance of entrances and daylight holes, the stream fauna throughout the cave is predominantly of surface origin. In effect, the stream through Bill Neilson Cave is a surface stream that happens to flow through a cave, with little opportunity for the development of true troglobitic or stygobiontic (aquatic troglobite) faunas. Of the aquatic species that were collected, only the amphipods show any troglomorphies, and these are no more strongly developed than forms that might be found in sheltered "surface" habitats such as rainforest seepages.

This situation is likely to be enhanced by the surface origin of most of the waterflow through Bill Neilson Cave, as opposed to flow from a primarily groundwater source. While it is possible that some troglobitic fauna may be found in the groundwater inflows that meet this stream, nothing was found in the course of the surveys. These inflows also appear to be well enough back in the cave for the impacts of Basslink operations to be minimal.

Although the cave stream presents a different environment to that of the open river (with potential impacts varying according to the hydrology of the cave), the aquatic fauna in the section likely to be affected by Basslink operations would appear to be composed of surface species and forms. These would be in keeping with the character of the aquatic fauna found throughout the river, and populations within Bill Neilson Cave would represent only a small proportion of total surface community structure and abundance. Although non-listed species of conservation significance were present (e.g. *Astacopsis tricornis*), these are widely spread surface species, and are not likely to be adversely affected by changes to stream levels and flow within the cave. As the stream flows directly into the Gordon River, there would in turn be little direct interaction or dependence of true cave species upon the aquatic fauna within or downstream of this section of the cave.

No specific cave fauna management issues would therefore appear to arise in relation to the aquatic fauna. Surface species are likely to be far more robust to such fluctuations than a true cave developed fauna would be, with such species either indifferent to fluctuations or able to re-establish from larger populations found in surface habitats. Recommendations for management are therefore not specifically cave related but would be in keeping with approaches to the management of Gordon River aquatic fauna as a whole.

4.3.4 Terrestrial fauna (streamway and siltbanks)

As outlined in the Introduction and Section 2.3.3.2, terrestrial cave faunas are also at the mercy of changes to environmental conditions, particularly to variations in food inflow, temperature, humidity, evaporation rate, and (very importantly) patterns and directions of airflow (Vandel 1965, Barr 1967 & 1968, Poulson & White 1969, Culver 1982, Howarth 1983). These issues are complicated within stream-bearing caves, and again would be greatly influenced by the frequency of entrances and daylight holes encountered in Bill Neilson Cave. For this reason, the fauna along the stream itself is a mixture of surface species, troglophiles and trogloxenes (prominently Hickman's cave spider, cave crickets and the glow-worms). Some life stages of these groups require greater environmental stability than others, and are found away from the main passage (see census and transect results: Attachments 1-3).

Although the troglophilic and trogloxenic fauna of the cave includes species of global, phylogenetic and evolutionary significance (e.g. *Hickmania troglodytes* and *Arachnocampa tasmaniensis*), these are common throughout the cave and the surrounding forest (and some throughout the State) and do not present a specific management issue for this cave.

The siltbank fauna, however, is the most representative of a deeper cave fauna (e.g. through its strong beetle, amaurobiid spider and opilionid fauna). While these areas are above the direct (physical) influence of the stream, this fauna could be susceptible to Basslink operational changes through effects that alteration of levels/flow may have on humidity, temperature and air flow patterns through the cave. Changes in external factors such as vegetation cover and water flow can change diurnal and seasonal patterns of 'cave breathing' and enhance drying and warm air penetration into the cave environment. This can influence the distribution of cave zones and the consequent survival and reproductive cues of cave obligate species.

While cave species can be acutely sensitive to such variations, however, the multitude of entrances and daylight holes to Bill Neilson cave are likely to reduce the relative impact of Basslink operations on this fauna (e.g. see Peck 1976). As with the entrance zone flora, the greater concern is likely to be depositional and erosional (slumping and collapse) issues that may undermine or swamp the lower foundations of the siltbank

4.4 Management issues

As described in Section 4.2, the flora and fauna of the Nicholls Range karst has most likely long since adjusted to the current hydrological regime on the Gordon River. While some depositional and displacement issues have been discussed, these are relatively minor and do not represent management issues that need to be addressed under the current operational regime.

Although the operational changes under Basslink could produce conditions that would affect many cave fauna, the atypical structure of the cave (with large numbers of entrances and daylight holes) leaves little habitat or conditions for true cave fauna development. Stream fauna is likely to be highly effected in the lower entrance, but this fauna is not cavernicolous and so is not a cave fauna issue. Only limited cave adapted aquatic fauna was found (e.g. amphipods), and this tended to be in inflows and pools away from the area that will be impacted by the operational changes.

Terrestrial fauna along the main streamway and entrance holes consists of a mix of surface species and troglophilic and trogloxenic forms. Although some of these are of significance, they are not of particular rarity and are either numerous in the cave and surrounding forest or are positioned far enough above the stream or in side tunnels to avoid direct inundation from the stream. These species are likely to be far less susceptible to Basslink driven changes to air flow than troglobites would be, particularly given the already complicated pattern of entrances and daylight holes within the cave. While some troglobitic fauna was found along the stream (e.g. amaurobiid spiders), these tended to be in side passages and groundwater inflows, again away from the influences of Basslink and the stream as a whole.

The siltbank/upper level fauna represents the truest cave adapted fauna in Bill Neilson Cave, and is itself far enough above the stream to avoid direct impacts from changes to the operational flow (particularly as the maximum levels of the peak flow will not change). Although this fauna may otherwise be susceptible to changes produced by stream-driven alteration of cave breathing and air currents, the impact of these changes (pending monitoring) is again likely to be limited in comparison to the effects and complicated nature of the multiple entrances and daylight holes throughout the cave.

Notably, Deakin *et al*. (2001) identify the higher level, dry sediments as potentially much older than the lower wet sediments and worthy of further investigation. These dry sediments are outside the direct effects of current and proposed Basslink operational flows, but could become a management issue under higher flood events (including operational water levels boosted by periods of natural flooding).

Under Basslink operations, it would therefore appear that erosional and depositional impacts on the streamside sediments and lower siltbanks (i.e. effects on the substrate itself) represent the greatest potential issue in terms of flora and fauna management.

4.5 Mitigation options

As outlined by Deakin *et al*. (2001), the primary hydrological management issue in Bill Neilson Cave and Kayak Kavern at the current time appears to be the deposition and transfer of fine sediment, which is likely to increase under Basslink operations. In addition to cumulative sedimentation, the karst hydrology report indicates that the increased frequency of drawdown events may produce additional slumping and collapse of sediment banks in Bill Neilson Cave.

As the major management issues for flora and flora appear to be related to erosion and deposition (including the stability of the foundations of the siltbank), it is recommended that mitigation options follow those recommended by the karst hydrology report. Supplementary biological monitoring (see the following section) should be conducted to measure the level of potential impact, ensure that the conclusions and priorities presented in this report are correct, and assess the degree of any mitigation required.

Non-cave species are covered by other reports. In terms of this assessment, mitigation of impacts on Bill Neilson cave should therefore focus specifically on those affecting true cave fauna rather than surface forms extending into the cave (unless the latter form a crucial part of the ecology on which the true cave forms depend). If the cave fauna is effected by increased erosion or sedimentation, mitigation efforts will need to buffer the cave from these impacts. This may either be attempted as part of a program to regulate/ease the effects of water level, flow rate, fluctuation frequency or sediment load across either the whole river or solely within the cave, depending on how these recommendations tally with other reports.

Potential mitigation actions need to be assessed in terms of their effectiveness, their cost/benefit value, and their own impacts on the cave environment. Physical structures (baffles, dams, weirs, or sumps) may lessen water flow and reduce its power within the entrance of the cave, to reduce erosion and slow the rate of water entry/loss. Deposition and erosion may also be reduced by the use of sediment basins or filters, or by the active stabilisation or reinforcement of stream and sediment banks (e.g. with netting). However, such actions are likely to lead only to a slowing of the rate of impact, which may still present a problem over the longer term.

If such methods are also specifically limited within the cave (where they would be easier to put in place), they will themselves represent drastic modifications to the existing cave hydrology and morphology. It is therefore inappropriate to make firm mitigation recommendations on the basis of this brief report. The potential effects of such actions would need to be subjected to more comprehensive assessment to ensure that they would themselves not have a more damaging impact on the hydrology, ecology, and geo-conservation value of the cave.

4.6 Monitoring considerations

Any further monitoring of Gordon River cave biota should consider the following.

The costs and benefits of future monitoring need to be considered, given that the potential impacts on flora and fauna may be limited to those outlined above. However, it must be stressed that the conclusions of this report are based on preliminary investigations only, and so it is crucial that monitoring is undertaken in future to ensure that no unforeseen environmental impacts – or unforeseen magnitudes of impact – occur to the detriment of species and communities of note (e.g. the siltbank fauna or the significant elements of the flora).

(1) Sediment

As recommended by Deakin *et al*. (2001) in Appendix 5 of this report series, it is important that the condition and movement of the sediment itself are monitored in Bill Neilson Cave both pre- and post-Basslink. Sediment transfer and abnormally high water levels (produced in synergy by operational flows and atypical natural levels) need to be examined in terms of both direct hydrological effects and the effects they may have on the biological communities within the cave. To this end, we support the sediment and water level monitoring protocols recommended in Appendix 5, and note that elements of biological monitoring could readily be established in conjunction with these.

(2) Biological

The sparse, small and cryptic nature of troglobitic cave fauna can make regular monitoring programs untenable, as sampling programs may not find the animals they seek, let alone enough of them to detect change in time to act. Such sampling can also be detrimental to the species and habitats they aim to study (Peck 1976, Doran *et al.* 1997, Slaney and Weinstein 1997). For this reason, troglophiles and trogloxenes are often used as surrogates for detecting environmental impacts within cave ecosystems (the validity of such surrogates in simplified environments such as caves is discussed in Doran *et al.* 1999a). Such monitoring can readily follow the patterns of long-term cave fauna monitoring programs already established in Tasmania (e.g. at Mole Creek, Exit Cave and Hastings Caves) by the University, the Forest Practices Board, and the Department of Primary Industries, Water and Environment (Eberhard 1990, Eberhard & Kiernan 1991, Doran *et al.* 1997, Richardson *et al.* 1997, Doran *et al.* 1999a, Eberhard 1999).

In keeping with the methodology developed for these programs, this work has identified key collection points and census areas for the flora and fauna (aquatic, streamway/entrance and siltbank) communities within the cave (see baseline data: Attachments 1-3). The same collections, transects and census counts may be replicated in future years to monitor whether the water level fluctuations are having any impact on flora and fauna composition, distribution and abundance at the respective locations.

It is recognised that the availability of true 'control' monitoring sites is limited, both through the lack of a replicate, unimpacted cave nearby and through limited opportunities for pseudo controls within the cave itself. In this way, assessment of hydro-related impacts is similar to the testing of an industrial process, where trials of different conditions within a single system can only be made over time.

Complications of natural seasonal and yearly variation can be compensated for by comparing the *degree* of change in flora and fauna communities between higher and lower survey sites (i.e. those above and below the projected extent of impact) rather than directly comparing communities *per se.* This is outlined in a modification of the general hypothesis presented by Doran (1999), whereby general community status (whether measured by growth, number, composition or biomass) is the sum of:

(i) the average growth, number, composition or biomass that would have persisted or occurred in a site irrespective of other variation; plus

(ii) time effects on growth, number, composition or biomass (such as seasonal or yearly changes in climate, natural events, etc); plus

(iii) community effects produced by ‘experimental’ regulation (in this case flow regulation under Basslink); plus
(iv) chance effects.

Assuming that (ii), (iii) and (iv) are independent, both (i) and (ii) would effectively nullify each other between the higher and lower sites on the stream. Provided these assumptions are kept in mind, this provides a general means of comparing the severity of potential Basslink regulation effects on cave biota over time.

To this end, monitoring would measure (a) flora and fauna species lists at these points and throughout the cave, and (b) the abundance of flora and fauna species within communities at these census points, to determine whether these lists and communities:

(1) remained the same above and below the projected zone of impact from Basslink (= no Basslink impact);
(2) changed to comparable degrees both above and below the projected zone of impact from Basslink (= no Basslink impact); or
(3) became markedly reduced in the lower regions of the cave (= a potential Basslink impact, the severity of which would depend on habitat stability whether species/communities remained represented throughout the cave or surrounding areas).

This monitoring would serve both as a measure of the condition of these specific floral and faunal communities (i.e. entrance zone flora, cave spiders, glow-worms, crickets, and the more common siltbank species), as well as a surrogate for the rarer communities within the cave.

The scale of such monitoring can be tailored to other Basslink monitoring needs and schedules, and can be comprehensive (incorporating all of the elements measured in this study and undertaken by specialists). It can also focus on a selection of key but straightforward counts and measures (designed to be undertaken by non-specialists following instruction), or can be a mixture of the two over time.

Whichever option is taken, future monitoring needs to follow a careful protocol to minimise disturbance to the fauna and sensitive habitat types such as the siltbank (i.e. through limiting movement to a distinct path, as used in this survey) and muddy entrance slopes. The basis for such visitor protocols can be found in the Australian Speleological Federation’s *Minimal Impact Caving Code* (1995), with modifications for scientific surveys and fauna protection outlined by Eberhard (1990, 1999), Eberhard and Kiernan (1991) and Doran *et al.* (1997).

Finally, in addition to such monitoring, future work needs to remain flexible enough to incorporate other developed karst of significance if discovered in the region.

5 SUMMARY

This report discusses the results of survey work on the cave fauna and entrance zone flora of the Nicholls Range karst (Bill Neilson Cave NR-001 and Kayak Kavern NR-002) on the Gordon River. The work was constrained by a number of factors, and so the results are at best a preliminary interpretation of the status of these communities.

Prevailing water management conditions on the Gordon River have been in place for so long that any impacts on the flora and fauna of the cave(s) are no longer likely to be detectable. Instead, the distribution and abundance of any sensitive species will have adjusted to the current conditions, and are most at mercy of future changes to this regime (such as proposed under Basslink).

Cave flora surveys produced only one species of significance in Bill Neilson cave: the bryophyte *Thuidium laeviusculum*, which has only been found on one other occasion since 1912 and has not previously been found on the west coast. Lichens and bryophytes represent a very rich and specialised field separate to other flora, and may benefit from specialist collections and surveys in future. Although there may be some scope for further work on such specialised flora groups, most of the flora species present are common and impacts are most likely to be erosional/depositional.

There appears to be relatively little development of a true cave adapted (troglobitic) fauna in Bill Neilson Cave in comparison to other caves, most likely due to the structure of the cave and the abundance of entrances and daylight holes. While some cave adapted species of conservation significance are and may be present (including some rarer forms not collected in the limited time available for this survey), these are likely to occur beyond the areas directly affected by fluctuations in the stream. Food and environmental conditions for these species are also likely to be less affected by the stream, and so major issues are again likely to be erosional/hydrological issues affecting the stability of the siltbanks and groundwater inflows themselves. Similarly, Kayak Kavern is little more than an extended overhang or entrance zone, and is of little significance in terms of troglobitic cave fauna.

Although both Bill Neilson Cave and Kayak Kavern contain terrestrial troglophilic, trogloxenic and accidental fauna of global/evolutionary and ecological significance, as well as some (non-listed) species of conservation importance, these species are not restricted to the cave, and are instead found extending throughout the surrounding forest. Some also have wider distributions throughout surrounding regions. While some of these animals may be directly affected by stream level fluctuations, the impact on their populations is likely to be negligible. Stream fauna within the main cave channel is of surface character, and its management requirements will be the same as for stream invertebrates along the Gordon River itself.

Potential long term monitoring sites, strategies and baseline data have been identified and provided, to allow these conclusions to be tested under the development and implementation of the Basslink proposal. Such monitoring should be coupled with hydrological monitoring of sediment deposition and transfer, atypical peak waterflows, and sediment slumping and collapse.

Finally, it needs to be emphasized that the above conclusions are based on very limited field investigations and a very small literature base. Because of the nature of caves, with their difficult topography and very dispersed food supply, troglobitic animals are always rare, usually small and cryptic, and consequently hard to find. Direct collecting is only possible in passages to which humans can gain access, and these may only be a small proportion of the caverns in the rock. Further work would undoubtedly enhance these results in future.

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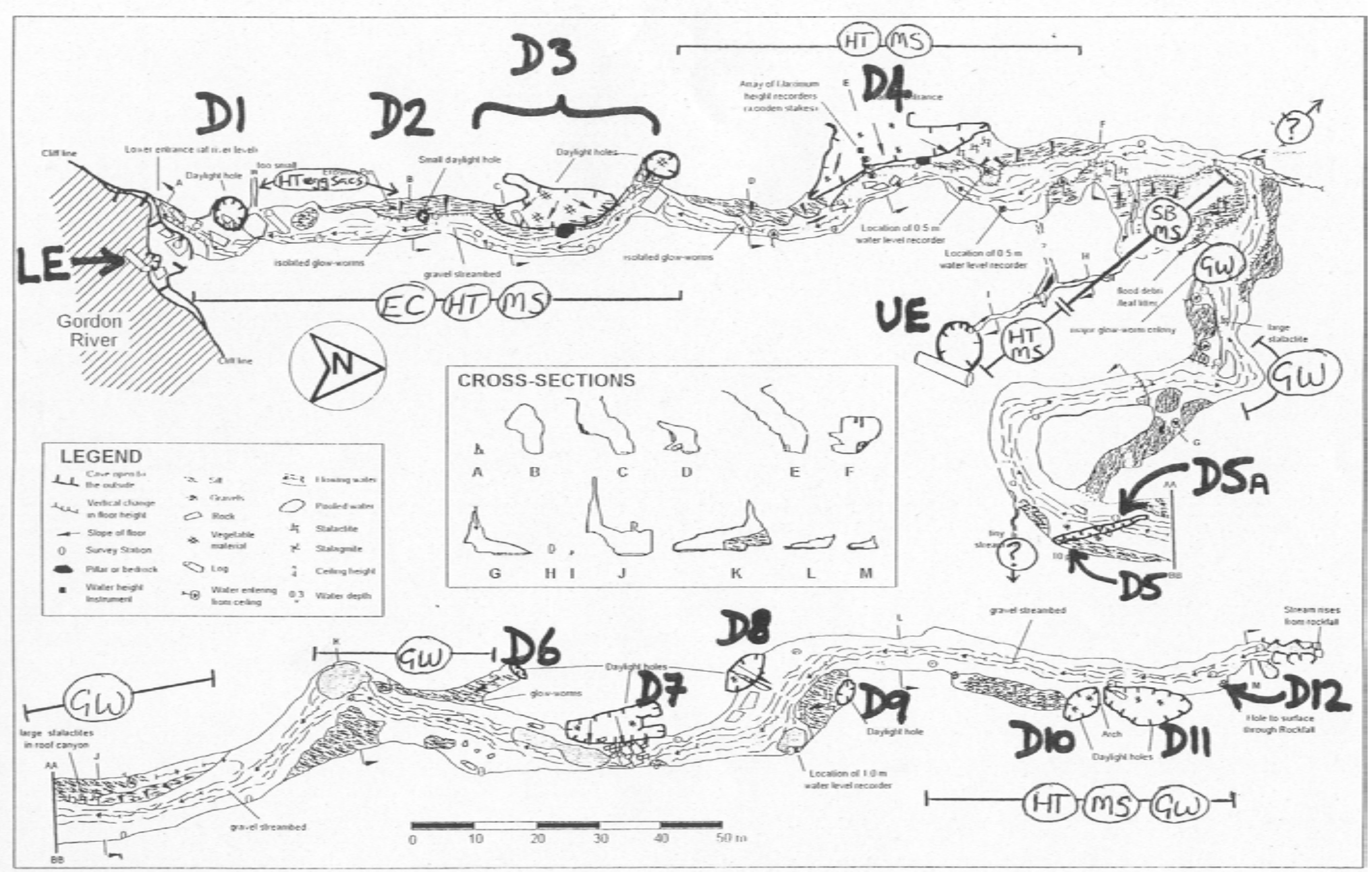
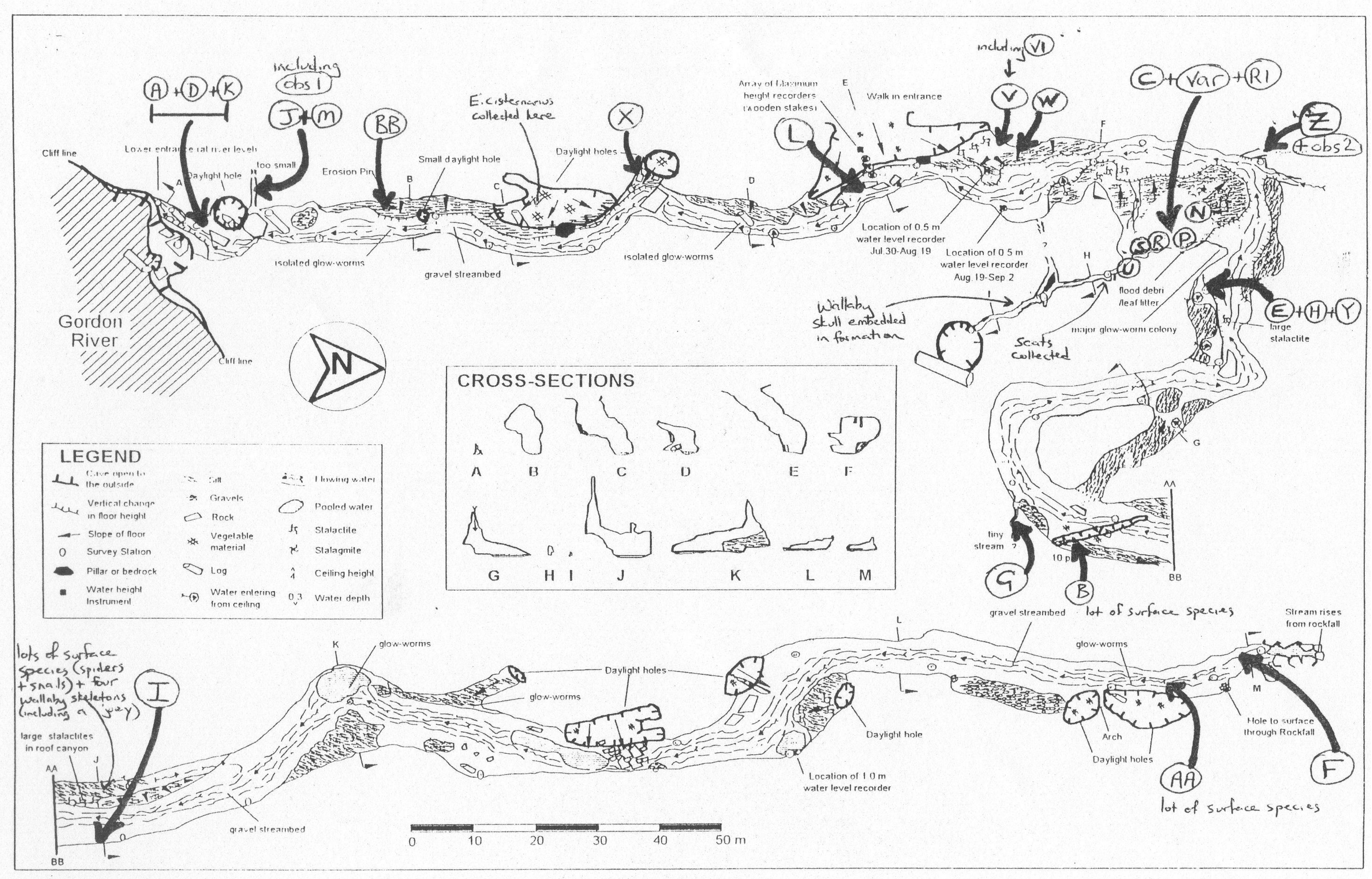
Figure 1. Daylight holes and major fauna populations in Bill Neilson Cave



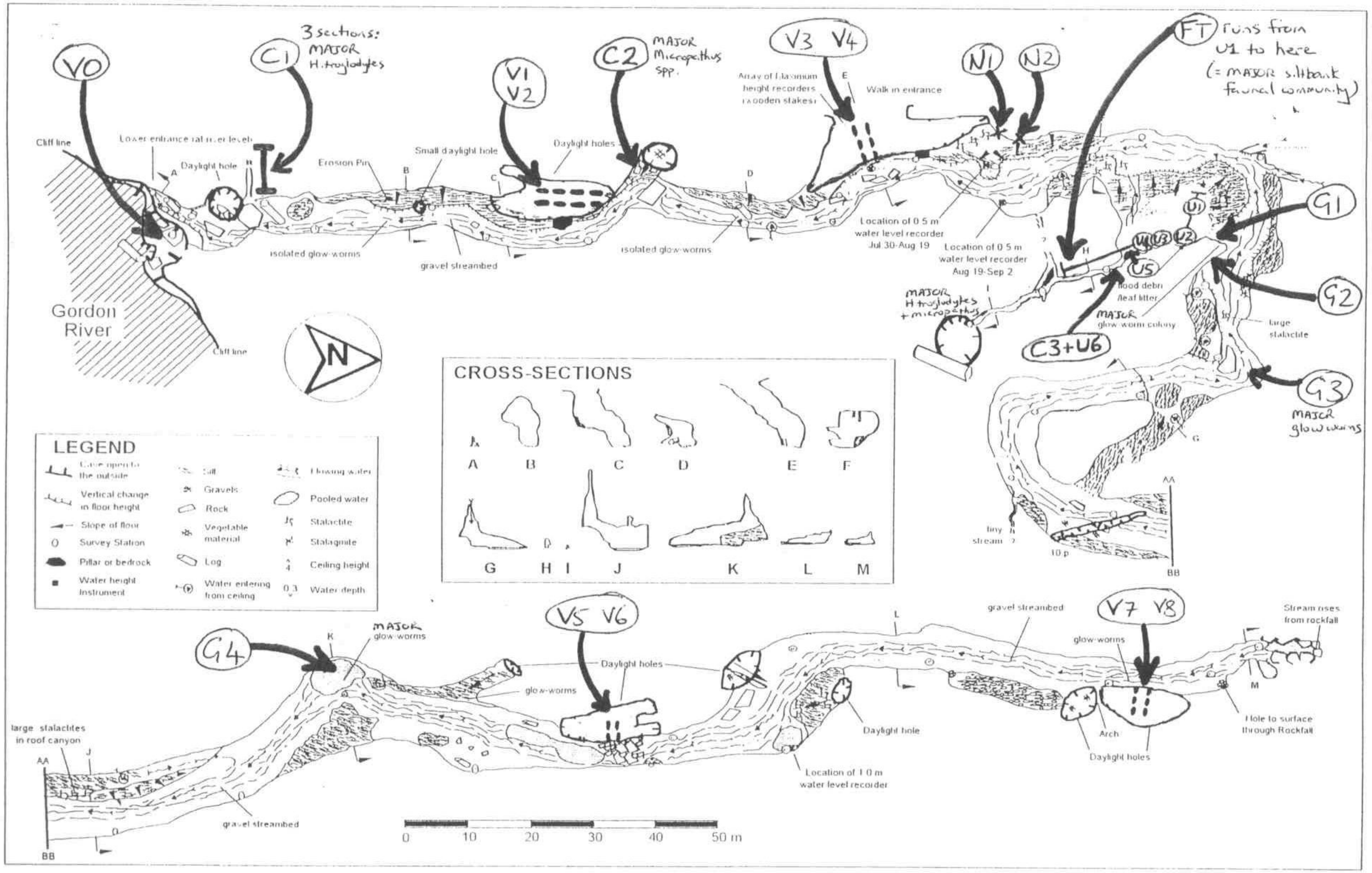
Daylight holes are numbered "D1" to "D12", while the lower (main) and upper entrances to the cave are labelled "LE" and "UE", respectively. Major fauna populations are as marked as "EC" (burrowing crayfish: *Engaeus cisternarius*, x1), "GW" (glow-worms: *Arachnocampa tasmaniensis,* x5), "HT" (Tasmanian cave spider: *Hickmania troglodytes*, x5), "MS" (cave crickets: *Micropathus* spp., x5), and "SB" (siltbank communities: including cave beetles, amaurobiid spiders and harvestmen, x1). Potential locations for groundwater faunas are marked as "?" (x2). The burrowing crayfish were found in streamside sediment banks, while the other marked fauna (with exception of the siltbank community and the possible groundwater species) tended to be found on the cave walls and roof. It must be noted that *H. troglodytes, Tupua* sp. (spider) and Micropathus spp. may also reach high numbers in other side passages, crevices and inaccessible folds of the roof throughout the cave (particularly near entrances). Metidate spiders and other predominantly entrance zone/.surface species are not marked. (map template by Jeff Butt: Appendix 5 of this report series**)**

Figure 2. Collection points in Bill Neilson Cave (sites as per Attachment 2)



(map template by Jeff Butt: Appendix 5 of this report series)

Figure 3. Census, transect, and trapping points in Bill Neilson Cave



Vegetation transect and collection sites are marked as follows: "VO" (main cave entrance, collection only), "V1, V2" (daylight hole D3 transects 1+2), "V3, V4" (daylight hole D4 transects 1+2), "V5, V6" (daylight hole D7 transects 1+2), and "V7, V8" (daylight hole D11 transects 1+2). General fauna census sites are marked as "C1" (lower entrance census shaft), "C2" (alcove at D3), and "C3" (the roof dome census in the upper passage). Glow-worm count sites are consecutively marked as "G1-G4", as per the numbering in the main text. Pitfall trapping sites are marked as "U1-U6" and "N1-N2", also as per the main text, while the siltbank fauna transect is marked as "FT". (map template by Jeff Butt: Appendix 5 of this report series)

ATTACHMENT 1: FLORA BY SITE

Flora abundances per site according to Braun-Blanquet scores.

	Daylight Hole D3 Transect 1 5 m	10 m	15 m	Transect 2 5 m	10 m	Daylight Hole D4 Transect 1 5 m	Transect 2 5 m	Daylight Hole D7 Transect 1 5 m	Transect 2 5 m	Daylight Hole D11 Transect 1 5 m	10 m	Transect 2 5 m
Silt/Mud	4	5	3	2		6	5		6	3	2	
Woody debris/litter								4		5	5	
Rock		2										
Dicotyledon												
Urtica incisa										2	2	
Ferns												
Hymenophyllum rarum	2											
Pteris comans		2	3			2	2	2				
Blechnum chambersii				2	3	3	3	2	2	2	2	2
Polystichum proliferum						2	2					
Mosses												
Cyathophorum bulbosum	3	3				2		2	2			
Lopidium concinnum	2	2	3			2	2					
Hypnodendron sp.						2	2			2	3	3
Thuidium laeviusculum										2		2
Thallose liverworts												
Marchantia foliacea	2	2	2	6	2	2	2	2	2	2	2	2
Marchantia sp.												2
Leafy liverworts												
Lepidolaena sp.	4		5	2	6	3	2	4	2	2	2	2
Schistochilia sp.	2					2	2	4	3			
Trichocolea mollissima			4									4
Plagiochila sp.						2	3			2	2	2

ATTACHMENT 2: FAUNA BY SITE

A presence/absence (not abundance) breakdown of species collected or observed per site and date within Bill Neilson Cave. Codes in the table are as per those for taxa in Table 3.2.

SAMPLES	Ordered by location in cave	Nemat	Oligo	Phran	Caryd	Nousia	Austp	Notoly	Eus_c	Eus_sp	Plecop	Mmon	Mcav	Hemip	Caloci	Hydro	Lepto	Prome	Glow	Tipul	Austg	Neonip	Ast_tri	E_cist	Poly	Hg_pal	Hg_pg	Htrog	Am	Cyclo	Met	Stiph	Syno	Thom	Aran
	Aquatic fauna																																		
A	LE stream fauna 30.7.00		1						1						1																				
D	LE stream fauna 19.8.00					1				1						1																			
K	LE stream fauna 20.8.00		1				1										1					1													
L	D4 stm fauna (at stakes) 20.8.00																																		Nil
Z	GW Stream 25.9.00																																		Nil
E+H	Roof drip (ast) site 20.8.00			1				1													1		1												
Y	Roof drip (ast) site 25.9.00																				1														
I	Standing pool opp. D5A 20.8.00					1																													
F	Stream fauna above D12 20.8.00		1			1																													
	Terrest fauna (streamway +ent)																																		
(A)	LE area 30.7.00 + obs											1	1											1	1			1			1			1	
J+M	LE census passage 20.8.00											1	1												1			1							**
(obs1)	LE census passage 25.9.00											1	1														1	1							**
BB	Bank & roof under D2 30.7.00		1									1	1						1					1				1							**
X	Shaft D3 census area 25.9.00											1	1						1					1				1			1	1	1		
(obs2)	GW Stream 20.8.00											1	1													1		1							
(E+H)	Roof drip (ast) site 20.8.00											1							1																
(I)	near D5A 20.8.00											1	1						1																
G	AM GW Inflow site 20.8.00											1	1														1	1	1						
B	under D5 30.7.00				1							1	1						1								1	1			1	1			
AA	Top of cave (D10-11) 25.9.00										1	1	1						1									1			1	1			
	Terrest fauna (siltbank)																																		

SAMPLES		Nemat	Oligo	Phran	Caryd	Nousia	Austp	Notoly	Eus_c	Eus_sp	Plecop	Mmon	Mcav	Hemip	Caloci	Hydro	Lepto	Prome	Glow	Tipul	Austg	Neonip	Ast_tri	E_cist	Poly	Hg_pal	Hg_pg	Htrog	Am	Cyclo	Met	Stiph	Syno	Thom	Aran
C	Upper level siltbank 19.8.00 + obs											1	1					1		1						1		1		1					1
var	as above 24.9.00 (O,Q,T + obs)											1	1					1	1									1	1						
(R1)	as above 25.9.00 + obs											1	1	1				1	1									1	1						
(V1)	Near N1 (obs) 24.9.00												1						1								1	1					1		
V	N1 Pitfall 24-25.9.00		1										1																						
W	N2 Pitfall 24-25.9.00												1																						
N	U1 Pitfall 24-25.9.00												1																						
P	U2 Pitfall 24-25.9.00											1																							
R	U4 Pitfall 24-25.9.00	1																																	
S	U5 Pitfall 24-25.9.00												1																						
U	U6 Pitfall 24-25.9.00		1																																
	Occurrences	**1**	**6**	**1**	**1**	**3**	**1**	**1**	**1**	**1**	**1**	**15**	**18**	**1**	**1**	**1**	**1**	**3**	**9**	**1**	**2**	**1**	**1**	**3**	**2**	**2**	**4**	**13**	**3**	**1**	**4**	**3**	**2**	**1**	**1**

Notes

The table includes occurrences of both collected and observed specimens from various points in the cave. Occurrences of the major species (marked in grey) are under-represented, as *Micropathus* spp, *Hickmania troglodytes* and *Arachnocampa tasmaniensis* are found throughout the cave, often in high numbers (including areas not scored above: see Figure 1 for major populations). *Arachnocampa tasmaniensis* is mainly found along the stream, particularly above Daylight Hole D4. *Engaeus cisternarius* is also highly abundant along the lower stream, from the lower entrance to Daylight Hole D4. Metidae & Stiphidiidae spiders and other surface species are common around most of the entrances and daylight holes, but were not all recorded. The **totals line** at the bottom of the table is of **numbers of occurences, not a sum** of the numbers in the columns (particularly where 0.5 figures are applied). 0.5 figures represent sites where the specific *Micropathus* species present was not determined, and could easily have been either of the two recorded.

ATTACHMENT 3: PITFALL, TRANSECT AND CENSUS DATA (FAUNA)

Stream fauna

Due to the surface (non-cave) character of the aquatic fauna, and the time constraints on field work, quantitative data were not collected on this section of the fauna.

Terrestrial fauna – stream passage and entrances

General census area 1: lower entrance (Census time: 1.45pm, 25.9.00)

Hickmania troglodytes

Cave spiders	Female	Male	Subadult	Juvenile
Section 1*	2	1	0	5
Section 2**	4	0	0	0
Section 3	2	0	1	0
(Total)	(8)	(1)	(1)	(5)

* *Note: one female H. troglodytes with an emerged eggsac (as per 20.8.00) in Scn 1*
** *Note: one female with an egg-sac in Scn 2; plus two discarded egg sacs collected from here on 20.8.00.*

Micropathus sp.

Cave crickets	Female <1 cm	Female 1-1.5cm	Female > 1.5cm	Other <1 cm	Other 1-1.5cm	Other > 1.5cm
Section 1*	0	4	4	75	23	3
Section 2	0	0	6	14	4	12
Section 3	0	0	8	7	4	14
(total)	(0)	(4)	(18)	(96)	(31)	(29)

Note: "Other" means a cricket that is not obviously expressing female characteristics, and so may be a juvenile, male or non-obvious female (e.g. without an extruding ovipositor).

Other animals noted

Section 1	Beetle elytra (large – not cave beetle)
Section 1	Orange harvestman (broad short legged forest type)
Section 1	Forest snail
Section 2	Harvestman (*H. goedei* – pigmented form)

General census area 2: alcove at daylight hole D3 (Census time: 2.00pm, 25.9.00)

Hickmania troglodytes

Cave spiders	Female	Male	Subadult	Juvenile
	0	0	0	1

Micropathus sp.

Cave crickets	Female <1 cm	Female 1-1.5cm	Female > 1.5cm	Other <1 cm	Other 1-1.5cm	Other > 1.5cm
	0	10	67	22	30	77

Glow-worm counts

	Count 1	Count 2	Count 3	Count 4	Count 5	Average
Site 1	36	39	37	34	34	**36**
Site 2	55	56	56	50	48	**53**
Site 3	38	40	42	45	45	**42**
Site 4	118	122	NA*	NA*	NA*	**120**

Note: counts 3-5 were not conducted at site 4 as the glow-worms switched off en-masse following the second count)

Terrestrial fauna – siltbanks

<u>*Pitfall traps: main siltbank and siltbank at D4*</u>
As outlined in the main text, all baits and bait wires were gone at the time of collection, but the traps, alcohol and preserved fauna remained intact.

U1-U6 (main siltbank):
(i) Observed: see transect notes below.
(ii) Pitfall trap contents
U1: Orthoptera – *Micropathus cavernicola* x 2
U2: Orthoptera – *Micropathus montanus* (several)
U4: Nematomorpha – unidentified sp.
U5: Orthoptera – *Micropathus cavernicola* (several)
U6: Oligochaeta – unidentified sp.

N1-N2 (siltbank at D4):
(i) Observed (24.9.00):
Orthoptera – *Micropathus* sp. x 2
Opiliones – *H. goedei* (pigmented form) x1
Araneae – *Tupua* sp. x1
(ii) Pitfall contents
N1: Orthoptera – *Micropathus cavernicola* (several)
Oligochaeta – unidentified sp.
N2: Orthoptera – *Micropathus cavernicola* (several)

<u>*Upper level transect*</u>

Note: leaf litter was found in low but notable amounts along the wall at the top of the siltbank. The area surrounding U3 was particularly rich in beetle remains, and was dubbed the ‘beetle graveyard’.

Run 1: 19.8.00
Orthoptera: *Micropathus montanus* (several – see census data)
Orthoptera: Micropathus *cavernicola* (several – see census data)
Coleoptera: *Promecoderus* sp. x 1
Diptera: Tipulidae (unidentified spp.) x 2 (one in the below *H. troglodytes* web)
(Diptera: occasional glow-worm strands - unattended)
Opiliones: *Hickmanoxyomma goedei* (pale form) x2
Araneae: *Hickmania troglodytes* x 1 (juvenile - no adults at this point)
Araneae: Cycloctenidae x 1 (female)
Araneae: unidentified (very small spider in web: escaped into crevice)

Run 2: 24.9.00
Orthoptera: *Micropathus montanus* (several – see census data)

Orthoptera: Micropathus *cavernicola* (several – see census data)
Coleoptera: *Promecoderus* sp. x 3 (two near U1, one near U6)
Diptera: *Arachnocampa tasmaniensis* x 2 (solitary specimens at U1 & U5: some distance from stream)
Araneae: *Hickmania troglodytes* x 2 (juveniles - no adults at this point)
Araneae: Amaurobiidae sp. x 2 (both female*)
(Vertebrata: miscellaneous scats, particularly near U6)

> *[* only one confirmed male amaurobiid was encountered in the cave, above an inflowing groundwater streamway along the main stream channel]*

Run 3: 25.9.00
Orthoptera: *Micropathus montanus* (several – see census data)
Orthoptera: Micropathus *cavernicola* (several – see census data)
Hemiptera: unidentified terrestrial sp. (near U4)
Coleoptera: *Promecoderus* sp. x 1 (in tunnel closer to entrance than U6)
Diptera: *Arachnocampa tasmaniensis* x 2 (solitary specimens at U1 & U5: some distance from stream)
Araneae: *Hickmania troglodytes* x 2 (juveniles - no adults at this point)
Araneae: Amaurobiidae sp. x 1 (in census area, sex not determined)
(Vertebrata: fresh scats at U6)

<u>*Roof dome census, upper level*</u>
Note: "other" has the same meaning for crickets as above.

19.8.00 (evening count, 7pm)

Crickets	<1 cm	1-1.5cm	> 1.5cm
female	0	1	2
other	3	0	2
(total)	(3)	(1)	(4)

Additional species	*H. goedei* (pale form) x 1

24.9.00 (evening count, 6.04 pm)

Crickets	<1 cm	1-1.5cm	> 1.5cm
female	0	0	0
other	3	0	4
(total)	(3)	(0)	(4)

Additional species	--

25.9.00 (morning count, 11.44 am)

Crickets	<1 cm	1-1.5cm	> 1.5cm
female	0	0	2
other	6	2	5
(total)	(6)	(2)	(7)

Additional species	Amaurobiidae x 1

<u>Note</u>: Cricket populations may shift according to time of year and time of day (as reflected above). Numbers were much higher near the actual entrance on these counts, but reasonable numbers were still roaming over the whole siltbank. Similarly, *Hickmania troglodytes* specimens, including large adults and subadults, were found in much higher numbers closer to the entrance than across the transect path. Only the occasional juvenile was found deeper.