Environmental Monitoring and Investigations of Gnangara Mound

Yanchep Cave Streams and East Gnangara (Lexia) – Egerton Spring & Edgecombe Spring: Invertebrate Monitoring

Report to

Department of Water
Government of Western Australia

by

B. Knott, A.W. Storey & D. Tang

May 2009

Aquatic Research Laboratory
School of Animal Biology

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Frontispiece: Water Cave on 4th December 2008, showing current water level, and historic water level as indicated by 'tide' marks on the exposed rock face, indicating a 40 – 50 cm drop since ~ 2000 (photo: AW Storey).

Study Team

Management:	Andrew Storey
Field Work:	Andrew Storey, Brenton Knott, Danny Tang
Cave Guide:	Lex Bastian
Invertebrate Identification:	Brenton Knott, Danny Tang
Report:	Andrew Storey, Brenton Knott
Photographic Vouchers	Danny Tang

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EXECUTIVE SUMMARY

Eleven caves in the Yanchep area were visited in early summer, 2008, to sample the aquatic invertebrate fauna and water chemistry Boomerang Cave (YN99), Cabaret Cave (YN31), Carpark Cave (YN18), Water Cave (YN11), Cave on Lot 51 (YN555), Mire Bowl (YN61), Orpheus Cave (YN256), Gilgie Cave (YN27), Twilight Cave (YN194), Fridge Grotto (YN81) and Spillway Cave (YN565). Gilgie Cave, Mire Bowl, Carpark and Fridge Grotto were dry, and therefore no fauna samples were collected. Twilight Cave and Spillway Cave had been classified as unsafe and therefore not entered. Two springs on the Gnangara Mound were also sampled; Egerton and Edgecombe Springs. Caves were sampled on 04 December, and the springs were sampled on 22 December, 2008. In addition, several newly discovered springs west of Bullsbrook; Sue's (Alpaca01) and Bill's springs and in Gaston Swamp were sampled on 02 February, 2008; on 22 August and 22 December, 2008, Alpaca01 and the tumulus spring Gaston01 in Gaston Swamp were sampled; the results are included here for comparison.

Water Quality and Quantity

Water levels in the caves were generally very low compared to historical levels and no surface water flow was evident. Water quality was relatively consistent across all caves and between years, indicating no fundamental change in basic water quality since the commencement of sampling in 1998. Water quality within the caves was generally characterised by low salinity, circum-neutral pH and medium dissolved oxygen levels, consistent with groundwater flowing from the Gnangara Mound. Ionic composition was as expected for groundwater-derived systems of the Swan Coastal Plain. Elevated concentrations of nitrogen (as nitrate + nitrite) and sulphate were again recorded from YN555.

Water levels in the springs contrasted between the relatively strong flow of Egerton Spring and the very thin film of water emerging from Edgecombe Spring. Fresh water of generally good quality? has been maintained relatively constantly over time, although a continuing downward trend in pH levels is evident at Egerton Spring. This decrease is of concern, both as low pH is detrimental to aquatic fauna and as Egerton Spring appears to be in a zone which has a high risk of acid sulphate soils (ASS). Hence, the possibility of the influence of ASS on this site should be investigated. Elevated concentrations of nitrogen (as nitrate + nitrite) were recorded from both springs, with levels at Edgecombe Spring approximately 40 times greater than the recommended ANZECC/ARMCANZ (2000) guidelines.

Aquatic Fauna

Faunal sampling of caves again recorded low abundance and diversity. Although there has been no evidence of recovery in the aquatic fauna in the caves, there appears to be some success from the reticulation systems resulting in observable improvement in the condition of the remaining tree root mats. Root mats observed in Cabaret Cave and Carpark Cave had declined in condition since November 2006, reflecting poor maintenance of the reticulation systems in these caves, both of which were not functioning in October 2007, with the liners predominantly dry. However, the reticulation was being maintained in 2008, and the condition of the root mats had improved when visited in 2008.

Caves, including that on Lot 51 (YN555), exhibited a decline in species diversity this sampling period and the significant ancient cavernicole taxa first recorded in YN555 in spring 2002 were notably absent. However, the amphipod discovered in Orpheus Cave was still present

Results continue to cause concern, particularly as a result of declining water levels. Hydrographs for caves which have had Australian Height Datum (AHD) surveyed, and have a bore in close

proximity, indicate a continuing decline in water levels. Therefore, loss of water from the cave streams continues as the major threat since there is no evidence of a decline in water quality.

With respect to the current state of the root mat communities, it must be hoped that there are some extant cave fauna on root mats located in inaccessible parts of the cave system, from which sources recolonisation may occur. Consequently, it is recommended that the first efforts towards recovering the root mat fauna from any refuge areas should be directed at (1) restoring flowing water to the cave streams, and (2) restoring the growth of extensive root mats in the cave streams. By ensuring the fundamental habitat requirements are catered for (*i.e.* permanent, flowing water and healthy root mats) there is the possibility that fauna may recolonise the caves, should it be present in some unknown nearby refuge.

Recharging the local aquifers under the caves from the newly constructed production bore (to the west) has the potential to increase flows, increase vigour of root mats (*i.e.* sustain habitat) and allow return of fauna from unknown refuge areas, assuming such areas exist. Return of fauna from such areas in unlikely to be rapid, as the cavernicole fauna is not highly mobile. However, monitoring should continue on an annual basis, whilst recharge occurs, to document any changes in water quantity, quality and in fauna assemblages. Unfortunately delays in implementing the recharge system, combined with inadequate maintenance of the existing reticulation systems, have resulted in the decline in condition of root mats in some caves. It is hoped they recover once the reticulation system is operational.

Species richness at Egerton Spring was again high, with all crustacean groups (Amphipoda, Copepoda, Cladocera, Ostracoda) represented and most in relatively high abundance.

The new springs to the west of Bullsbrook appear very promising in terms of condition, flows and fauna. They are relatively intact and, from discussions with landholders, the springs (and other unvisited springs in the immediate vicinity), flow all year, and are particularly fast flowing in winter. Studies of these springs in 2008 confirm their high conservation value. These springs may be the best remaining examples on the Gnangara Mound, and worthy of protection before impacted by development. Nevertheless, investigations should be established to locate other tumulus springs in the area and document their attributes.

Recommendations

Based on these results, the following recommendations are made:

- Permanent water flows must be restored to the cave streams, and maintained at a level whereby the majority of the root mats are submerged.
- Upon restoration of permanent water flows to the cave streams, the liners currently in place beneath root mats should be removed to re-establish connectivity between the root mats and the ground water, facilitating recolonisation by ground-water fauna.
- Active management should be initiated to develop and then maintain extensive root mats in the cave streams to provide suitable habitat to support fauna should it recolonise from inaccessible refuges.
- Continue cave monitoring as per current methods to assess recovery of cave stream communities following recharge by the new recharge system/bores.
- Monitoring of the fauna should be undertaken in September/October when habitat area is likely to be greatest to assess recovery of the fauna, should it occur.

- Boomerang Cave, which dried in 2003, and both Carpark and Cabaret Caves, which dried in 2007 due to issues associated with maintenance of the local recharge system, should continue to be monitored to determine if the TEC has been lost from these sites.
- A gauge for measuring flows should be established on Egerton Spring. This is now a critical issue given the encroachment of suburbia around this spring.
- The influence of Acid Sulphate Soils/Potential Acid Sulphate Soils (ASS/PASS) should be investigated at Egerton Spring, and regular monitoring of pH should be initiated.
- The status of the Edgecombe Spring Threatened Ecological Community (TEC) should be re-assessed and, based on the faunal diversity listed as extinct, monitoring should cease.
- Setting traps in the cave on Lot 51 (YN555) for the goldfish is of high priority.
- Continue monitoring YN555 to determine if the isopod and hydrobiid snail populations return.
- The sampling strategy be revised, and expanded to include a regional focus. The results emerging from the monitoring over the years highlight the significance of the copepod and amphipod elements, but also the decline of these elements. Monitoring alone will not yield insights into the regional changes of groundwater fauna distribution/losses. A regional focus of sampling bores should be instituted as a matter of urgency to determine the regional distribution of groundwater fauna, as well as develop an understanding of what measures should be put in place to conserve these elements, regionally.
- A study in 2008 of recently discovered springs west of Bullsbrook highlighted their significance for conservation of ecological units. Floristic survey of these springs should also be undertaken. Other potential springs in the area should be investigated for their conservation value.

1 INTRODUCTION

1.1 Background

The Department of Water (DoW) is required to implement appropriate monitoring programmes as part of the environmental commitments outlined by the Water Authority of Western Australia (1995) and WRC (1997). Key commitments include the ongoing monitoring of cave stream invertebrate fauna and seepage (spring) macroinvertebrates. The aim of ongoing monitoring is to determine whether groundwater abstraction and pine plantation management impact on the identified ecological values of the cave streams in Yanchep National Park, and Edgecombe and Egerton Springs. Monitoring provides valuable information which can be used by the Yanchep Caves Recovery Team for ongoing management, and in particular for assessing the effectiveness of groundwater recharge, and by the DoW for inclusion in the annual and triennial reports to the Environmental Protection Authority (EPA).

This current work represents a one year phase of an ongoing monitoring program and is managed in conjunction with the Department of Environment and Conservation's (DEC; previously Department of Conservation and Land Management's (CALM)) WA Threatened Species and Communities Unit and the Swan-Avon region of the Department of Water (nee Department of Environment / Water & Rivers Commission).

As an addendum to this year's report, several new springs identified by DEC in the Bullsbrook area were sampled in 2008 (in February, August and December) at the request of DEC to determine their conservation significance. Data collected from these new springs are reported here to allow comparison with Edgecombe and Egerton Springs.

1.2 Objectives

The aim of this study was to report on the current status of the aquatic invertebrate fauna of the cave streams of Yanchep National Park and two nominated springs (Egerton & Edgecombe Springs) on the Gnangara Mound (East Lexia area): Egerton and Edgecombe Springs, during spring when water levels were anticipated to be at their highest. Resultant data are to be used to assess the status of the Threatened Ecological Community in the cave streams and evaluate the impact of changes in groundwater and wetland water levels. Conclusions will be included in Annual and Triennial reports to the EPA and to aid management of groundwater resources. Data collected will be compared with historical (1998) and more recently collected data (November 2000, September 2001, January 2002, September 2002, September 2003, October 2004 and November 2005, October 2007).

1.3 Scope

1. In spring 2008 monitor cave stream invertebrate populations in:
   - Boomerang Cave (YN99),
   - Cabaret Cave (YN31),
   - Carpark Cave (YN18)
   - Water Cave (YN11)
   - Cave on Lot 51 (YN555)
   - Mire Bowl (YN61)
   - Orpheus Cave (YN256)

   Sampling is to provide an indication of the status of the invertebrate communities compared against historical data. Of caves previously sampled, Twilight Cave (YN194) and Spillway Cave (YN565) are considered unsafe to enter, and so were not sampled, Gilgie Cave (YN27) has been dry since 1996, and Jackhammer Cave (YN438) appears not to support cave fauna (Knott & Storey 2003).

2. Sampling of water quality parameters should be undertaken concurrently at all caves. This should include temperature, conductivity, salinity, dissolved oxygen, pH, turbidity, and Na, Ca, Mg, K, SO_4^{2-}, PO_4^{3-} and NO_X.

3. In consultation with National Park rangers and local caving experts, identify any additional caves in the Yanchep area that hold water and potentially may contain root mats, and sample new caves for aquatic invertebrate fauna and water quality, additional data to be incorporated in this report.

4. In spring 2008, monitor macroinvertebrate populations of:
   - Egerton Spring (East 403508, North 6484428), and
   - Edgecombe Spring (East 404893, North 6481948).

   Access to wetlands on private property will be obtained in consultation with the Department of Water prior to undertaking fieldwork and then with the two property owners.

   Sampling of these springs is to provide an indication of the status of the invertebrate communities compared against historical data. It is critical that the macroinvertebrate fauna of Egerton spring be sampled from runnels on the mound before the point of discharge from the tumulus spring, and not from the wetland downstream of the discharge which will contain a diverse fauna of macroinvertebrates cosmopolitan to wetlands of the Swan Coastal Plain.

5. Sampling of water quality parameters should be undertaken concurrently at both springs. This should include temperature, conductivity, salinity, dissolved oxygen, pH, turbidity and Na, Ca, Mg, K, Cl^-, total Fe, SO_4^{2-}, and NO_X.

To allow direct comparison across the existing springs and the newly identified springs at Bullsbrook, the same sampling methods were used and the same suite of water quality parameters were taken from the new springs.

2 METHODS

2.1 Study Sites

2.1.1 Caves

All caves were sampled on 4th December 2008. This was later than previous years, but was due to delays in the issuing of the project contract as a result of a.) the extended tendering process and b.) the intervening 'Caretaker Period' during State elections. All caves occur within the area of the Gnangara Mound Groundwater Resources study area and, with the exception of the cave on Lot 51, all study sites were within the Yanchep National Park (Figures 1 & 2).

Froend *et al.* (2004) identified the ecological water requirements of the Yanchep Caves stream fauna to be permanent inundation (i.e. sufficient level of water to inundate cave floor/maintain flowing streams). As such, the ecological values of the caves are considered to be dependent on maintaining adequate water levels within the caves. There is a large number of groundwater monitoring bores in the Yanchep area; however, few of these are adjacent to the caves supporting threatened ecological communities (TECs). Caves and positions of the nearest bores are presented in Table 1. The Australian Height Datum (AHD) of the floor of some of the caves holding TECs have been surveyed and used to relate changes in groundwater levels in adjacent bores (reported as mAHD) to the water level in each cave as estimated from cave floor AHD levels (Table 2).

Eleven caves were considered for sampling in 2008, with nine caves visited and five caves actually sampled for fauna and water quality. As anticipated, Fridge Grotto (YN81) and Gilgie Cave (YN27) contained no water and were not sampled. Mire Bowl (YN61) similarly was dry and could not be sampled (water level was ~60 cm below the top of the PVC sump). Boomerang Cave (YN99) was also dry (water level was ~80 cm below the top of the PVC sump), and the pump was not functioning in this cave. Following an assessment of the safety of all caves in 2007, conducted by DoW, Twilight (YN194) and Spillway caves (YN565) were considered too unstable to enter and therefore were not visited. The various caves known to contain root mats and/or water are listed in Table 1, together with the GPS location of each and sample date, if visited.

Table 1. Names and codes of caves considered in 2008 - and whether sampled.

Cave	Code	Easting	Northing	Visited	Sampled	Nearest Bores[1]
Cabaret Cave	(YN30)	375650	6509600	Yes	Yes	YN4 (100 m SE)
Boomerang Cave	(YN99)	375660	6509520	Yes	No (dry)	YN4 (100 m SE)
Carpark Cave	(YN18)	375250	6508440	Yes	Yes	YN3 (300 m NE) YN2 (400 m SE)
Water Cave	(YN11)	374990	6508640	Yes	Yes	YN7 (1100 m SSE) YN5 (1500 m NE)
Cave on Lot 51	(YN555)	376921	6505901	Yes	Yes	YN8 (~910 m NW) GNM9 (~820 m NNW) GNM10 (~960 m NNW) JP23 (~600 m NE)
Gilgie Cave	(YN27)	375714	6506702	Yes	No (dry)	-
Twilight Cave	(YN194)	375778	6506788	No	No (unsafe)	-
Spillway Cave[2]	(YN565)	374404	6509263	No	No (unsafe)	-
Orpheus Cave	(YN256)	373673	6512354	Yes	Yes	-
Fridge Grotto	(YN81)	373844	6511733	No	No (dry)	-
Mire Bowl	(YN61)	374254	6511387	Yes	No (dry)	-

[1] Long-term groundwater monitoring bores developed by DoW and monitored on a monthly basis.
[2] Cave visited November, 2005.

Table 2. AHD of the floor of the caves containing root mat communities listed as TECs.

Cave	mAHD
Carpark Cave	7.660
Water Cave	6.186
Cabaret Cave	11.175
Boomerang Cave	11.316

Figure 1. Aerial showing location of Cave YN555 on Lot 51 relative to encroaching market garden and turf farms to the north and south-west.

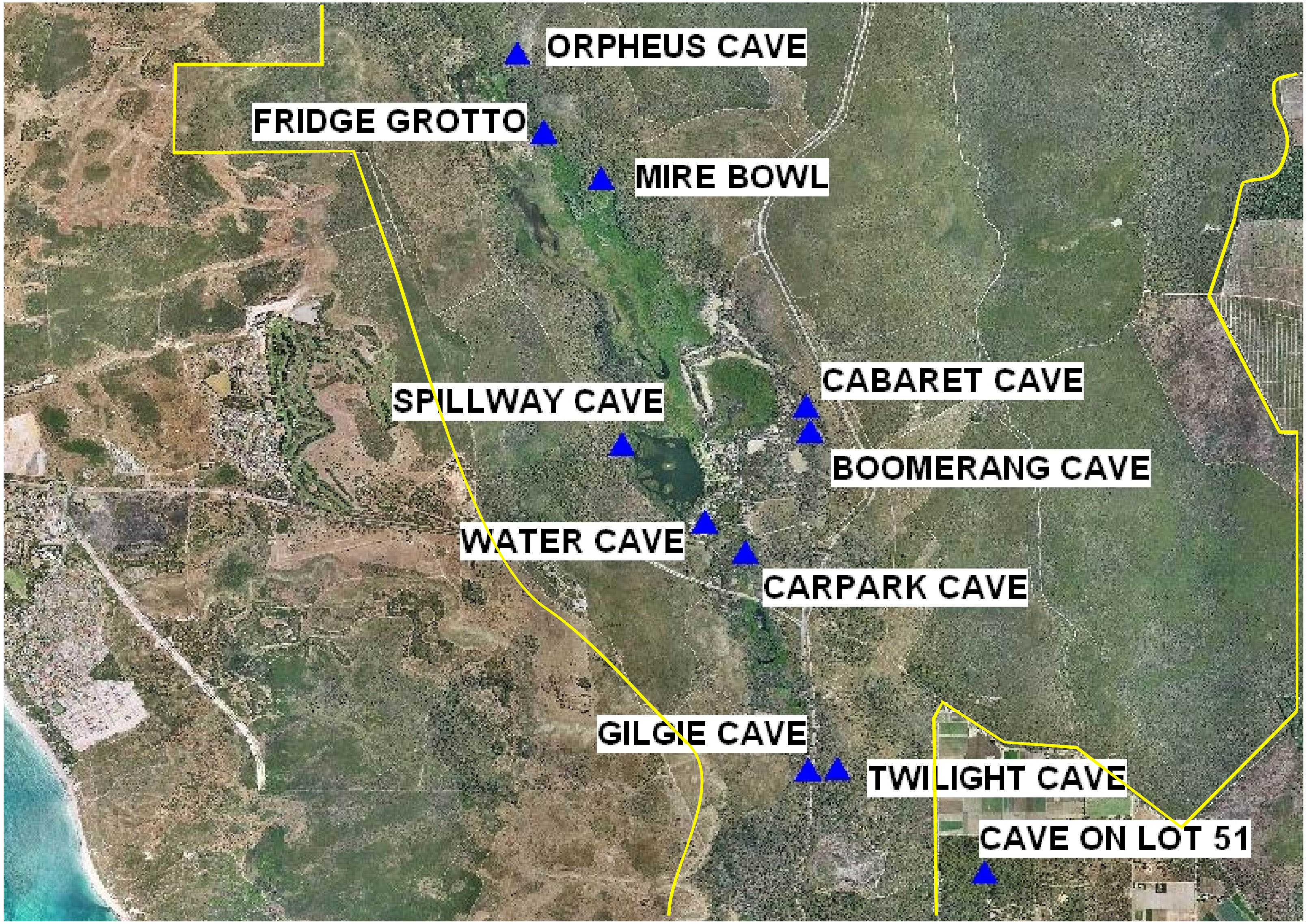


Figure 2. Aerial showing location of Yanchep caves. Yellow outline indicates border of Yanchep National Park.

2.1.2 Springs

Both Egerton and Edgecombe springs were sampled on 22nd December 2008. The ecological value of the springs is considered to be dependent on water levels. Bore water levels adjacent to Edgecombe and Egerton Springs have been monitored since 1994. From April 1994 to February 1996, water depth in bore B10 (144 m upstream of Edgecombe Spring) was reasonably constant at approximately 14.0 – 14.5 m AHD. Water depth on Bore B25 (130 m upstream of the Egerton Spring) was also reasonably constant at approximately 39 m AHD. Bore data supplied for the current trend analysis commenced in March 2000 for both bores, and levels at the start of the data series were comparable to levels recorded pre-2000.

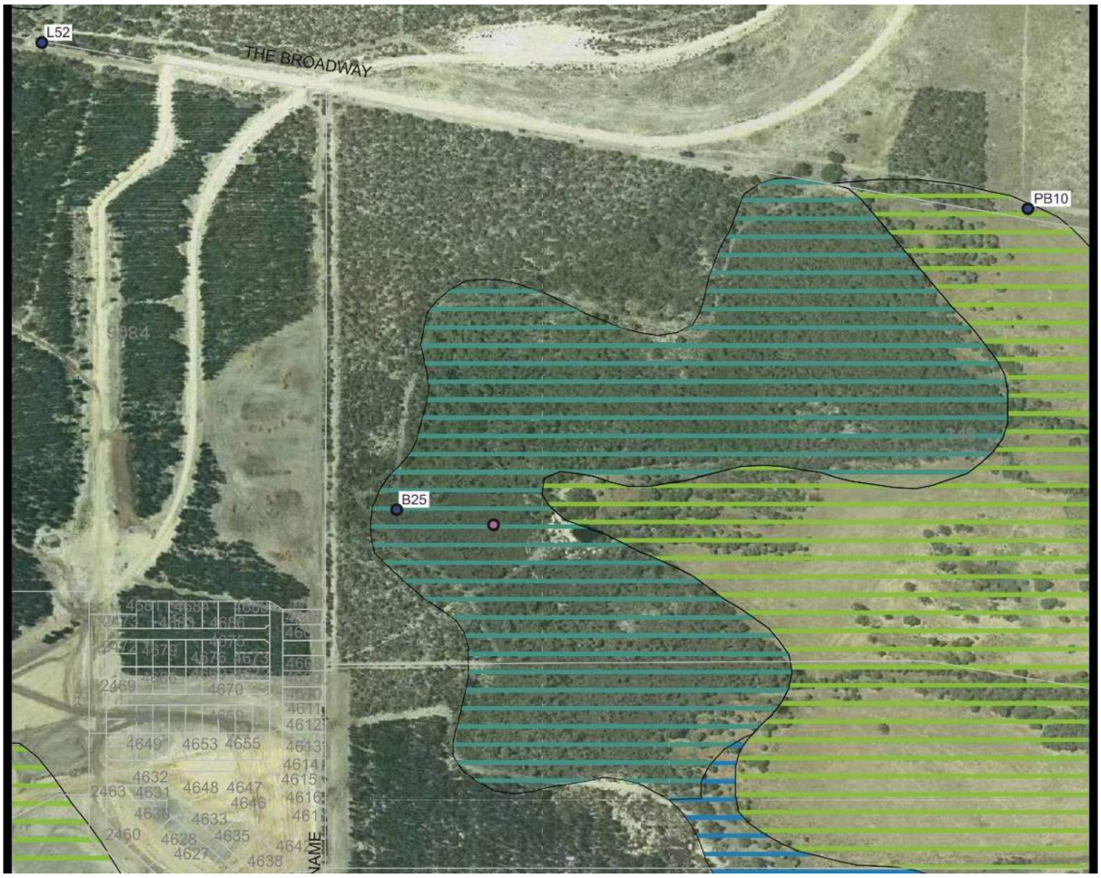
Egerton Spring

The tumulus spring (WGS84 E403508 N6484428) is located in the northwest section of what formerly was Egerton Stud, Ellenbrook, but the area now is owned by Multiplex Ltd. The spring is a permanent limnocrene spring *sensu* Williams (1983), with water welling vertically to ground level and discharging from a peat mound. The biological significance of the structures relates to the provision of humid microhabitats in the midst of an essentially xeric environment. Forms now restricted to the extreme southern region of the State persist in these moist microhabitats. The Egerton tumulus spring, consequently, assumes considerable scientific importance and is a feature worthy of detailed study of its structure and hydrological dynamics. Low reeds and rushes, liverworts and club mosses grow over the mound. Urban development has encroached to the west and south of the spring, and development is planned to the north. The extent of urban development and encroachment in December 2006 compared with January 2004 is evident in Figure 3. The current state of development (October 2007) is significantly more than in December 2006. This development will undoubtedly affect the hydrology of the site.

Edgecombe Spring

Edgecombe Spring (WGS84 E404893, N6481948) is located on Lot 15 Gnangara Rd, at the eastern end of Gnangara Road, Ellen Brook. The spring was a permanent rheocrene spring *sensu* Williams (1983), with water flowing along an epiphreatic conduit formed in quartz sand under about 0.15 m of dark, organic soil (Jasinska & Knott 1994). The spring, wedged between paddocks at higher elevation some 30 m to the west and an impoundment 15 m to the east, upon emerging flowed through a wide band of vegetation (of reeds, rushes, bracken fern, fig, *Eucalyptus* and *Melaleuca*) to the dam.

When sampled on the 25th of April, 1999, there was only a thin veneer of moisture at the normal outflow point of the spring, with almost imperceptible flow. By 9th November 2000, stronger flow was observed, but a fire break had been cleared along the fence-line of the property and the spring area cleared and badly degraded which altered the lines of discharge, with substantial flow noted along the tractor wheel ruts. As noted by Horwitz & Knott (2002), the area immediately about the spring continues to repair to its original semblance and the discharge through the original spring channel was slow. However, since monitoring in 2003, the area immediately west of the spring site and encroaching to within a few metres has been cleared for suburban development. This is likely to cause major change and possible destruction of the spring. The extent of urban development and encroachment in March 2008, compared with December 2006 and January 2004 is evident in Figure 4. This will undoubtedly affect the hydrology of the site.


L52
THE BROADWAY
PB10
B25

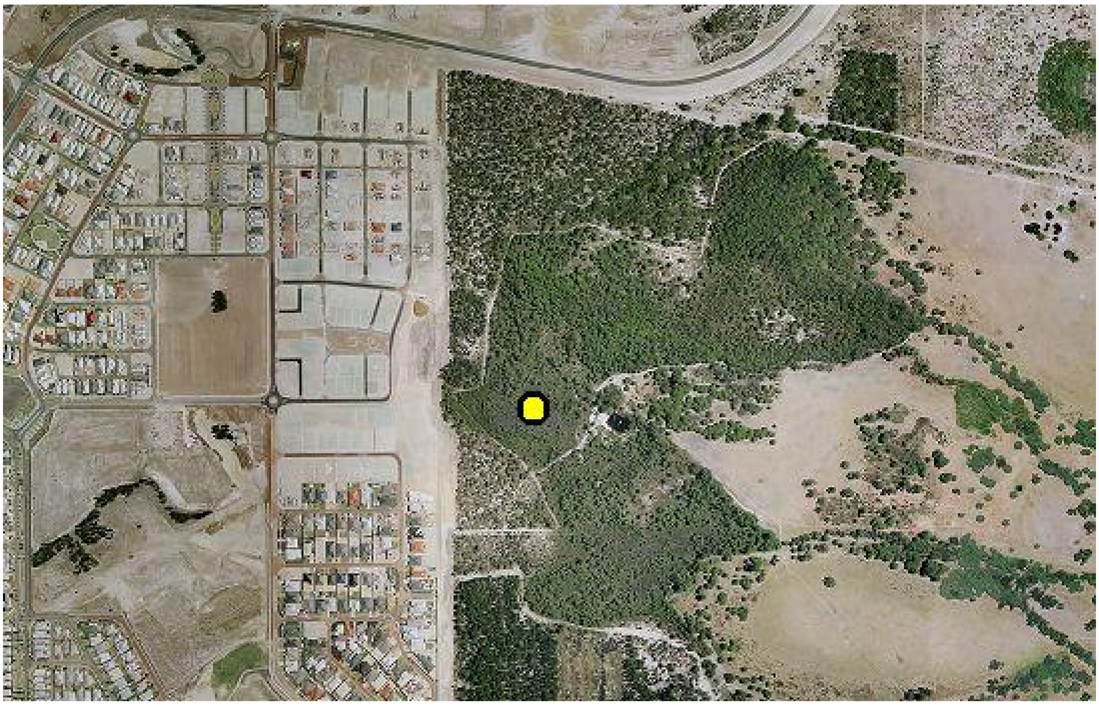


Figure 3. Aerial photos showing location of Egerton Spring (approx location of the spring is indicated with the yellow marker) and encroaching urban development; TOP = January 2004, MIDDLE = December 2006, BOTTOM = March 2008.

Figure 4. Aerial photos showing location of Edgecombe Spring (approx location of the spring is indicated with the yellow marker) and encroaching urban development: TOP = January 2004, BOTTOM = December 2006.

2.1.3 Additional Gnangara Mound Springs

Environmental surveys, conducted as part of a proposed realignment of the Great Northern Highway to bypass Bullsbrook and the Pearce Airbase, have revealed the existence of a series of previously unknown mound springs and wetland seeps in the area. Sues Spring South (Alpaca01), Bill's Spring and Gaston Swamp were identified and originally sampled in February 2008. The area was visited again on 22nd August and 22nd December 2008, when springs were re-sampled, including the mound spring feeding Gaston Swamp (GastonRd) and the spring, as opposed to the swamp was sampled. Locations of the springs sampled are presented in Table 3 and the approximate locations are shown in Figure 5. Data from this survey were reported by Tang *et al.* (2008).

Table 3. Names and locations (WGS84) of new springs visited in February, August and December 2008 and whether sampled.

Site	DEC Code	Easting	Northing	Feb08 Date Sampled	Aug08 Date Sampled	Dec08 Date Sampled
Sue's Spring South	ALPACA01	402481	6498461	01 February 2008	22 August 2008	22 December 2008
Sue's Spring North	-	402400	6498450			
Bill's Spring	-	402441	6498561	01 February 2008		
Gaston Swamp	-	402771	6498892	01 February 2008	22 August 2008	22 December 2008
Gaston Road Spring	GastonRd	402812	6499003		22 August 2008	22 December 2008

2.2 Water Quality

2.2.1 Caves

In-situ measures of water quality were made at each site using Wissenschaftlich-Technische-Werkstätten (WTW) water quality meters (Table 4). Undisturbed water samples were taken from each site, using pre-cleaned 500 ml and 125 ml bottles for laboratory analyses of additional water quality parameters (Table 4). Laboratory analyses were conducted by the Environmental Chemistry Section of the Chemistry Centre of WA, a National Association of Testing Authorities (NATA) accredited laboratory.

Table 4. *In-situ* and laboratory-determined water quality parameters measured in each cave in 2006.

***In-situ* water quality measures**	**Laboratory-determined water quality measures (mg/L)**
Dissolved Oxygen (mg/L)	Calcium (Ca^{2+})
Dissolved Oxygen (% sat.)	Potassium (K^{+})
pH	Magnesium (Mg^{2+})
Redox	Nitrate and nitrite (N_NO_3)
Water Temperature (˚C)	Sodium (Na^{+})
	Soluble reactive phosphorus (P_SR)
	Sulphate (SO_4_S)
	Conductivity (µS/cm)

2.2.2 Springs

In-situ measures of water quality were made at each site using WTW water quality meters (Table 5). Undisturbed water samples were taken from each site, using pre-cleaned 500 ml, 125 ml and 50 ml bottles for laboratory analyses of additional water quality parameters (Table 5). Laboratory analyses were conducted by the Environmental Chemistry Section of the Chemistry Centre of WA, a NATA accredited laboratory.

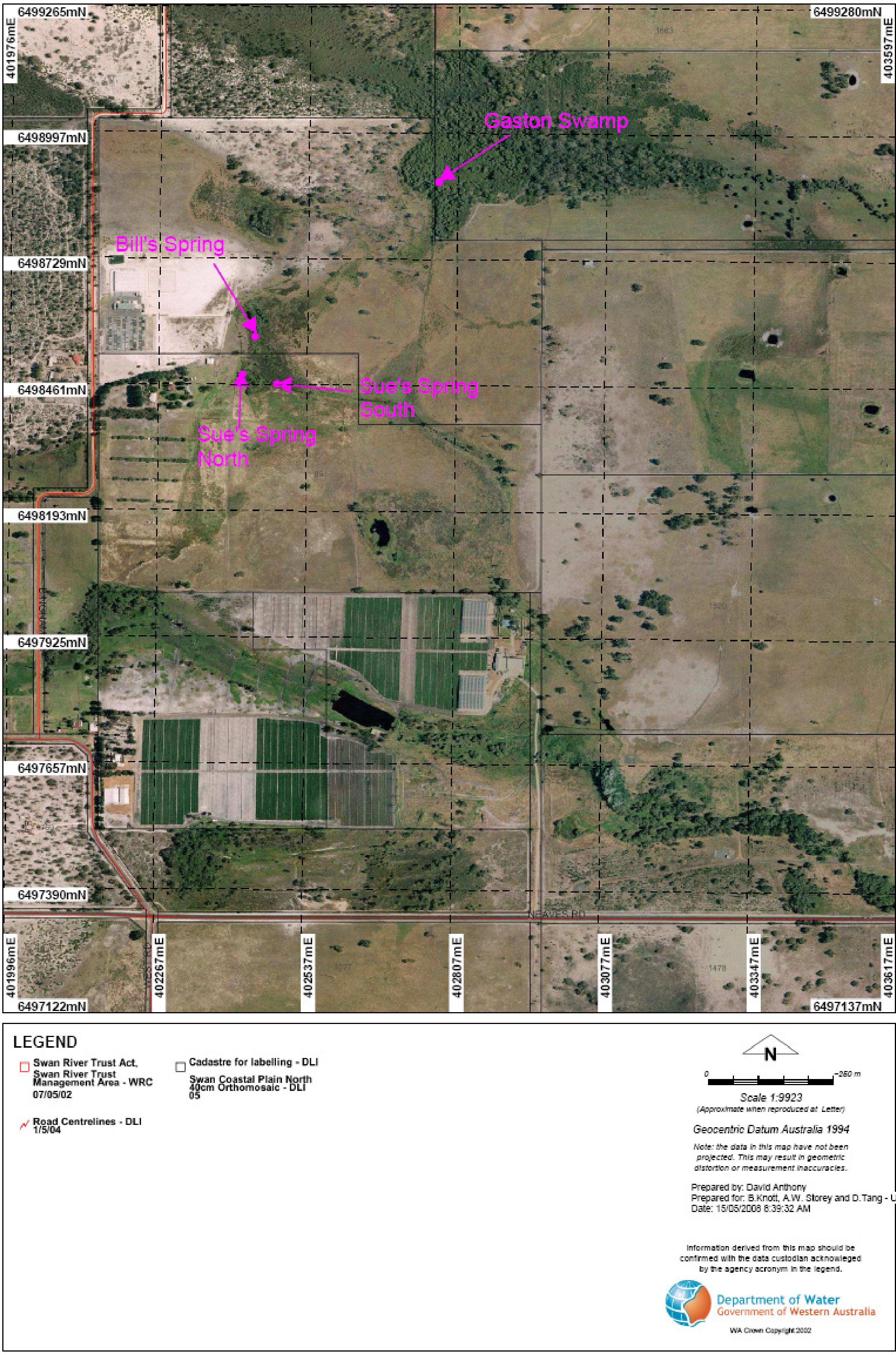


Figure 5. Aerial photo showing the east end of Neaves Road, Bullsbrook, with the location of new mound springs sampled in February, August and December 2008.

Table 5. *In-situ* and laboratory-determined water quality parameters measured at each spring in 2006.

In-situ water quality measures	***Laboratory-determined water quality measures (mg/L)***
Dissolved Oxygen (mg/L)	Sodium (Na)
Dissolved Oxygen (% sat.)	Potassium (K)
pH	Magnesium (Mg)
Redox	Calcium (Ca)
Water Temperature (˚C)	Total Iron (Fe)
	Chloride (Cl)
	Nitrate and nitrite (N_N0_3)
	Sulphate (SO_4_S)
	Conductivity (µS/cm)
	Turbidity (NTU)

2.3 Aquatic Invertebrate Fauna

Sampling in the caves was conducted using the modified sampling regime developed when sampling caves in mid-January 2002 (Knott & Storey 2003). The aim of the sampling technique was to collect as many species as possible whilst causing the least disturbance and damage to the remaining root mats. This was achieved by taking composite sweep samples across all accessible submerged root mat habitat in each cave using small (~10 cm diameter), custom-made fine-mesh nets (70 µm mesh aperture). Each sample was placed in a sealed, labelled plastic bag covered with water from the site, returned to the laboratory under cool, light-tight conditions and sorted alive in the laboratory under a dissecting microscope.

Fauna at each spring was collected as close to the point of the spring discharge as possible and, if not accessible, along the runnels as they exit from the mound. Access to the actual point of discharge of Egerton spring was difficult due to the density of the vegetation on the mound. Using a 500 µm mesh sieve, sediment and detritus were sampled and bulked in a sealed, labelled plastic bag, covered with water from the site, and returned to the laboratory for sorting of live specimens under a dissecting microscope. Sampling Edgecombe spring was very difficult because of the discharge was basically reduced to a thin film of water. The new springs at Bullsbrook were sampled using the same method, and Alpaca01 has the same difficulty of access as does Egerton spring.

Photographic Voucher Collection
A photographic voucher identification collection of invertebrates was prepared, displaying diagnostic features with appropriate microscope scaling. The voucher includes all invertebrate species collected, where possible. Some photographs were based on historically collected voucher specimens, if specimens were not collected during the current sampling, or if only single specimens were collected. Specimens deemed new species were included in the voucher and allocated an interim name.

3 RESULTS

3.1 Caves

3.1.1 General Condition

Ideally, sampling should be conducted in late spring when water levels are expected to be at their highest. However, due to a protracted tendering process in 2008, the contract was not awarded until late in the year, and sampling could not be conducted until early summer. Water levels were very low when compared to historical levels (*cf* 1990s) and no surface water flow was evident in any cave. It is unlikely conditions would have been much different had the caves been sampled in late spring. Water levels in the vicinity of root mats in Cabaret, Boomerang and Carpark caves continue to be artificially maintained using sumps, pumps, floats and black plastic liners, however the pump system in Boomerang Cave was not working and the liner was dry. Generally, water levels in the sumps in the remaining caves were very low, with pumps struggling for water. Water levels in each cave at the time of sampling are summarised below:

Cabaret Cave: All three pumps were operational and all three areas of liner/pondage contained water (Plate 1). This cave was in far better condition than in 2007 when only one pump was operational, and the majority of liners/ponds were dry. The root mats appeared to be in better condition than in 2007, with areas of visible regrowth. Water level (WL) was approx 1.50 m below the floor of cave in the sumps. WQ and fauna samples were taken.

Plate 1. Main pondage in Cabaret Cave with pipe work and showing water in the liner (December 2008).

Plate 2. Main pool in Boomerang Cave, dry in December 2008.

Boomerang Cave: The pump in Boomerang Cave was not working, the liner/pond was totally dry, and the root mats dried and senescing (Plate 2). The water level in the sump was approximately 0.8 m below the floor of the cave. No fauna or WQ samples were taken.

Water Cave: Water was present in Water Cave, but was very low, and ~40 – 50 cm lower than the normal water mark in the cave (Plate 3 - 5). Substantial areas of the main pool were dry, with a rapid decline in water levels in recent years. All root mats were exposed. No gilgies or Nightfish were seen in the pool. Interestingly, the supplementation pipe work had been removed from this cave, suggesting it will not be supplemented when the recharge system in finally operational? WQ and fauna samples were taken.

Carpark Cave: The stream at the entrance to the cave was totally dry, however, the pumps inside Carpark Cave were working, and there was water in the liner/pond (Plate 6). However, the pumps were struggling to find water, which was ~1 m below the floor of the cave, and the water in the liner was not 'flowing', with a build-up of mould/fungus along the edges. All liners in

Carpark Cave were dry in 2007, so conditions in 2008 were an improvement. Root mats also showed some regrowth. WQ and fauna samples were taken.

Plate 3. Main pool in Water Cave, showing water level just below historical water marks on the exposed rock face, and floor covered by water (Sept 2001).

Plate 4. Main pool in Water Cave, showing water level below historical water marks on the exposed rock face (Oct 2007).

Plate 5. Main pool in Water Cave, showing current water level well below historical water marks on the exposed rock face (December 2008).

Plate 6. Main pool in Carpark Cave, showing water in the main liner (December 2008).

LOT51: The water level in the cave was much lower than ever seen at this time of year (20 cm lower than this time last year), with water only in the very inner, right-hand chamber (Plates 7-10). No isopods were seen but the resident goldfish was once again observed suggesting there are deeper cavities which contain water below the point where we can access. As for last year, it is recommended that baited traps are deployed to catch and remove the goldfish. Another fish was observed briefly in 2007, suspected to be a Nightfish. Trapping would also confirm the identity of this second fish (which was not seen on this occasion, but is assumed to be present). WQ and fauna samples were taken.

Orpheus Cave: There was no obvious change in condition of Orpheus Cave, except that the water level was once again lower than in 2007 (Plates 11 – 14). We had an unconfirmed sighting of a free-swimming amphipod on first arriving at the pool, but the individual seen by Lex Bastion was not re-sighted by Lex or other members of the sampling team. This compares with three amphipods observed swimming in the pool in 2007. WQ and fauna sample were taken.

YN61: There was no surface water in this cave, with the deep mud across the floor of the cave dry and cracked. There was water in the very bottom of the PVC pipe – but ~50 – 60 cm below the floor of the cave. The curtain of root mat at the far end of the cave, from where amphipods were sampled when the cave held water, was also dry. No fauna or WQ samples were taken.

Plate 7. Sampling a pool in the cave on lot 51 (YN555), in 2005.

Plate 8. . Showing extent of water loss in the same pool in the cave on lot 51 (YN555), in 2006.

Plate 9. Extent of water loss in the same pool in cave on lot 51 (YN555), in 2007 (arrow shows water level).

Plate 10. The same pool in the cave on lot 51 (YN555), in December 2008, with water now totally absent

Twilight & *Spillway caves*: These caves were not accessed due to ongoing safety concerns over their stability.

Fridge Grotto: This cave continues to be dry, and has never held water in recent years

Gilgie Cave: This cave was not accessible due to a rock slide at the entrance, however, Gilgie Cave has been dry for many years.

3.1.2 Water Levels

Comparison of water levels (mAHD) in adjacent groundwater bores with the surveyed AHD of the floor of the caves (Table 2) indicated that the maximum water level in 2008, in winter was 0.94 m and 1.09 m below the AHD of Cabaret and Boomerang Gorge caves, respectively (Figure 6), showing that water levels are well below the level of the cave streams. The minimum summer water level in the bore closest to Carpark Cave (Figure 6) was 3.5 m above the AHD of the cave, which would suggest the cave always contains water. However, the stream in Carpark Cave is always dry, which may indicate that local topography and local ground water levels are critical, and bore YN3 is too far away from Carpark Cave to be representative. In bores YN3 and YN4 there is a continuing, almost linear decline in summer minimum water levels, with no indication of the rate of decline decreasing with time. This suggests water levels in the caves will continue to decline for the foreseeable future.

Water levels in four groundwater bores in the vicinity of the cave on Lot 51 (YN555) also show an almost linear decline in water levels for the past ten years (Figure 7). The only exception is Bore GNM9, which shows a slight reduction in rate of decline in the last two years. All bores show a continuing decline in water levels which is reflected in water levels in the cave pools, which have declined over the last three years (Plates 7 - 10).

Although there are no groundwater water level monitoring bores in the vicinity of Orpheus Cave, water levels there have also declined in recent years (Plates 11 - 14).

Plate 11. Pool in Orpheus Cave, 2005. Arrow indicates water level

Plate 12. Pool in Orpheus Cave, 2006. Arrow indicates water level

Plate 13. Pool in Orpheus Cave, 2007. Arrow indicates water level.

Plate 14. Pool in Orpheus Cave, 2008. Arrow indicates water level.

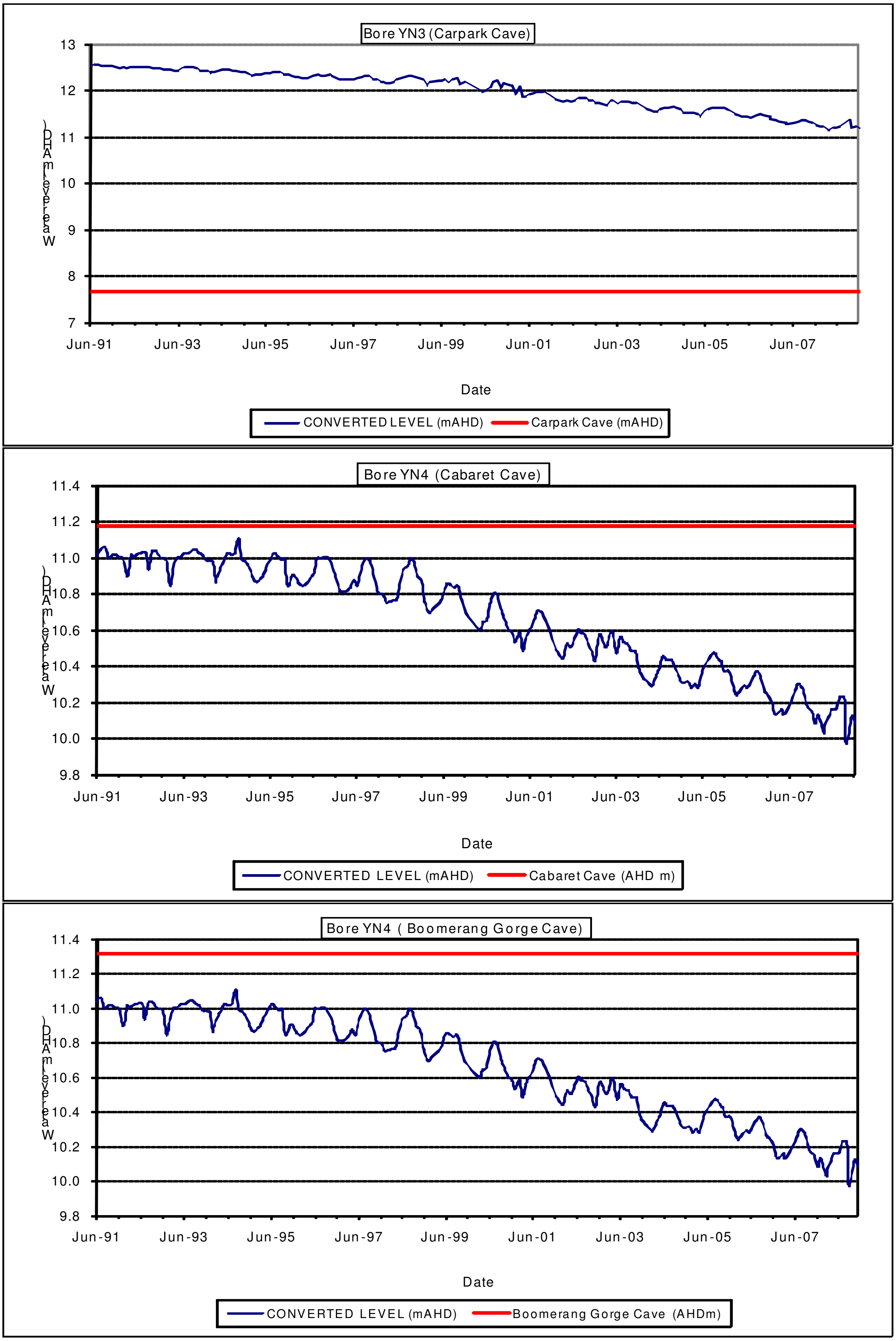


Figure 6. Temporal changes in water levels (mAHD) in monitoring bores YN3 and YN4 against surveyed bed levels (mAHD) of adjacent caves in Yanchep National Park.

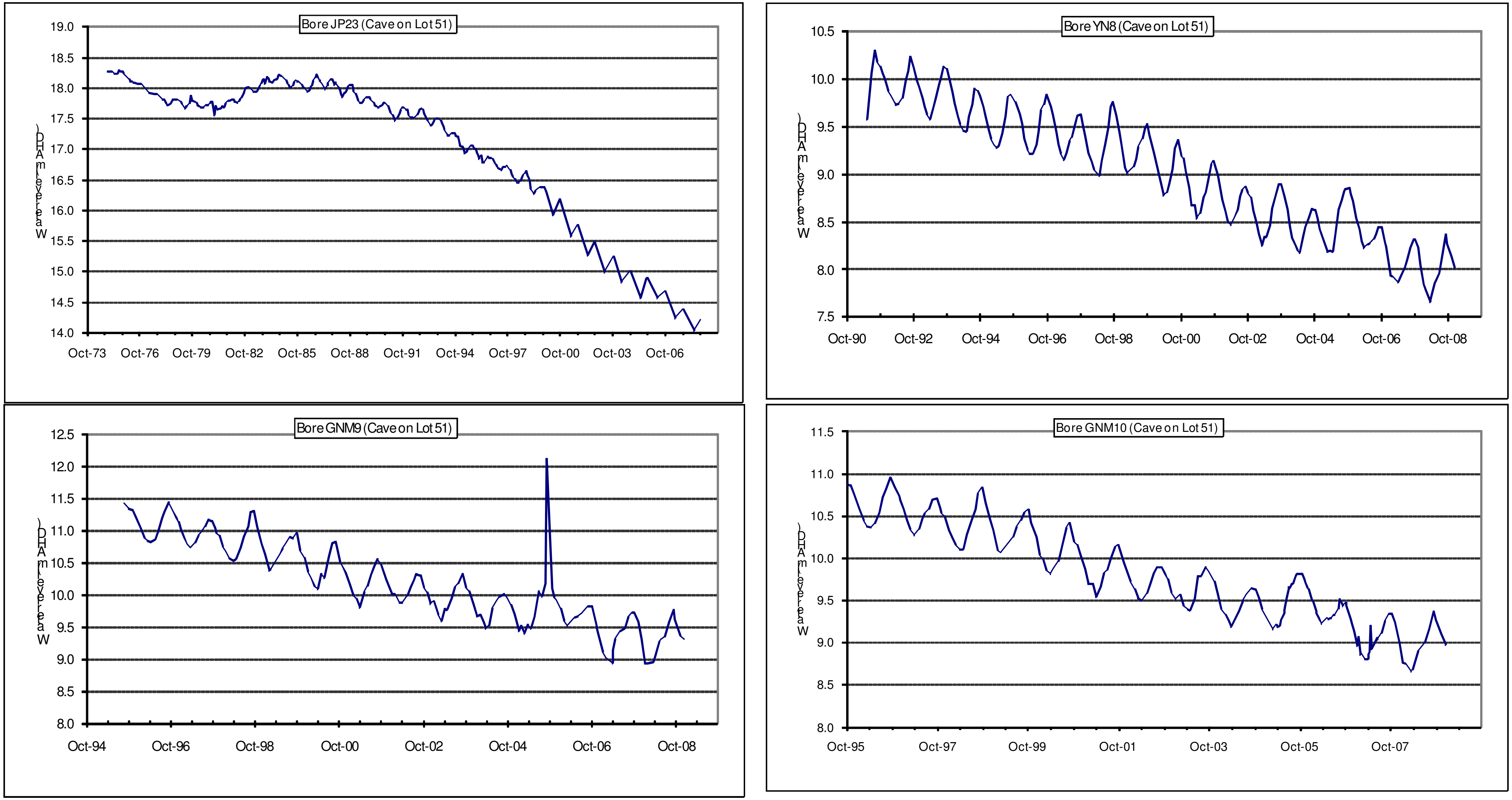


Figure 7. Temporal changes in water levels (mAHD) in monitoring bores JP23, YN8, GNM9 and GMN10 near the cave on Lot 51 (YN555).

3.1.3 Water Quality

As in previous reports (Knott & Storey 2001, 2002, 2003, 2004; Cook & Janicke 2005; Knott *et al.* 2006, 2007, 2008) *in-situ* water quality parameters were relatively consistent across caves and constant over time in those caves repeatedly sampled (November 2000 to current study) (Table 7, Appendix 1).

Dissolved oxygen (DO) levels varied over time. Levels in caves sampled this year were within the range measured on previous occasions (Table 7, Appendix 1). This indicates that the low levels of DO recorded in 2005 were likely due to a fault subsequently discovered in the DO probe.

Salinity in all caves was ≤ 0.5 ppt, during the current sampling period, except YN555 on Lot 51, which was 0.53 ppt. Levels were generally consistent across all occasions indicating that the water was fresh (<0.5 ppt, Department of Environment 2003). Lot 51 experienced 'spikes' in salinity during 2003 and 2005 (Figure 8) which may reflect some evapoconcentration of salts in the waterbody in the cave. Sulphate showed similar spikes (Figure 8), suggesting the conductivity is driven by changes in sulphate levels.

All caves had circum-neutral pH (pH 6.5 – 7.5), reflecting the influence of the Gnangara groundwater, combined with some dissolution of calcium carbonate into the water of caves with a long residence time (*i.e.* Lot 51, Water and Orpheus caves). The cave on Lot 51 had slightly higher pH (7.58), which may reflect the lower water levels in this pool and some effect of evapoconcentration.

Water temperatures were very comparable across caves, being less than 20 °C in all caves, with Cabaret Cave and cave on Lot 51 having the lowest temperatures of 17.4 and 16.4 °C, respectively.

Concentrations of laboratory-determined parameters also were relatively consistent across caves and years (Table 7, Appendix 1). As in previous years, the composition of cations was dominated by calcium (Ca^{2+}) and sodium (Na^{+}), with lower levels of potassium (K^{+}) and magnesium (Mg^{2+}). YN555 on Lot 51 continued to have the highest Na^{+} concentrations (95.8 mg/L), and this correlated with the consistently higher conductivities recorded from this cave.

In most caves, levels of nitrogen (nitrate + nitrite) were below the recommended guideline concentrations for protection of aquatic ecosystems (ANZECC/ARMCANZ 2000), using the guideline for southwest WA wetlands (Table 6). There were two caves which exceeded the guideline; YN555 on Lot 51 recorded 0.80 mg/L of nitrogen (nitrate + nitrite), and Carpark Caves recorded 0.14 mg/L. A precautionary approach should be used when applying ANZECC/ARMCANZ (2000) trigger values, as guidelines specifically applicable for groundwater ecosystems have yet to be developed. The elevated levels of nitrogen may indicate anthropogenic influences, or could reflect a high organic loading in the caves.

Concentrations of soluble reactive phosphorus were generally low in all caves (≤0.01 mg/L) and were below the recommended guideline concentrations for protection of aquatic ecosystems (ANZECC/ARMCANZ 2000) (Table 6).

Sulphate levels were low in most caves; with YN555 having the highest level of 18.4 mg/L, compared with 18.2 mg/L in 2006 and 13.8 mg/L in 2007. These levels were considerably lower than those recorded in 2003 and 2005 (Figure 8; Appendix 1). A trend between sulphate levels and conductivity is apparent in YN555 (Figure 8). While there are currently no Australian guideline limits for sulphate in freshwaters, overseas guidelines indicate levels greater than 50 - 100 mg/L are likely to be detrimental to aquatic biota (refer BC Ministry of Environment Lands and Parks (2000)). Elevated sulphate in southwest Western Australian wetlands is used to indicate disturbance of acid sulphate soils.

Apart from water quality in YN555 (Lot 51), concentrations of parameters measured over time were very consistent when compared with levels recorded in 1998 (Cabaret Cave), and 2000 and 2001 (Carpark and Water caves) (Table 7, Appendix 1). This indicated no fundamental change in basic water quality over time, as would be expected for well buffered waters arising from the Gnangara groundwater system.

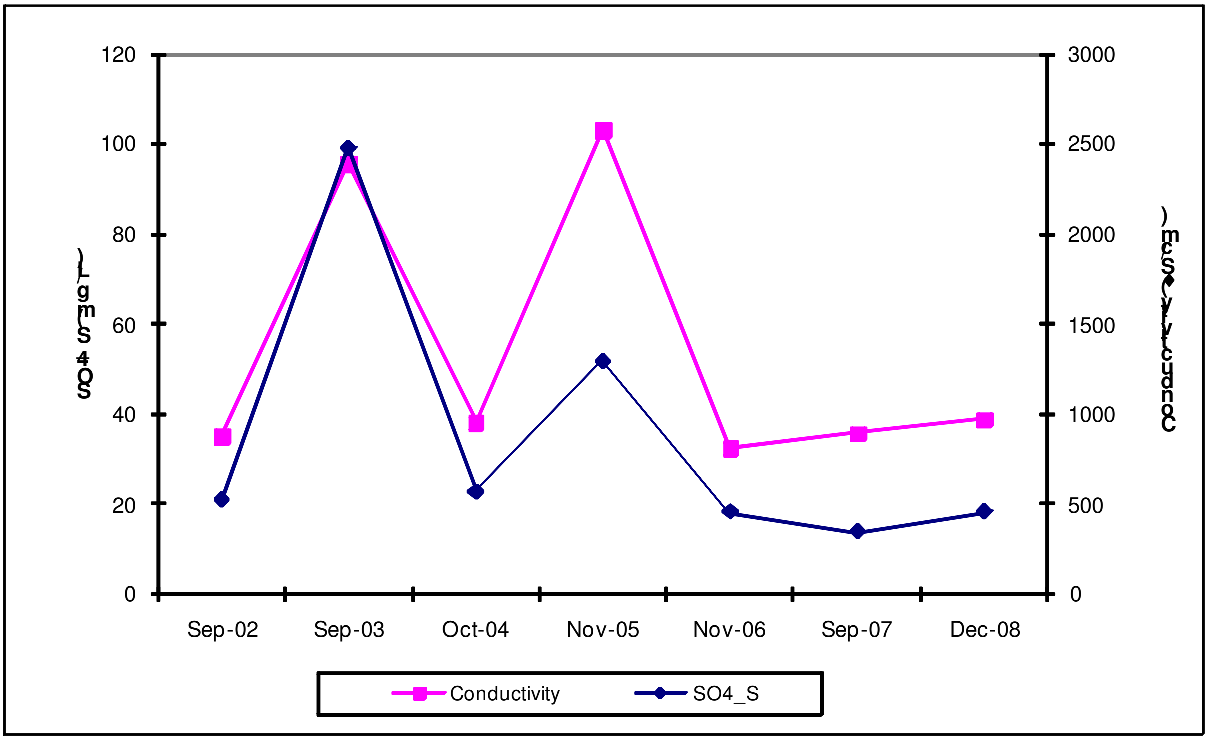


Figure 8. Conductivity (µS/cm) and sulphate (SO_4_S, mg/L) over a seven year sampling period for the cave on Lot 51 (YN555).

Table 6. ANZECC/ARMCANZ (2000) trigger values for nutrients, dissolved oxygen and pH for the protection of aquatic ecosystems, applicable to south-west Western Australia (TP = total phosphorus; FRP = filterable reactive phosphorus; TN = total nitrogen; NOx = total nitrates/nitrites; NH_4^+ = ammonium).

	TP (mg/L)	**FRP** (mg/L)	**TN** (mg/L)	**NO_x** (mg/L)	****NO_3** (mg/L)	****NO_2** (mg/L)	**NH_3** (mg/L)	**NH_4^+** (mg/L)	**DO** % saturation[2]	**pH**
Aquatic Ecosystem										
Upland River[1]	0.02	0.01	0.45	0.2	NP	NP	0.9[5]	0.06	90	6.5 – 8.0
Lowland River[1]	0.065	0.04	1.2	0.15	NP	NP	0.9[5]	0.08	80 - 120	6.6 – 8.0
Lakes & Reservoirs	0.01	0.005	0.353	0.01	NP	NP	0.9[5]	0.01	90	6.5 – 8.0
Wetlands[3]	0.06	0.03	1.5	0.1	NP	NP	0.9[5]	0.04	90 - 120	7.0 – 8.5[4]

** Where 1mg/L NO3-N = 4.43 mg/L NO3; 1 mg/L NO2-N = 3.29 mg/L NO2.
NP = value not provided.
1 All values during base river flow not storm events.
2 Derived from daytime measurements; may vary diurnally and with depth; data loggers required to assess variability.
3 Elevated nutrients in highly coloured wetlands do not appear to stimulate algal growth.
4 In highly coloured wetlands, pH typically ranges 4.6 – 6.5.
5 General level for slightly-moderately disturbed ecosystems and not specifically formulated for south-west WA; figure may not protect species from chronic toxicity.

Table 7. *In-situ* and analytically-determined water quality parameters measured in 2008. Shading indicates elevated levels.

		Cabaret Cave YN30	**Carpark Cave YN18**	**Water Cave YN11**	**Cave on Lot 51 YN 555**	**Orpheus Cave YN256**
In-situ						
Dissolved Oxygen	**%**	81	83	71	79	84
Dissolved Oxygen	**mg/L**	7.9	7.8	6.5	8.0	7.8
pH		7.25	7.25	7.32	7.58	7.25
Redox	**milliV**	-25.0	-24.9	-29.1	-43.4	-25.9
Temperature	**˚C**	17.4	20.1	19.4	16.4	19.3
Laboratory determined						
Calcium (Ca^{2+})	**mg/L**	37.3	42.1	52.3	85.8	63.1
Potassium (K^+)	**mg/L**	2.3	2.5	2.0	2.0	2.3
Magnesium (Mg^{2+})	**mg/L**	6.4	5.0	5.6	8.5	6.1
Sodium (Na^+)	**mg/L**	60.4	53.5	61.5	95.8	64.8
Conductivity	**µS/cm**	540	514	615	971	681
Nitrate/nitrite (N_NO_3)	**mg/L**	0.06	0.14	0.06	0.8	0.06
Total reactive phosphorus	**mg/L**	<0.01	0.01	<0.01	0.01	<0.01
Sulphate (SO_4_S)	**mg/L**	10.7	8.1	10.8	18.4	17.1
Turbidity	**NTU**	<0.5	0.6	<0.5	0.6	<0.5

3.1.4 Aquatic Fauna

Species richness recorded from root mat samples taken in December, 2008, ranged from no specimens in Cabaret and Orpheus caves to 4 species in Water cave (Table 8; Figures 9 & 10). Abundance of each species was very low, generally consisting of one specimen of each of the forms listed in Table 8. The specimens collected comprised, predominantly worms (Microturbellaria, Nematode, Oligochaeta and Copepoda (Table 8).

A photographic voucher collection of specimens not included in the 2005 report (Knott *et al.* 2006) is presented in Appendix 3.

Taxonomic resolution and description of remaining Copepoda specimens from groundwaters of the Gnangara Mound is currently progressing [and a summary incorporating results of cave and spring studies by Danny Tang is included later in this Report (Table 14)] The cyclopoid species so far identified are listed in Table 9, along with the site and dates collected. Future reports will include the updated species list.

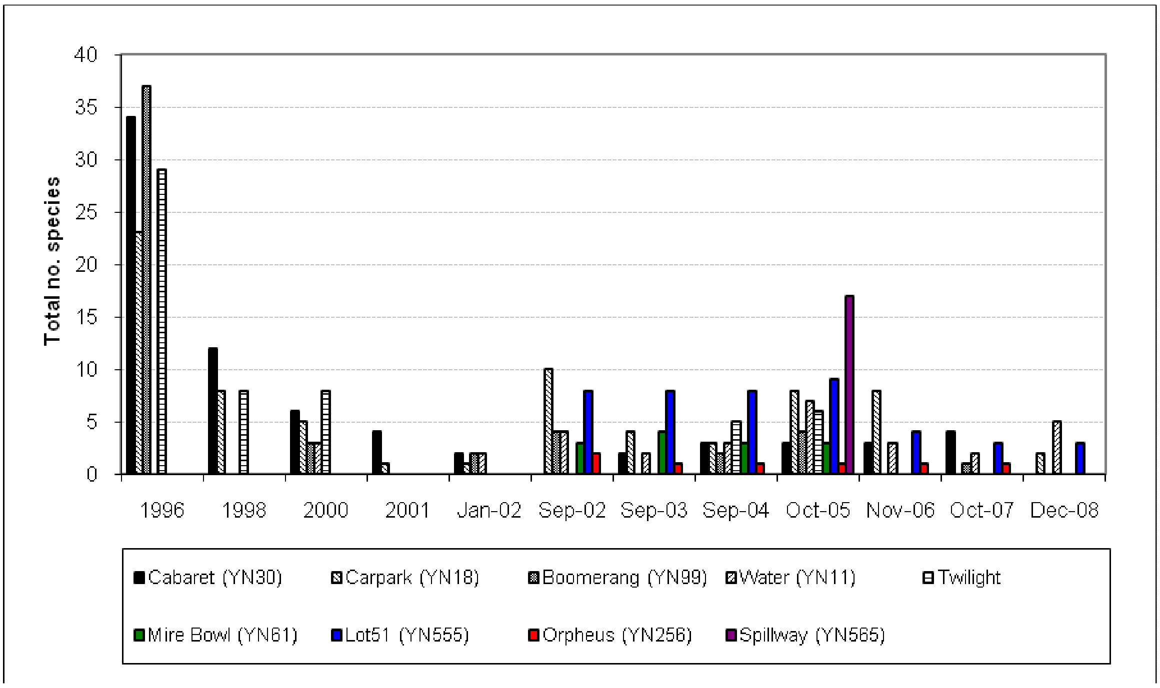


Figure 9. Total number of taxa recorded from Yanchep caves over the entire sampling period.

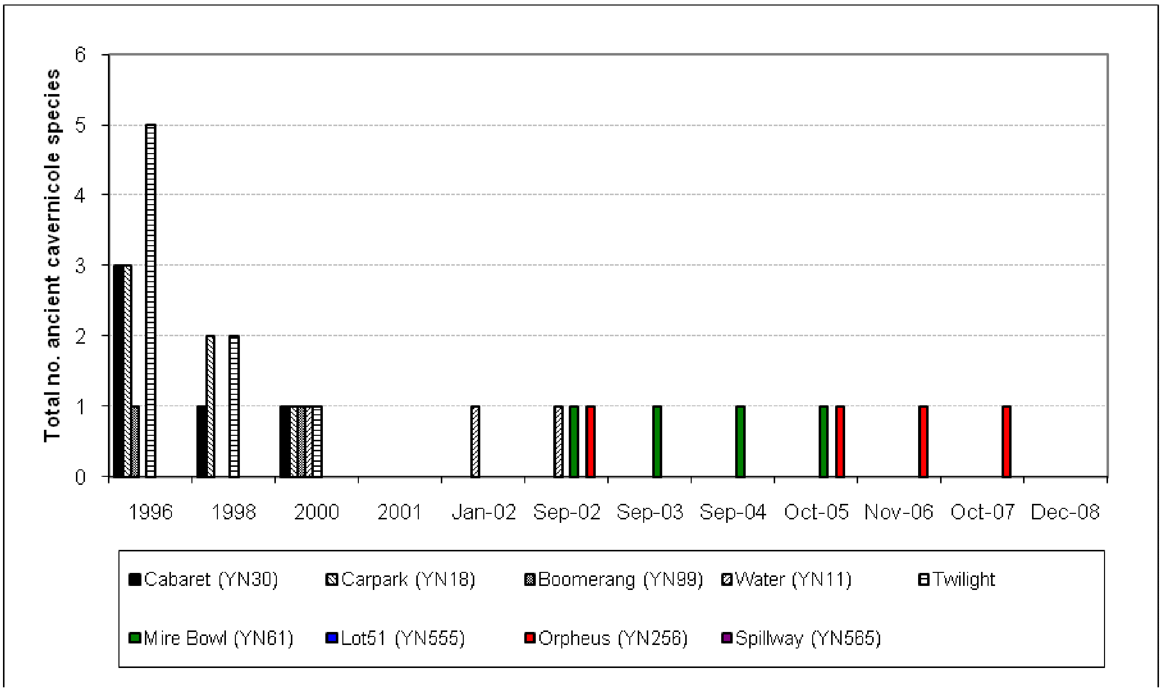


Figure 10. Total number of ancient cavernicole (stygofauna) taxa over the entire sampling period.

Table 8. Systematic list of aquatic invertebrates recorded from Yanchep Caves in December 2008. The source of each taxon, as classified by Jasinska is indicated whereby I = widespread marine & freshwater interstitial fauna, S = derived from surface waters of Loch McNess, T = insects with terrestrial adults and aquatic larval stages, A = ancient cavernicoles (stygofauna), and U = unclassified.

			TAXON	Source of fauna	Cabaret (YN30)	Carpark (YN18)	Water (YN11)	Lot51 (YN555)	Orpheus (YN256)
PLATYHELMINTHES	**TURBELLARIA**		Turbellaria spp.	I			1		
	NEMATODA		Nematoda spp.	U		1		1	
ANNELIDA	**APHANONEURA**	**Aeolosomatidae**	*Aeolosoma* sp.	I				1	
	OLIGOCHAETA	**Enchytraeidae**	Enchytraeidae UWA1	I			1	1	
		Tubificidae	*Pristine aequiseta*	U			1		
CRUSTACEA	**DECAPODA**	**Parastacidae**	*Cherax* sp.	S					
	AMPHIPODA	**Paramelitidae Gen 3**	Paramelitidae Gen 3	A					
	COPEPODA								
	Cyclopoida		*Australoeucyclops* sp. nov.	U			4		
			Eucyclops edytae.	U					
			Paracyclops chiltoni	I					
	Harpacticoida		Juvenile specimen			1			
	OSTRACODA	**Darwinulidae**	*Gomphodella* sp.	U					
			Candona sp.	U				1	
ARACHNIDA	**ACARINA**								
	Acariformes								
	Oribatida		Oribatida spp.	U					
	Parasitiformes								
	Mesostigmata		Mesostigmata spp.	U			1		
INSECTA	**COLEOPTERA**	**Curculionidae**	Curculionidae spp. (L)	S					
	DIPTERA	**Empididae**	Empididae spp.	T					
			Total number of taxa recorded		**0**	**2**	**5**	**4**	**0**
			No. taxa in each group						
			Ancient cavernicoles (stygofauna)	A					
			Widespead marine & freshwater interstitial fauna	I			3	2	
			Surface waters of Loch McNess	S					1
			Insects with terrestrial adult and aquatic larval stages	T					
			Unclassified	U		1	2	1	

Table 9. Updated taxonomic decisions for cyclopoid copepods recorded in Yanchep Caves. Numbers of specimens from each sampling period are given.

		Cabaret (YN30)							**Carpark (YN18)**	**Boomerang (YN99)**			**Cave in Boomerang Gorge (YN7)**	**Mire Bowl (YN61)**				**Lot51 (YN555)**					**Orpheus (YN256)**	**Twilight (YN194)**			**Spillway (YN565)**	**Gilgie Cave (YN27)**		**Water (YN11)**			**Jackhammer (YN438)**	**Fridge Grotto (YN81)**
TAXON	**Source of fauna**	1/06/1990	19/06/1990	27/01/1991	5/02/1992	29/07/1993	9/10/2007	?	?	17/07/1992	28/08/1994	14/11/1996	17/07/1992	17/07/1992	18/09/2002	22/09/2003	2005	2003	2004	2005	2006	2007	17/07/1992	2/06/1996	27/11/1996	2005	2005	17/03/1993	28/08/1994	19/09/2003	9/10/2007	04/12/2008	4/10/2003	17/07/1992
Cyclopoida copepodites	U	1									3	2								1						1								
Cyclopidae: Eucyclopinae																																		
Tropocyclops confinis	S																	2																
Macrocyclops albidus	S																										24							
Paracyclops chiltoni	S	1	3									1													5		2				2			
Australoeucyclops sp. nov.	S†	15		16	10	1		15	4					2	1	2	4	10	5	114		19	1	1	4		2	8	11	14		4	409	3
Eucyclops sp. nov.	S†						1																											
Cyclopidae: Cyclopinae																																		
Mesocyclops brooksi	S																	1	4	31							1							
Mixocyclops sp. nov.	S†												2								1							1						

For Source of fauna column: U = Unclassified; I = widespread freshwater interstitial; S = derived from surface waters of Loch McNess; S† = Not known for sure, but suspected to be surface water species, maybe stygophiles (able to live both surface and underground).

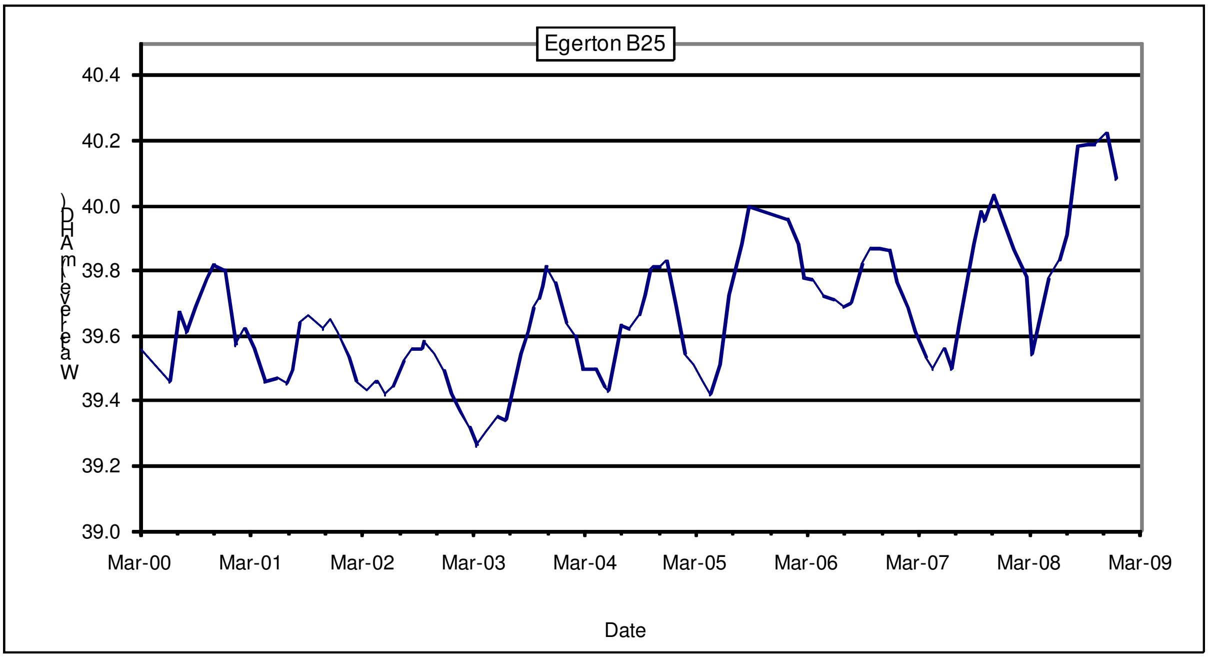
3.2 Springs

3.2.1 Water Quantity

Egerton Spring was flowing quite strongly when sampled in December, 2008, possibly reflecting late spring rains. Urban development continues to encroach on this site with substantial clearing and new houses immediately to the west, and substantial new clearing to the east and south.

Edgecombe Spring had stopped flowing in December, 2008, and the spring looked in very poor condition with an abundance of weeds and weed species within and around the spring.

Data from groundwater water level monitoring bores adjacent to Egerton (B25) and Edgecombe (B10) Springs have shown similar patterns of low and slightly decreasing water levels in the late 1990s and early 2000, but both have shown a trend of increasing winter maxima and summer minima at both locations, with this trend strengthening in the last year (Figure 11). This is even in light of a very dry winter in 2005. Increasing water levels may reflect greater local recharge as a result of urban development immediately to the west of both sites (see Figures 3 & 4). The AHD for Egerton and Edgecombe Springs is unknown and so the relationship between bore water levels and the surface level of the springs cannot be determined. However, it is known that Edgecombe Spring ceased flowing in spring/summer 1999. Therefore, by inference it may be assumed that at this time the minimum groundwater level in bore B10 fell below the AHD of Edgecombe Spring. Estimated AHD of the springs and the trend on minimum summer water levels in bores B10 (Edgecombe) and B25 (Egerton) are presented in Figure 11. The direct relevance of data from these bores to the respective springs is unknown, but given their relative close proximity to the springs it is assumed that water levels in these bores relate relatively closely to flow from the springs.



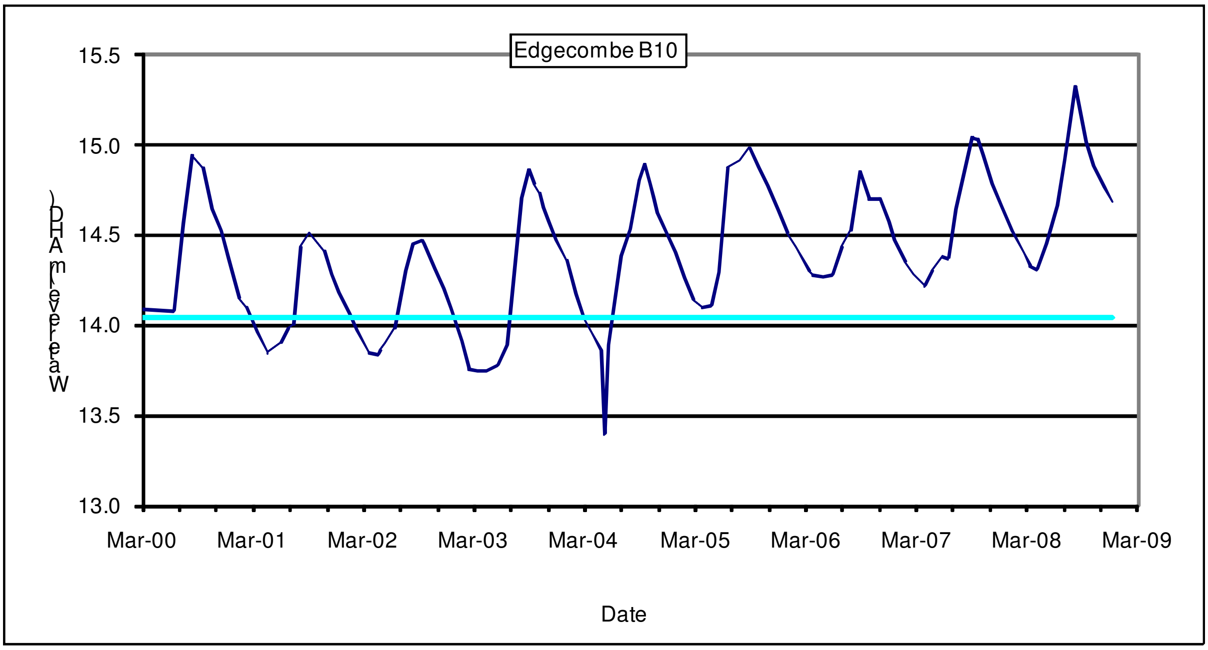


Figure 11. Temporal changes in water levels in Bores B10 and B25. Estimated bed level (m AHD) of Edgecombe Spring is illustrated, based on water level when it dried in spring/summer 1999.

3.2.2 Water Quality

As in previous reports (Horwitz & Knott 2002, 2004; Cook & Janicke 2005; Knott *et al.* 2006, 2007, 2008), *in situ* and laboratory determined water quality parameters were generally indicative of good quality, fresh water and were relatively constant over time. Salinity at both springs was less than 0.5 ppt and fresh[3] while pH ranged from circum-neutral (pH 6.94) at Edgecombe to strongly acidic (4.15) at Egerton Spring. Data collated over the past nine sampling periods show a strong upward trend in salinity at Edgecombe and Egerton Springs (Figure 12), although the most recent data for Edgecombe show a marked reduction in late 2008. There has been a strong downward trend in pH at Egerton Spring, with a gradual increase at Edgecombe (Figure 13), however, the most recent reading from Egerton indicates a sharp rise in pH. This is against the recent trend, and should be reassessed in the next visit to the site (i.e. determine it was not a fault with the pH meter).

Concentrations of other water quality parameters were relatively consistent over time (Table 10, Appendix 1). The composition of cations at Egerton Spring was dominated by sodium (Na) with lower levels of magnesium (Mg), calcium (Ca) and potassium (K) (Table 10). In contrast Ca was dominant in waters at Edgecombe Spring, with Na sub-dominant (Table 10). Levels of nitrogen (as nitrate + nitrite, NO_X) exceeded ANZECC/ARMCANZ guidelines (Table 6, Figure 14) at both springs. Levels of sulphate at both springs appear to be variable over time, with no strong pattern (Figure 15).

Table 10. *In-situ* and analytically-determined water quality parameters measured in 2008. Levels of concern are indicated by shading.

		Egerton Spring		Edgecombe Spring
		22-08-08	*22-12-08*	*22-12-08*
In-situ				
Dissolved Oxygen	%	107.0	75.0	52.0
Dissolved Oxygen	mg/L	10.0	6.3	4.7
pH		4.15	6.32	6.94
Temperature	˚C	18.8	23.0	22.9
Laboratory determined				
Calcium (Ca^{2+})	mg/L		35.3	2.3
Potassium (K^+)	mg/L		7.2	1.1
Magnesium (Mg^{2+})	mg/L		6.5	6.2
Sodium (Na^+)	mg/L		49.5	33.4
Chloride (Cl^-)	mg/L		98	55
Conductivity	µS/cm	338	489	238
Total iron[4]	mg/L		160	0.45
Nitrate/Nitrite (N_N0_3)	mg/L		1.8	0.82
Sulphate (SO_4_S)	mg/L		52.2	14.6
Colour	TCU		25	48

[3]Department of Environment (2003) *Stream and catchment hydrology*, River Restoration Report No. RR19, Department of Environment, Perth.
[4] Includes the deposit and in solution iron.

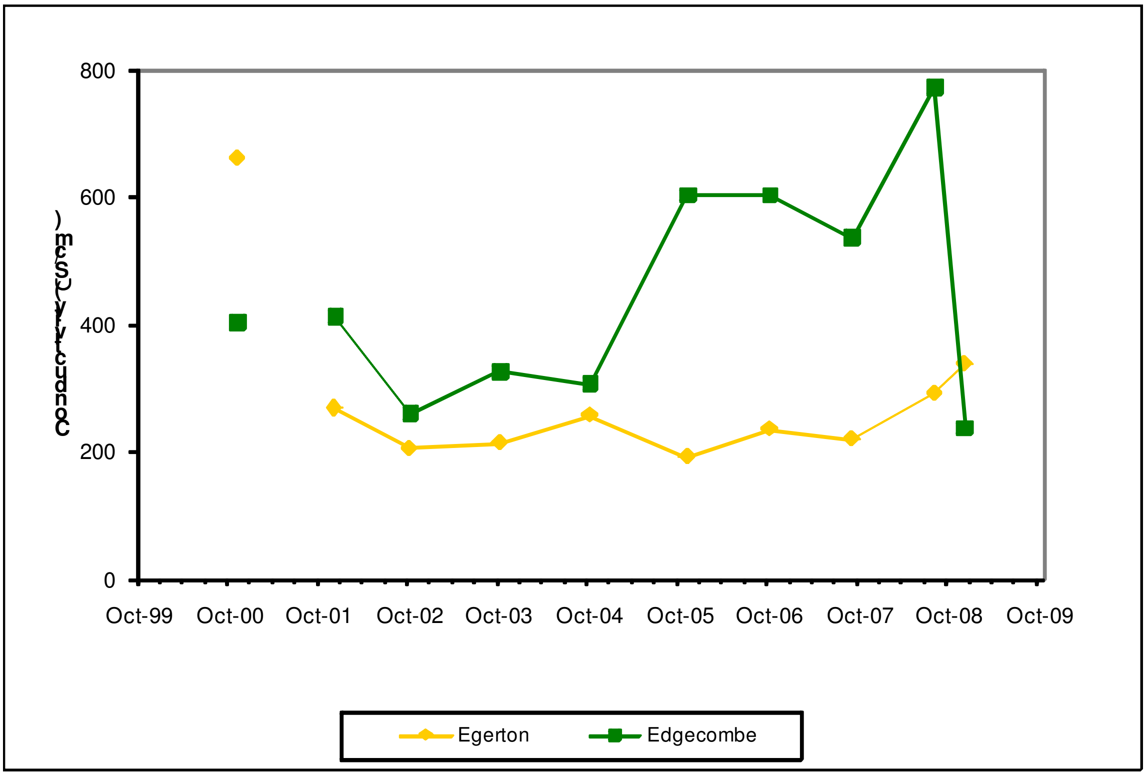


Figure 12. Salinity (ppt) over time for Egerton and Edgecombe Springs.

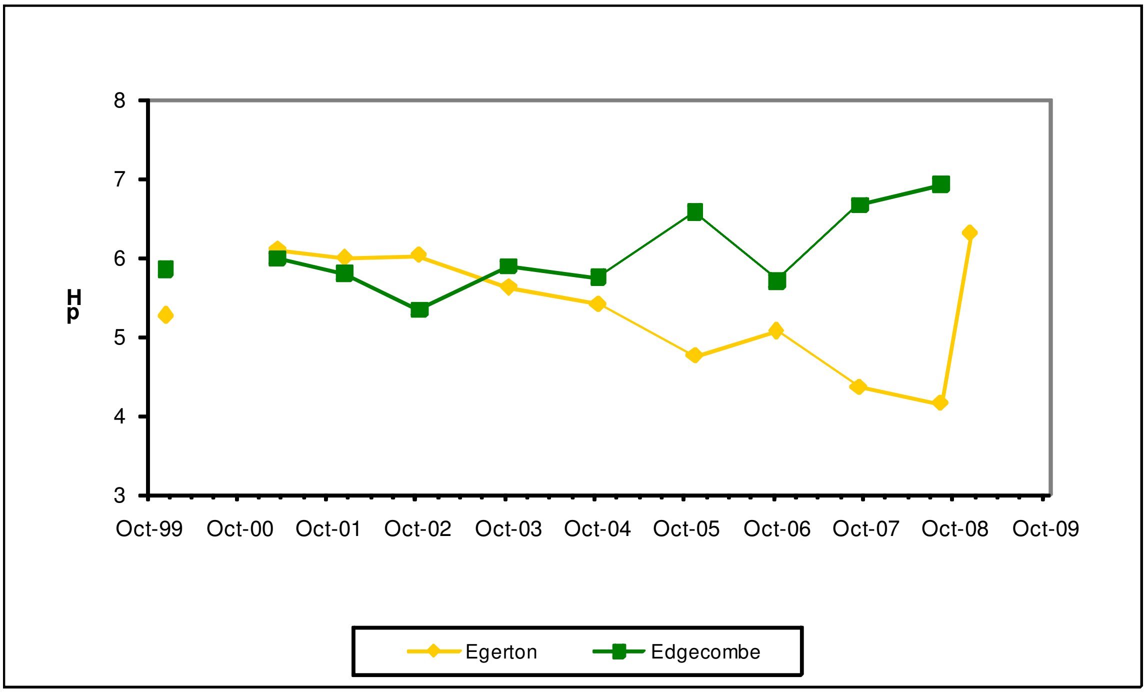


Figure 13. pH over time for Egerton and Edgecombe Springs.

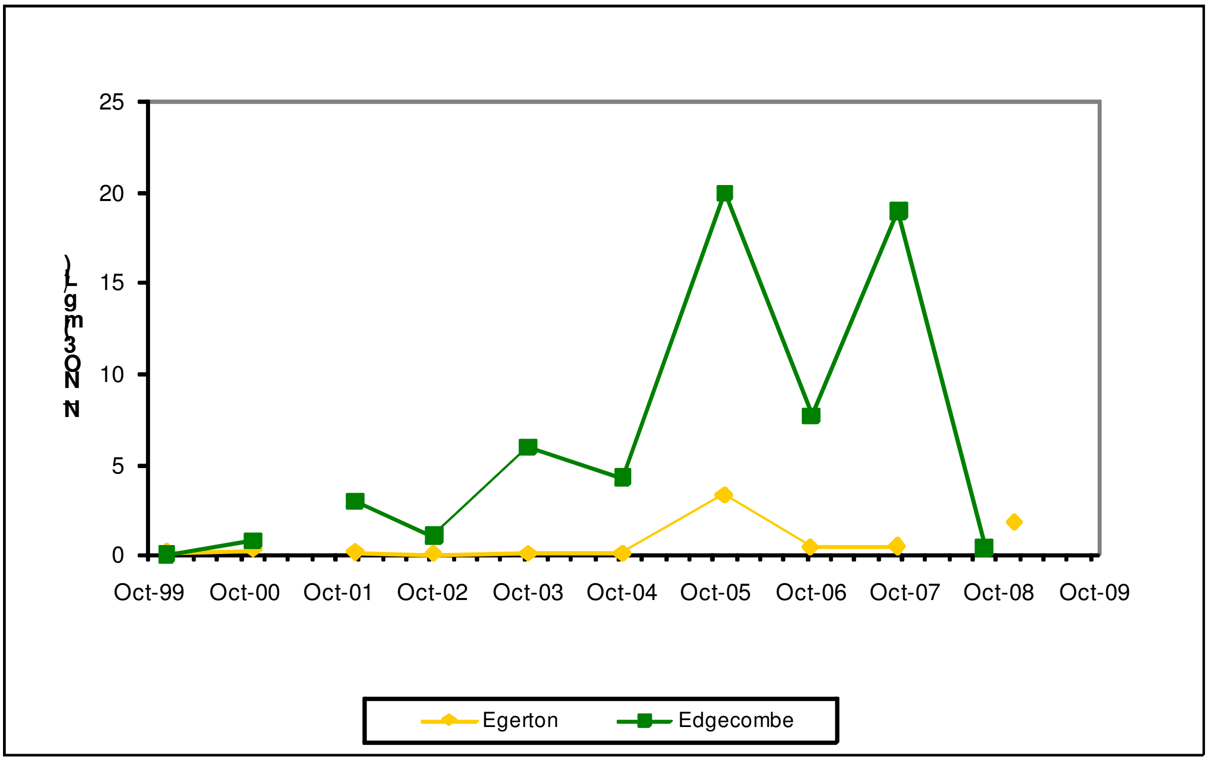


Figure 14. Nitrate and nitrite levels (mg/L) over time for Egerton and Edgecombe Springs.

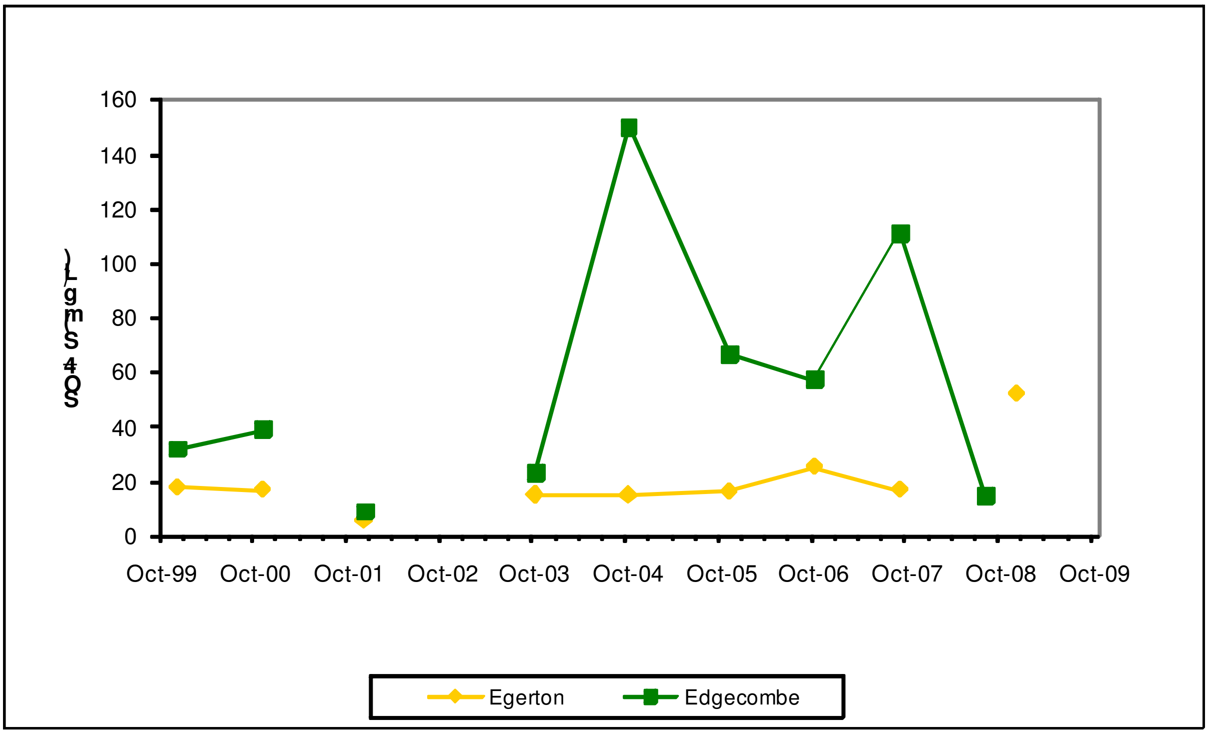


Figure 15. Sulphate (SO4_S mg/L) over time for Egerton and Edgecombe Springs.

3.2.3 Aquatic Fauna

Species richness at Egerton Spring was again relatively high (Table 11), with all crustacean groups (Amphipoda, Cladocera, Copepoda, Ostracoda) represented and most in relatively high abundance. Four copepod taxa were collected (Table 11). Of interest were the recently recognised species *Paracyclops intermedius* and *Eucyclops edytae* and a harpacticoid copepod of the family Canthocamptidae, *Australocamptus*.

The fauna sampled from Edgecombe Spring, with seven species continued as depauperate (Table 11).

The results of Danny Tang's are becoming available, and are summarised her at the conclusion after the Bullsbrook springs are introduced (Table 14).

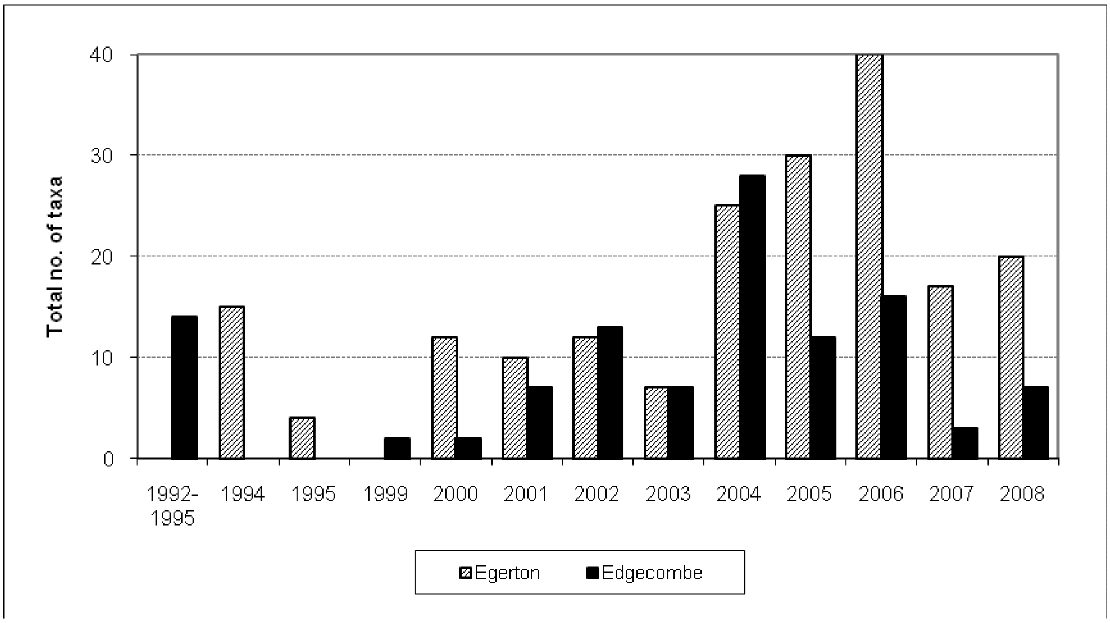


Figure 16. Total number of taxa recorded at the springs over the entire sampling period.

Table 11. Systematic list of aquatic invertebrates recorded from sites at Egerton and Edgecombe Springs in December, 2008.

			TAXON	Egerton	Edgecombe
TURBELLARIA			Turbellaria spp.	1	1
NEMATODA			Nematoda spp.	1	1
ANNELIDA					
OLIGOCHAETA	**Tubificidae**				
		Naidinae	*Pristina aequiseta*	1	1
			Pristina leidyi	0	0
			Pristina cf osborni	0	0
	Phreodrilidae		*Insulodrilus bifidus*	0	0
			Insulodrilus lacustris s.l (form WA28)	1	0
			immature Phreodrillidae with similar ventral chaetae	1	1
ARTHROPODA					
CRUSTACEA					
Cladocera	**Ilyocryptidae**		*Ilyocryptus* sp.	1	0
Copepoda					
	Cyclopidae				
		Eucyclopinae	*Paracyclops intermedius*	1	0
			Eucyclops edytae	2	0
	Canthocamptidae		Canthocamptid sp.	0	0
			Attheyella (*Chappuisiella*) *hirsuta*	65	0
			Australocamptus sp.		1
Ostracoda					
	Darwinulidae		*Darwinula sp.*	0	0
	Candonidae		*?Candona* sp.	1	1
Amphipoda	**Paramelitidae**		*Wesniphargus* sp. .	1	0
CHELICERATA					
ACARINA					
Oribatida			Oribatida spp.	0	0
Prostigmata	**Hygrobatidae**		Hygrobatiidae spp.	0	0
	Limnesiidae		Anisitsiellinae sp. nov.	1	0
	Trombidioidea		Trombidioidea spp.	0	0
INSECTA					
ODONATA					
Zygoptera	**Megapodagrionidae**		*Archiargiolestes* sp.	0	0
Anisoptera	**Synthemistidae**		*Archaeosynthemis occidentalis*	0	0
HEMIPTERA	**Hebridae**		*Hebrus* sp.	1	
COLEOPTERA	**Dytiscidae**		*Sternopriscus* sp. (L)	1	0
	Hydrophilidae		*Enochrus ?peregrinus*	0	0
			Enochrus sp. (L)	0	0
	Scirtidae		Scirtidae spp. (L)	1	0
DIPTERA	**Chironomidae**				
		Chironominae	*Polypdedilum ?oresitrophus*	1	1
			Riethia sp. (V4)	1	0
			Riethia sp. (V5)	0	0
			Stempellina ?australiensis	0	0
			Tanytarsus sp.	0	0
		Orthocladiinae	Orthocladiinae sp. V31	0	0
		Tanypodinae	*Apsectrotanypus ?maculosus*	0	0
			Paramerina levidensis	0	0
			Pentamura sp.	0	0
			Chironomidae spp. (P)	0	0
	Ceratopogonidae		Ceratopogoniinae spp.	1	0
	Empididae		Empididae spp.	0	0
	Tipulidae		Tipulidae spp.	0	0
TRICHOPTERA	**Hydroptilidae**		*Oxyethira* sp.	1	0
	Leptoceridae		*Notalina* sp.	1	0
			Total no. of species	**20**	**7**

3.3 Additional Gnangara Mound Springs

3.3.1 Water Quantity

The new springs to the west of Bullsbrook, originally sampled in February 2008, were visited again in August and December 2008. As before, the springs are relatively intact and had good flows. The tumulus (mound) spring on the Moran Property (GastonRd within Gaston Swamp) was sampled on 22 August and 22 December, 2008. The spring identifiers as used by DEC have been incorporated here and in Tang *et al.* 2008.

Although no groundwater monitoring bores were adjacent to these springs, there are bores in the area (Figure 17). Temporal changes in water levels in these bores (Figure 18) showed some were declining and others were variable and steady. The bores closest to the springs (#5384; Old GN24) indicated an approximate 50 cm drop in summer minimum water levels over the last ~30 years, whereas bores to the south showed a drop of 8 m (AM26) and 20 m (AM26B) over the last 30 years. So, it appears that water levels in the area are very variable.

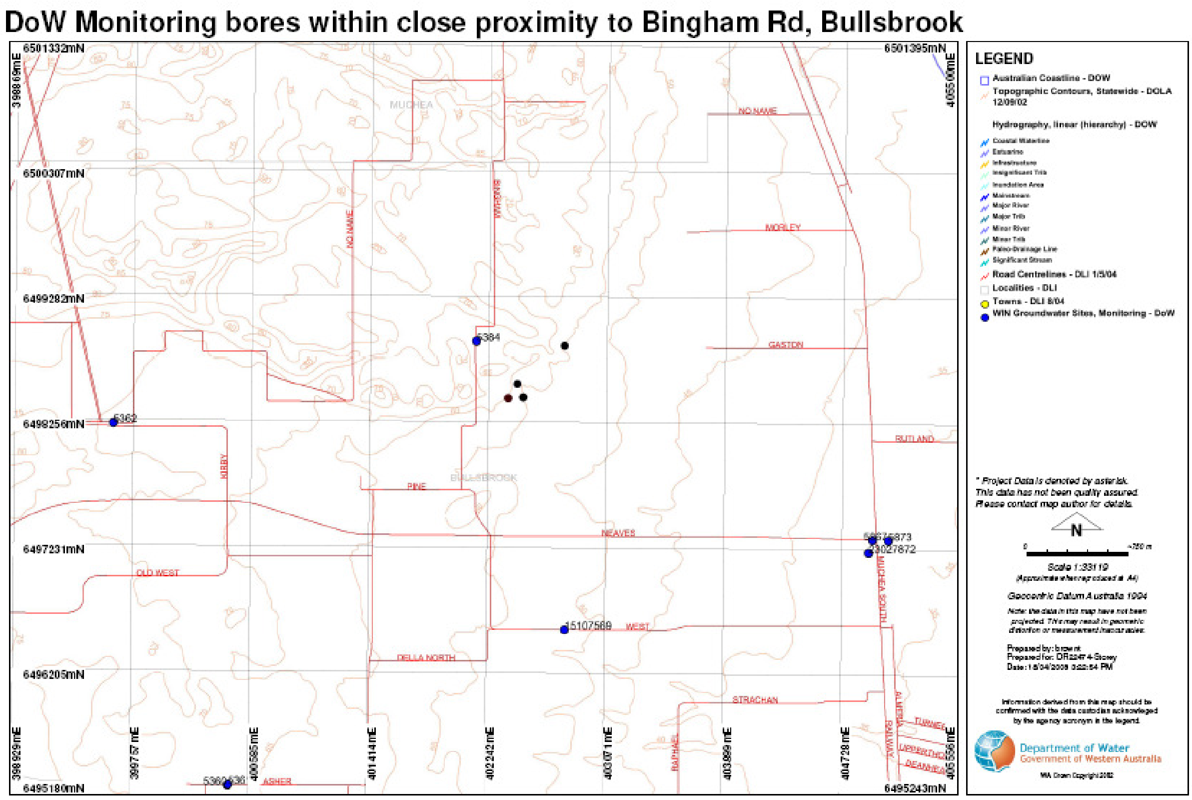


Figure 17. Groundwater water level monitoring bores in the vicinity of new springs at Bullsbrook.

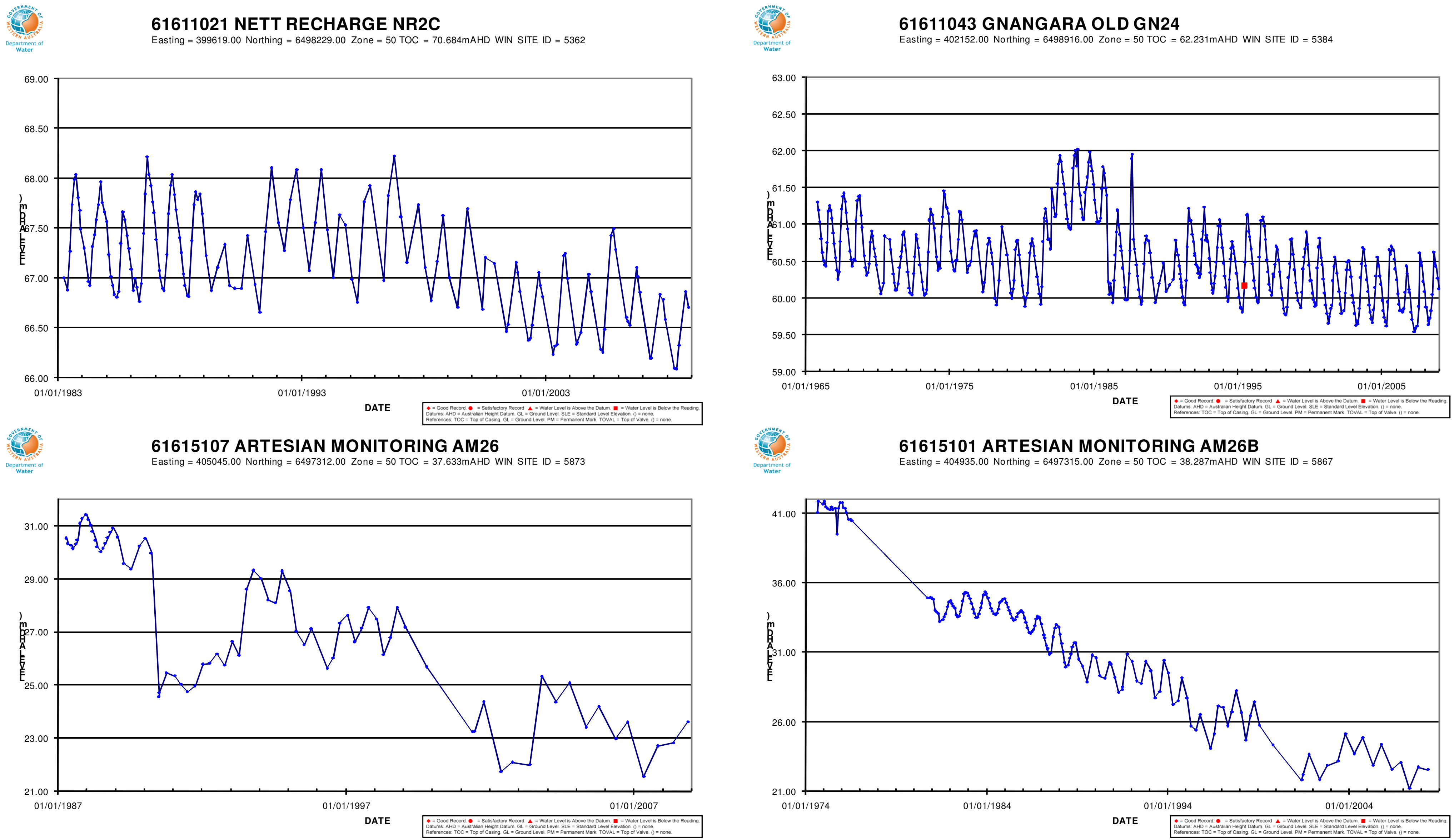


Figure 18. Temporal changes in water levels (m above AHD) in groundwater monitoring bores near the new springs at Bullsbrook (bore codes, from top left clockwise: 5362 (61611021 NETT RECHARGE NR2C), 5384 (61611043 GNANGARA OLD GN24), 5873 (61615107 ARTESIAN MONITORING AM26) & 5867 (61615101 ARTESIAN MONITORING AM26B).

3.3.2 Water Quality

In situ and laboratory determined water quality parameters were generally indicative of good quality, fresh water at the springs. Salinity was less than 0.5 ppt and fresh[5] while dissolved oxygen was high at ALPACA01 and GastonRd in August, but lower at both in December, with very low levels at GastonRd (approaching anoxia). pH was circum-neutral at ALPACA01, and strongly acidic at GastonRd (4.2 & 4.5) (Table 12).

The composition of cations was dominated by sodium (Na), with lower levels of magnesium (Mg), calcium (Ca) and potassium (K) (Table 12). Ca was sub-dominant in waters at ALPACA01. Levels of nitrogen (as nitrate + nitrite, NO_X) exceeded ANZECC/ARMCANZ guidelines at ALPACA01 (ref. Table 6).

Table 12. *In-situ* and analytically-determined water quality parameters measured in 2008. Levels of concern are indicated by shading (NR = not recorded).

Preliminary Names(2007)		Sue's Spring South	Sue's Spring South	Gaston Swamp	Gaston Swamp
Names assigned by DEC		ALPACA01	ALPACA01	Gaston Rd	GastonRd
		22-8-08	22-12-08	22-8-08	22-12-08
In-situ					
Dissolved Oxygen	%	90.0	52.0	72.0	1.0
Dissolved Oxygen	mg/L	8.8	4.8	7.6	0.1
pH		5.27	6.44	4.2	4.5
Temperature	˚C	17.5	20.9	13.4	20.1
Calcium (Ca^{2+})	mg/L	8.8	11.8	3.7	2.8
Potassium (K^{+})	mg/L	4.3	4	1.6	1.9
Magnesium (Mg^{2+})	mg/L	4.9	5.1	9.6	3.7
Sodium (Na^{+})	mg/L	32.2	32.1	79.5	29.3
Chloride (Cl^{-})	mg/L	52	49	140	50
Conductivity	mS/m	237	247	552	238
Total iron	mg/L	NR	0.24	NR	2.00
Nitrate/Nitrite (N_N0_3)	mg/L	1.7	2.2	0.08	0.05
Sulphate (SO_4_S)	mg/L	14.5	14.9	14.8	12.7
Colour	TCU	490	480	1200	680

3.3.3 Fauna

The aquatic fauna identified to date comprises two categories: 1. Highly vagile forms (Coleoptera, Odonata, Diptera) with some life-history stage (juvenile or adult) that is aquatic; and 2. Obligate, fresh water forms that live their entire life cycle in water. Commenting here just on the crustaceans, they are by far the best known with respect to their classification and zoogeographical significance (Table 13). The copepods are especially noteworthy. Sampling of

[5]Department of Environment (2003) *Stream and catchment hydrology*, River Restoration Report No. RR19, Department of Environment, Perth.

the tumulus springs of the Ellen Brook catchment has yielded 10 species of copepod (Table 14; Table 7, p. 17 in Tang *et al.,* 2008), with the two species in Edgecombe, *Elaphoidella bidens, Kinnecaris eberhardi,* not recorded from the annual monitoring or from the other springs listed in Table 14. The benthic cladocerans from the tumulus springs also present an important array of diversity and the occurrence of the two crustacean groups presents an important question concerning their ecological associations in these tumulus spring waters. The amphipod from Alpaca01 is conspecific with the amphipod from Egerton Spring. The species occurs in higher numbers in Egerton but that spring faces an uncertain future. The specimens belong to a new species of the genus *Wesniphargus* and until the complete distribution of the species is known, the two sites assume considerable importance for conservation of the species. Given the paucity of *W. nichollsi* specimens (Williams and Barnard, 1988) available for study, it will be especially important to maintain sites of living populations of the new species.

Table 13. Systematic list of crustaceans recorded from the Bullsbrook sites, 2008 (Table 5, p. 12 in Tang *et al.*, 2008, where locations of the additional sites sampled on 22 December, 2008, namely near the Maze and PETERS01 but not mentioned above, are presented)

Taxon	Site
Copepoda	
Order Cyclopoida; Family Cyclopidae	
Macrocyclops albidus (Jurine, 1820)	Alpaca01 Maze 'pond'
Paracyclops chiltoni (Thomson, 1882)	Alpaca01
Paracyclops intermedius Tang & Knott	Maze 'pond'
Eucyclops edytae Tang & Knott	Alpaca01; GastonRd, site 2, site 3; Egerton spring PETERS01 and near PETERS01 Maze 'pond'
Metacyclops arnaudi (Sars, 1908)	GastonRd, site 2, site 3
Mixocyclops mortoni Tang & Knott	GastonRd, site 2, site 3 (in our paper)
Mesocyclops sp	Maze 'pond'
Australoeucyclops sp.	Maze 'pond'
Order Harpacticoida	
Family Canthocamptidae	
Attheyella (*Chappuisiella*) *hirsuta* Chappuis, 1951	Alpaca01 Egerton spring
New species	near PETERS01
Unidentified male	GastonRd, site 3
Cladocera	
Family Macrothricidae	
Macrothrix cf. *breviseta* Smirnov, 1976	GastonRd, site 2, site 3
Neothrix armata Gurney, 1927	GastonRd, site 2
Family Chydoridae	
Unidentified sp. 1	GastonRd, site 2, site 3
Unidentified sp. 2	J. Moran, site 2
Family Ilyocryptidae	
Ilyocryptus sp.	GastonRd, site 2, site 3 Egerton spring
Amphipoda	
Family Neoniphargidae	
Wesniphargus sp.	Alpaca01 Egerton spring

Table 14. Copepoda records from tumulus springs of the Ellen Brook catchment, Western Australia (after Tang & Knott in press). P: present; YNP: Yanchep National Park (12 sampled). Edgecombe spring, a limnocrene spring, is also included (Table 7, p. 17 in Tang *et al*. 2008).

	TUMULUS SPRINGS						
	PETERS01	**Egerton**	**KINGS01**	**ALPACA01**	**Edgecombe**	**Bores**	**Caves (YNP)**
ORDER CYCLOPOIDA							
***Australoeucyclops* sp.**			P			0	11
Eucyclops edytae	P	P	P	P		0	1
Macrocyclops albidus			P	P		0	1
Paracyclops chiltoni	P	P		P	P	2	5
Paracyclops intermedius	P	P	P			0	0
Mixocyclops mortoni		P			P	1	2
Mesocyclops sp.			P*				
ORDER HARPACTICOIDA							
Family Canthocamptidae							
Attheyella (Ch) hirsuta		P		P		0	2
Australocampus hamondi		P				0	3
Elaphoidella bidens					P	0	3
Family Parastenocarididae							
Kinnecaris eberhardi					P	1	4
TOTAL	3	6	5	4	4	3	13

* recorded from the 'pond', 22 December, 2008 and not in Tang & Knott, 2009.

It is anticipated that an intensive survey to locate further tumulus springs in the Ellen Brook area, and sample them, would reveal additional taxa, especially those with stygal associations. Additional springs in the area observed from a distance but not visited looked in similarly good condition, and may also reveal important fauna.

4 DISCUSSION

4.1 Water Quality

As in previous years, water quality parameters measured from each cave indicated relatively constant conditions both between caves and years (Jasinska 1995, 1996; Jasinska & Knott 2000; Knott & Storey 2001, 2002, 2003, 2004; Cook & Janicke 2005; Knott *et al.* 2006, 2007, 2008). In general terms, waters were of low salinity, slightly alkaline pH, with medium to low dissolved oxygen levels consistent with groundwater from the Gnangara Mound. The cation dominance was $Na^{+}>Ca^{2+}>Mg^{2+}>K^{+}$, again consistent with groundwater-derived systems of the Swan Coastal Plain (Davis *et al.* 1993).

Across all years dissolved oxygen levels were variable but consistently above levels likely to pose a threat to fauna. There is a danger of the ponds in the reticulation liners stagnating if there is insufficient flow. It would appear that the pumps and reticulation lines result in sufficient mixing to maintain oxygen levels at a safe level.

After installation of the reticulation lines and drips/sprays in 2005/2006, there was fresh growth of root material, which was encouraging, and indicated better conditions for root mat growth, which may also enhance conditions for the fauna. Where reticulation lines have failed, and caves dried (i.e. Cabaret and Carpark were both dry in 2007), the root mats in these caves had rapidly deteriorated. However, as seen in December 2008, the root mats appear to be quite resilient, showing good recovery in Cabaret and Carpark caves once the reticulation lines have been repaired. This is encouraging for recovery of root mat habitat once full-scale supplementation commences.

Cave YN555 on Lot 51 continued to exhibit elevated concentrations of nitrogen (nitrate + nitrite) and sulphate, however levels of sulphate were comparable to last year. Levels may indicate anthropogenic influence on groundwater entering these caves, or higher natural organic loading (*i.e.* detritus). Data for the last four years appear to indicate there is a relationship between elevated levels of sulphate and conductivity in YN555 (Figure 8).

Previous sampling has determined water quality parameters from Egerton and Edgecombe Springs were generally indicative of good quality, fresh water and were relatively constant over time. In general terms the water had a low salinity, circum-neutral pH, with medium to low dissolved oxygen levels, consistent with groundwater from the Gnangara Mound. Egerton Spring showed a sharp jump in pH which was against the trend of a gradual, long term reduction and acidification. This latest value needs to be confirmed. Declining pH at Egerton was raised as a concern, because low pH is known to be detrimental to aquatic fauna. pH should continue to be monitored.

Water quality at ALPACA01 and GastonRd springs, east of Bullsbrook was similarly of good quality. These springs are extremely close to the alignment of the proposed Perth – Darwin highway (Figure 19), with the highway alignment going through Gaston Swamp. This raises the potential for the highway and associated works to affect water quality or quantity at the springs.

This aspect requires careful monitoring, and ideally high resolution modelling of the local aquifer to assess the risk of the highway to the springs.

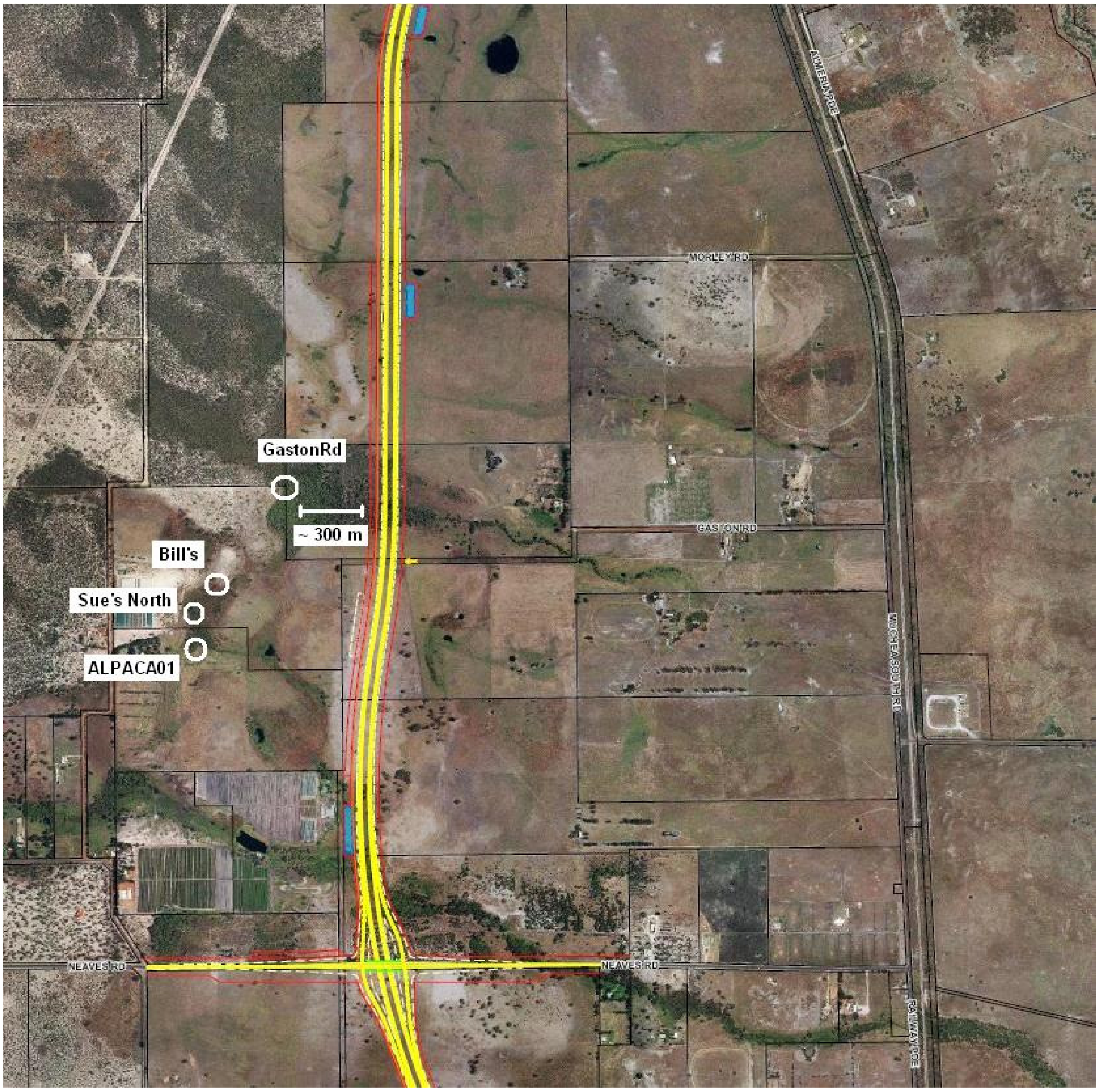


Figure 19. Alignment of the proposed Perth – Darwin Hwy, showing proximity to the Neaves/Gaston Road springs.

4.2 Aquatic Invertebrate Fauna

The results continue to indicate that species diversity has been reduced in the caves, at least in those root mat communities accessible to sample. This decline is still attributed to one over-riding cause, namely, the decline in groundwater levels. Another consequence of the lowering water table has been a decline in quality of the root mats, many reducing in extent and now being exposed to the air when previously they were submerged.

The dramatic reduction of water observed in all caves this year is of concern. As previously stated (Knott & Storey 2002, 2003; Knott et al., 2006, 2007), the likely cause for the decline in the fauna is loss of water from the cave streams as there is no evidence of a decline in water quality, only water quantity. There was a lack of noteworthy specimens collected from the caves this year. No aquatic fauna was recovered from Orpheus although the amphipod species was observed, and the isopods and hydrobiid snails were absent from YN555; these absences still are attributed to this decline in water levels. However, the presence of a goldfish and an unidentified fish remains the more immediate threat in YN555, which would likely have contributed to the population decline of macroinvertebrates in the pool we sampled through predation.

With respect to the current state of the root mat communities, it must be hoped that there are some extant cave fauna on root mats located in inaccessible parts of the cave system from where recolonisation may occur (though none is known, presumably only a small percentage of the total root mat habitat is accessible for study). Consequently, it is recommended that the first efforts towards recovering the root mat fauna from any refuge areas should be directed at:

1) restoring flowing water to the cave streams, and
2) restoring the growth of extensive root mats in the cave streams.

By ensuring the fundamental habitat requirements are catered for (*i.e.* permanent, flowing water and healthy root mats) there is the possibility that fauna may recolonise the caves, should it be present in some unknown refuge.

There was extensive clearing of vegetation and encroachment of urban development on the up-hill slopes about the Egerton Spring. Although the spring appeared to be in good health in December, 2008, one can only wonder at the continuing survival of this structure. The developments are situated over the likely recharge areas for the spring. This spring needs to be monitored very carefully.

The critical feature in maintaining the spring communities, undoubtedly, remains: water quantity. This point needs to be understood implicitly against the context that the relevant animal communities occur in a very thin layer: a rapid drop of the water table may well be sufficient to cause local extinctions in populations. This said, water quality may become an issue if disturbance of acid sulphate soils is the cause of decreasing pH levels in Egerton Spring.

One insight that is emerging from the work to date is the diversity and importance of the amphipods and copepods. Tang and Knott (UWA) plan to complete the amphipod descriptions in 2008/9. However, given that sampling of bores in areas of the central and northern Gnangara Mound over the past 20 years has yielded amphipods and copepods as reasonably consistent stygofaunal elements with reasonable diversity, in an area of declining water table, it is becoming clear that the sampling strategy should be expanded to include sampling bores across the Gnangara Mound to develop regional understanding and develop insights how best to sound management protocols that will minimise loss of stygofaunal biodiversity.

Finally, the recognition of new, relatively intact springs west of Bullsbrook, with healthy vegetation and strong flows is very encouraging. Study of these springs should continue, following high winter flows, with attempts to penetrate the dense vegetation to the source of the springs in an attempt to capture their complete copepod and cladoceran diversity, a fauna of substantial conservation value.

5 RECOMMENDATIONS

- Permanent water flows must be restored to the cave streams, and maintained at a level whereby the majority of the root mats are submerged.
- Upon restoration of permanent water flows to the cave streams, the liners currently in place beneath root mats should be removed to re-establish connectivity with the ground water, facilitating recolonisation by ground-water fauna.
- Active management should be initiated to develop and then maintain extensive root mats in the cave streams to provide suitable habitat to support fauna should it recolonise from inaccessible refuges.
- Continue cave monitoring as per current methods to assess recovery of cave stream communities following recharge by the new recharge system/bores.
- Monitoring of the fauna should be undertaken in September/October when habitat area is likely to be greatest to assess recovery of the fauna, should it occur.
- Boomerang Cave, which dried in 2003, Carpark and Cabaret Caves which dried in 2007 due to issues associated with maintenance of the local recharge system, should continue to be monitored to determine if the TEC has been lost from these sites.
- A gauge for measuring flows should be established on Egerton Spring. This is now a critical issue given the encroachment of suburbia around this spring.
- The influence of Acid Sulphate Soils (ASS/PASS) should be investigated at Egerton Spring, and regular monitoring of pH should be initiated.
- The status of the Edgecombe Spring Threatened Ecological Community (TEC) should be re-assessed and, based on the faunal diversity listed as extinct monitoring should cease.
- Setting traps in the cave on Lot 51 (YN555) for the goldfish is of high priority.
- Continue monitoring YN555 to determine if the isopod and hydrobiid snail populations return.
- The sampling strategy be revised, and expanded to include a regional focus. The results emerging from the monitoring over the years highlight the significance of the copepod and amphipod elements, but also the decline of these elements. Monitoring alone will not yield insights into the regional changes of groundwater fauna distribution/losses. A regional focus of bores should seek to determine greater regional distribution, as well as develop an understanding of what measures should be put in place to conserve these elements, regionally.
- A study in 2008 of recently discovered springs west of Bullsbrook highlighted their significance for conservation of ecological units. Floristic survey of these springs should also be undertaken. other potential springs in the area should be investigated for their conservation value.

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7 APPENDICES

7.1 Appendix 1: Water Quality 1998 – 2008

Table A1-1. Caves water quality for the total sampling period 2000 - 2008. Parameters not measured indicated by "-". Levels of concern are highlighted in bold.

		In situ measurements								*Laboratory measurements*							
Parameter units		DO (mg/l)	DO (% sat.)	Turbidity (NTU)	Salinity (ppt)	Conductivity (µs/cm)	pH	Redox	Temperature (^{o}C)	Ca mg/L	Econd mS/m	K mg/L	Mg mg/L	Na mg/L	N_NO3 mg/L	P_SR mg/L	SO4_S mg/L
Boomerang	**Dec-08**																
	Sep-07	9.7	97		0.33	644	6.97		16.5	43	70	2.1	5.2	67	0.32	<0.01	11.6
	Nov-06																
	Nov-05	3.6	37.4	3.4	0.31	603	7.33	277	16.73	45	58.1	2.1	4.4	62.4	**0.56**	0.01	11.7
	Oct-04	12.6	100	3.6	0.314	629	7.68	513	16.97	44.7		1.8	4.5	61.1	**0.3**	0.01	11.3
	Sep-03																
	Sep-02	6.1	65	1.8	0.33	561	7.09		18.4	46		2	5	63	0.17	0.01	10
	Jan-02	6.2	72		0.33	664	7.22		23.3								
	Sep-01	8.8	82.7	1.8	0.37	769	7.47	253	12.3	73		5	10	79	0.01	0.08	12
	Nov-00	3.2	32	22.8	0.33	507	9.43	94	15.2	52		2	8	64	0.19	0.02	9
Carpark	**Dec-08**	7.8	83	0.6	0.28	514	7.25	-24.9	20.1	42.1	51.4	2.5	5	53.5	0.14	0.01	8.1
	Sep-07	6.7	73		0.56	695	7.25		17.1	58.3	70.5	2.5	6.2	75.7	0.02	<0.01	11.5
	Nov-06	6.7	66.5	44.1	0.29	685	7.69	137	18.03	63.9	72.8	2.2	6.4	69.1	0.03	<0.01	10.6
	Nov-05	3.6	36.2	132	**0.59**	**1125**	8.04	247	15.9	94.5	108	3.6	10.6	109	0.07	0.01	18.3
	Oct-04	9.1	91	23.3	0.316	632	7.64	496	16.8	56.9		1.8	5.8	57.9	0.12	0.01	9.1
	Sep-03	6.8	70	3.1#	0.36	760	8.17	-72	17.1	33.4		1.3	4	37.7	0.04	<0.01	11.4
	Sep-02	7.4	76	5.5	0.38	645	7.24		17.7	61		2	8	62	0.07	0.01	11
	Jan-02	4.9	54		0.28	556	7.41		19.3								
	Sep-01	6.9	73.9	6.2	0.22	451	6.66	180	18	36		3	5	52	0.11	0.01	9
	Nov-00	2.8	29.7	3.1	0.32	488	9.24	81	17.8	31		2	6	51	0.09	<0.01	8

		In situ measurements								*Laboratory measurements*							
Parameter		DO	DO	Turbidity	Salinity	Conductivity	pH	Redox	Temperature	Ca	Econd	K	Mg	Na	N_NO3	P_SR	SO4_S
units		(mg/l)	(% sat.)	(NTU)	(ppt)	(µs/cm)			(^{o}C)	mg/L	mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Water	**Dec-08**	6.5	71	<0.5	0.34	615	7.32	-29.1	19.4	52.3	61.5	2	5.6	61.5	0.06	<0.01	10.8
	Sep-07	7.3	78		0.28	545	7.19		19	44.5	57.3	2.6	5.4	61.8	0.14	0.01	7.5
	Nov-06	5.6	60.5	246	0.2	508	7.29	151	19.07	44.6	56.8	3.3	5.4	54.1	0.12	0.01	6.4
	Nov-05	2.8	30.2	0	0.25	526	7.7	260	18.9	44.2	51.4	2.3	4.2	49	0.1	0.01	6.8
	Oct-04	5.3	57	6.2	0.285	570	7.68	488	18.7	45.8		2.1	4.6	48.4	0.11	0.01	7.5
	Sep-03	4.4	47.3	0.1#	0.28	576	7.88	265	18.5	36.6		1.4	3.9	39.3	0.04	0.01	11.1
	Sep-02	5.2	55	0.8	0.31	532	7.26			48		2	5	54	0.09	0.01	9
	Jan-02	5.8	68		0.25	506	7.36		21.6								
	Sep-01	6.2	66.7	0.5	0.25	519	7.39	232	18.6	50		2	6	56	0.09	0.01	9
	Nov-00	4.2	45.3	6.7	0.27	413	9.42	74	18.6	28		2	4	43	0.08	0.01	6
Cabaret	**Dec-08**	7.9	81	<0.5	0.3	540	7.25	-25	17.4	37.3	54	2.3	6.4	60.4	0.06	<0.01	10.7
	Sep-07	10.2	104		0.27	520	7.08		15.5	35.9	73.3	2.3	6	52.8	0.08	<0.01	10.5
	Nov-06	6.8	68.5	52.5	0.17	440	7.37	149	15.74	32.9	48.4	2.2	5.6	51.8	0.07	<0.01	10.3
	Nov-05	3.7	36.6	46.8	0.28	512	7.72	300	14.6	35	50.4	2.2	5.8	53	0.09	0.01	12
	Oct-04	8.3	79.8	9.6	0.253	504	7.95	526	16.8	44.7		1.9	6.3	52.8	0.01	0.01	11.8
	Sep-03	7.4	71.4	1.9#	0.23	463	7.45	328	13.4	32.1		1.4	5.3	44.6	0.01	0.01	15.8
	Sep-02	5.3	56	7	0.3	509	7.17		17.7	42		3	6	53	<0.01	0.01	10
	Jan-02	6.4	68		0.25	503	7.11		17.9								
	Sep-01	8.9	90.7	0.5	0.22	450	7.5	235	16	44		2	5	50	0.13	0.01	10
	Nov-00	6.8	70.4	62.9	0.26	397	9.49	76	16.9	27		2	6	49	0.19	0.01	9
	1998									36		2	5	55	0.17	0.01	8
Mire Bowl	**Dec-08**																
	Sep-07	6.3	63		0.31	607	7.38		18.1	59.4	71.5	3.5	6.3	53.1	0.28	0.13	17
	Nov-06																
	Nov-05	2	22.1	10.1	0.3	620	7.67	169	18	56.1	58.8	2.7	6.7	53.1	0.01	0.01	12.1
	Oct-04	11.1	100	5.5	0.311	621	7.52	471	18.6	61.6		2.4	7.2	48.2	0.04	0.01	11.6
	Sep-03	2.8	29.4	2.0#	0.38	769	7.96	-17	17.6	55		2	6.7	54.3	0.02	<0.01	19.8
	Sep-02	6.4	69	20*	0.35	598	7.14		18.8	70		2	7	51	0.08	0.05	12

		In situ measurements								*Laboratory measurements*							
Parameter		DO	DO	Turbidity	Salinity	Conductivity	pH	Redox	Temperature	Ca	Econd	K	Mg	Na	N_NO3	P_SR	SO4_S
units		(mg/l)	(% sat.)	(NTU)	(ppt)	(µs/cm)			(°C)	mg/L	mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Lot 51	**Dec-08**	8	79	0.6	0.53	971	7.58	-43.4	16.4	85.8	97.1	2	8.5	95.8	0.8	0.01	18.4
	Sep-07	9.1	91		0.46	893	7.46		14.4	85.8	92.1	1.9	7.6	90	0.85	<0.01	13.8
	Nov-06	7.2	78.5		0.36	810	8.56	134	19.4	75.6	86.5	2	6.2	85.9	**0.99**	<0.01	18.2
	Nov-05	1.5	15	11.2	**1.41**	**2582**	7.47	207	14.3	128	223	2.1	14.6	323	**0.88**	0.01	**51.8**
	Oct-04	7.9	74	8	0.478	956	7.67	502	16.6	81.8		1.8	6.5	105	**1.36**	0.01	22.8
	Sep-03	3.3	32	1.1#	**1.29**	**2397**	7.86	6	13.5	108		1.6	11.6	264	**0.93**	<0.01	**99.3**
	Sep-02	8.2	77	1.8	**0.51**	875	6.65		14	78		2	6	98	1.6	0.01	21
Orpheus	**Dec-08**	7.8	84	<0.5	0.37	681	7.25	-25.9	19.3	63.1	68.1	2.3	6.1	64.8	0.06	<0.01	17.1
	Sep-07	6.1	63		0.36	710	7.53		18.5	65.5	74.4	2.4	6.3	72.9	0.11	0.01	16.3
	Nov-06	7.1	82.4		0.28	636	7.33	95	22.2	65.2	70.1	2.3	6	67.7	0.05	<0.01	16.1
	Nov-05	2.7	28.5	4.2	0.4	768	7.94	184	18.27	60.8	73.5	2.3	5.3	76	0.09	0.01	18.5
	Oct-04	4.85	50.6	3.6	0.369	746	7.54	474	19.01	64.5		2.3	5.8	71.3	0.08	0.01	17
	Sep-03	3.7	39.1	1.0#	0.42	846	8.26	127	17.7	55		1.7	5.2	61.7	0.03	<0.01	23.2
	Dec-02	3.2	67.4	0.9	**0.8**	734	7.81	117	18.1	75		3	7	79	0.05	<0.01	19
Twilight	**Dec-08**																
	Sep-07																
	Nov-06																
	Nov-05	2.7	27.2	20.1	0.49	922	7.72	201	15	77.7	87	2.3	7.1	91	**4.2**	<0.01	25.6
	Oct-04				0.467	936	7.67			84.9		2.3	7.4	88	**3.89**	0.01	31.5
	Sep-03																
	Sep-02																
	Sep-01	7.6	75.6	0.5	0.44	902	7.51	149	14.9	98		2	9	94	**0.75**	0.01	33
	Nov-00	5.4	54.4	7.2	0.47	755	9.49	76	16	53		2	7	67	**1**	0.01	25
Spillway (YN565)	**Sep-07**																
	Nov-06																
	Nov-05	3.1	34.4	5.7	0.24	495	7.85	98	20.5	30.5	49.7	2.9	5.8	60.5	0.12	0.01	7.8
Jackhammer	**Sep-02**	7.3	79	1.5	0.32	549	6.91		18.8	52		2	5	53	0.11	0.01	8

* shallow water and fine mud on bottom resulted in unavoidable contamination of the water sample. Visually, turbidity would have been < 2 NTUs
# Turbidity determined by W.A. Chemistry Centre on samples returned to the laboratory

Table A1-2. Springs water quality for the total sampling period 1999 – 2008. "-" indicates parameters not measured.

Site	Date	Egerton Spring												Edgecombe Spring										
Parameter	units	Dec-99	Nov-00	Mar-01	Dec-01	Oct-02	Oct-03	Oct-04	Nov-05	Oct-06	Sep-07	Aug-08	Dec-08	Dec-99	Nov-00	Mar-01	Dec-01	Oct-02	Oct-03	Oct-04	Nov-05	Oct-06	Sep-07	Dec-08
In situ parameters																								
Dissolved Oxygen	(mg/L)	-	-	-	7.41	8.3	8.5	9.55	3.9	8.85	8.6	10	6.3	-	-	-	5.48	8.4	9.4	6.4	4.3	8.5	6.9	4.7
Dissolved Oxygen	(% sat.)	-	-	-	77.4	82	84	98	38.3	89.5	86	107	75	-	-	-	61.8	82	94	68	45.2	92	75	52
Turbidity	(NTU)	-	-	-	-	-	-	-	185	-				-	-	-	-	-	-	-	0	-		
Salinity	(ppt)	-	-	-	-	-	-	-	0.12	-	0.15	0.19	0.13	-	-	-	-	-	-	-	0.32	-	0.399	0.131
TDS	(mg/L)	350	-	134	-	126	131	140	120	113	150	190	130	194	-	212	-	192	156	360	320	277	399	131
Conductivity	(µs/cm)	662	-	269	206	214	258	192	236	220	292	338	238	405	-	413	261	327	307	604	604	537	773	238
pH		5.27	-	6.11	6	6.04	5.63	5.42	**4.76**	**5.07**	4.36	4.15	6.32	5.87	-	6	5.81	5.35	5.9	5.76	6.59	5.72	6.68	6.94
Redox	(mV)	-	-	-	87	121	-	-	60	-				-	-	-	171	123	-	-	269	-		
Temperature	(^{o}C)	-	-	-	-	15.8	15	17.95	14.86	15.1	15.5	18.8	23	19.4	-	20.8	22	17.1	17.5	19.1	18.3	19.6	17.5	22.9
Laboratory determined parameters																								
Ca	mg/L	1	1	-	-	-	1.8	2	1.3	2.8	4		35.3	13	16	-	-	-	20.3	63.6	42.9	33.8	68.7	2.3
Cl	mg/L	93	46	-	-	-	54	52	51	45	69		98	28	31	-	-	-	43	65	78	81	79	55
Econd	mS/m	-	-	-	-	-	-	-	23.5	25.6	40.4	33.8	48.9	-	-	-	-	-	-	-	59.2	53.8	86.3	23.8
Fe	mg/L	-	-	-	-	-	-	-	0.33	-				-	-	-	-	-	-	-	0.026	-		
Fe_total	mg/L	-	-	-	0.97	-	0.18	0.54	0.49	4.7	0.38		160	-	-	-	10	-	0.11	0.42	**200**	6.4	11	0.45
K	mg/L	1	<1	-	-	-	0.8	0.85	1	4	3.4		7.2	<1	<1	-	-	-	1.5	6.3	11.6	10.5	16.4	1.1
Mg	mg/L	5	5	-	-	5	5	5.45	4.7	5.6	7		6.5	5	5	-	-	-	6.3	15.4	8.3	7.5	11.8	6.2
Na	mg/L	32	32	-	-	-	30.5	32.65	33.1	34.7	42.2		49.5	21	20	-	-	-	17.7	37	44.3	43.7	62.6	33.4
N_NO3	mg/L	0.13	0.27	-	0.15	0.047	0.1	0.095	3.3	0.43	0.48		1.8	0.07	0.82	-	**3**	**1.1**	**6**	**4.3**	**20**	**7.7**	19	0.45
SO4_S	mg/L	18	17	-	5.5	-	15.2	15.05	16.4	25.4	16.9		52.2	32	39	-	9.1	-	23.2	**150**	**66.9**	**57.5**	111	14.6
Chloro_a	mg/L	<0.001	<0.001	-	-	0.00016	-	-	-	-				0.004	0.001	-	-	0.0017	-	-	-	-		
Chloro_b	mg/L	<0.001	<0.001	-	-	-	-	-	-	-				0.002	<0.001	-	-	-	-	-	-	-		
Chloro_c	mg/L	<0.001	<0.001	-	-	-	-	-	-	-				0.003	<0.001	-	-	-	-	-	-	-		
Phaeoph_a	mg/L	<0.001	<0.001	-	-	0.00267	-	-	-	-				<0.001	<0.001	-	-	0.00456	-	-	-	-		
N_NH3	mg/L	<0.01	0.02	-	0.053	0.035	-	-	-	-				<0.01	<0.01	-	0.014	0.009	-	-	-	-		
N_total	mg/L	0.4	0.51	-	0.47	0.48	-	-	-	-				1.2	1.3	-	3.8	2.8	-	-	-	-		
P_SR	mg/L	<0.01	<0.01	-	0.033	0.007	-	-	-	-				<0.01	<0.01	-	0.016	0.007	-	-	-	-		
P_total	mg/L	0.02	0.02	-	0.062	0.013	-	-	-	-				0.01	0.02	-	0.056	0.086	-	-	-	-		
S	mg/L	-	-	-	-	5.6	-	-	-	-				-	-	-	-	5.6	-	-	-	-		
HCO_3	mg/L	3	3	-	-	-	-	-	-	-				18	3	-	-	-	-	-	-	-		

7.2 Appendix 2: Aquatic Macroinvertebrates 1990-2008

Table A2-1. List of macroinvertebrates recorded from Yanchep Caves for the period 1990-2008.

TAXON	Source of fauna	Cabaret (YN30) ?	1990	1991	1992	1993	1996	1998	2000	2001	Jan-02	Sep-02	Sep-03	2004	2005	2006	2007	2008
CNIDARIA																		
Hydra sp. 1	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydra sp. 2	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PLATYHELMINTHES																		
TURBELLARIA																		
Turbellaria spp.	I	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
Stenostomum sp. or spp.	I	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Macrostomum sp. or spp.	I	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
RHABDOCOELA: *Temnocephala*	S	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Dalyellioida sp.	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gyratrix hermaphroditus	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Typhloplanidae spp.	I	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
ROTIFERA																		
Rotifera spp.	U	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
NEMATODA																		
Nematoda spp.	U	0	0	0	0	0	1	1	0	1	0	0	0	0	1	1	0	0
Sp. 1 (hooks present)	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sp. 2 (hooks absent)	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MOLLUSCA																		
GASTROPODA																		
Hydrobiidae: *Westrapyrgus* sp. nov.	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glacidorbidae: *Glacidorbis sp.*	S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANNELIDA																		
APHANONEURA																		
Aeolosomatidae: Aeolosomatidae sp.	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aeolosoma sp.	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aeolosoma sp. 1	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aeolosoma aff. *leidyi*	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aeolosoma tracanvorense	I	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Aeolosoma sp. 2	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OLIGOCHAETA																		
Oligochaeta spp.	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oligochaete sp. 1	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oligochaete sp. 2	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oligochaete sp. 3	U	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Oligochaete sp. 4	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tubificidae: Tubificidae sp. 1	U	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0
Tubificidae sp. 2	U	0	0	0	0	0	1**	0	0	0	0	0	0	0	0	0	0	0
Ainudrilus nr WA14	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
immature tubificid with all bifid chaetae	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dero digitata	S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pristina longiseta	U	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Pristina aequisita	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Pristina sp. 1	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pristina sp. 2	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pristina sp. 3	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pristina sima	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enchytraeidae: Enchytraeidae sp. 1	U	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Enchytraeidae sp. 2	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enchytraeidae sp.3	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enchytraeidae sp.	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enchytraeidae UWA1	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phreodrilidae: *Insulodrilus lacustris*	U	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Phreodrillidae sp.	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phreodrillidae sp. 1	U	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Phreodrillidae sp. 2	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
immature Phreodrilidae with similar ventral chaetae	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
immature Phreodrilidae with dissimilar ventral chaetae	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HIRUDINEA																		
Erpobdellidae: Erpobdellidae spp.	U	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
TARDIGRADA																		
EUTARDIGRADA																		
Hypsibiidae: *Hypsibius* sp.	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA																		
COPEPODA																		
Tropocyclops confinis	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macrocyclops albidus	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paracyclops chiltoni	I	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Australoeucyclops sp. nov.	U	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Eucyclops sp. nov.	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Mesocyclops brooksi	S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mixocyclops sp. nov.	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitocra lacustris pacifica	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitocrella sp. nov.	A	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Attheyella (Chappuisiella) hirsuta	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Australocamptus hamondi	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elaphoidella bidens	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parastenocaris eberhardi	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXON	Carpark (YN18) ?	1996	1998	2000	2001	Jan-02	Sep-02	2003	2004	2005	2006	2007	2008	Boomerang (YN99) 1992	1996	2000	2001	Jan-02	Sep-02	2004	2005	2007
CNIDARIA																						
Hydra sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Hydra sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
PLATYHELMINTHES																						
TURBELLARIA																						
Turbellaria spp.	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0
Stenostomum sp. or spp.	0	1	1	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Macrostomum sp. or spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
RHABDOCOELA: *Temnocephala*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dalyellioida sp.	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Gyratrix hermaphroditus	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Typhloplanidae spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ROTIFERA																						
Rotifera spp.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
NEMATODA																						
Nematoda spp.	0	1	1	0	0	0	1	1	0	1	1	0	1	0	1	0	0	1	0	0	1	0
Sp. 1 (hooks present)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0
Sp. 2 (hooks absent)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
MOLLUSCA																						
GASTROPODA																						
Hydrobiidae: *Westrapyrgus* sp. nov.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Glacidorbidae: *Glacidorbis sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANNELIDA																						
APHANONEURA																						
Aeolosomatidae: Aeolosomatidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aeolosoma sp.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Aeolosoma sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Aeolosoma aff. *leidyi*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aeolosoma tracanvorense	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Aeolosoma sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OLIGOCHAETA																						
Oligochaeta spp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oligochaete sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Oligochaete sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oligochaete sp. 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oligochaete sp. 4	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Tubificidae: Tubificidae sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Tubificidae sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ainudrilus nr WA14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
immature tubificid with all bifid chaetae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dero digitata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pristina longiseta	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Pristina aequisita	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Pristina sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
Pristina sp. 2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pristina sp. 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pristina sima	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Enchytraeidae: Enchytraeidae sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enchytraeidae sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
Enchytraeidae sp.3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enchytraeidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enchytraeidae UWA1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Phreodrilidae: *Insulodrilus lacustris*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phreodrillidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phreodrillidae sp. 1	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Phreodrillidae sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
immature Phreodrilidae with similar ventral chaetae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
immature Phreodrilidae with dissimilar ventral chaetae	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
HIRUDINEA																						
Erpobdellidae: Erpobdellidae spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
TARDIGRADA																						
EUTARDIGRADA																						
Hypsibiidae: *Hypsibius* sp.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
CRUSTACEA																						
COPEPODA													1									
Tropocyclops confinis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macrocyclops albidus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paracyclops chiltoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Australoeucyclops sp. nov.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucyclops sp. nov.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mesocyclops brooksi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mixocyclops sp. nov.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Nitocra lacustris pacifica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitocrella sp. nov.	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Attheyella (Chappuisiella) hirsuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Australocamptus hamondi	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Elaphoidella bidens	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Parastenocaris eberhardi	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXON	Water (YN11) 2000	2001	Jan-02	Sep-02	2003	2004	2005	2006	2007	2008	Mire Bowl (YN61) 1992	Sep-02	2003	2004	2005
CNIDARIA															
Hydra sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydra sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PLATYHELMINTHES															
TURBELLARIA															
Turbellaria spp.	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
Stenostomum sp. or spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macrostomum sp. or spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RHABDOCOELA: *Temnocephala*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dalyellioida sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gyratrix hermaphroditus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Typhloplanidae spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ROTIFERA															
Rotifera spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NEMATODA															
Nematoda spp.	0	0	0	1	0	0	1	1	0	0	0	0	1	0	1
Sp. 1 (hooks present)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sp. 2 (hooks absent)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MOLLUSCA															
GASTROPODA															
Hydrobiidae: *Westrapyrgus* sp. nov.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glacidorbidae: *Glacidorbis sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANNELIDA															
APHANONEURA															
Aeolosomatidae: Aeolosomatidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aeolosoma sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aeolosoma sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aeolosoma aff. *leidyi*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aeolosoma tracanvorense	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aeolosoma sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OLIGOCHAETA															
Oligochaeta spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oligochaete sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oligochaete sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oligochaete sp. 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oligochaete sp. 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tubificidae: Tubificidae sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tubificidae sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ainudrilus nr WA14	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
immature tubificid with all bifid chaetae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dero digitata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pristina longiseta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pristina aequisita	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Pristina sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pristina sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pristina sp. 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pristina sima	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enchytraeidae: Enchytraeidae sp. 1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Enchytraeidae sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enchytraeidae sp.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enchytraeidae sp.	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Enchytraeidae UWA1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
Phreodrilidae: *Insulodrilus lacustris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phreodrillidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phreodrillidae sp. 1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Phreodrillidae sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
immature Phreodrilidae with similar ventral chaetae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
immature Phreodrilidae with dissimilar ventral chaetae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HIRUDINEA															
Erpobdellidae: Erpobdellidae spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TARDIGRADA															
EUTARDIGRADA															
Hypsibiidae: *Hypsibius* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA															
COPEPODA															
Tropocyclops confinis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macrocyclops albidus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paracyclops chiltoni	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Australoeucyclops sp. nov.	0	0	0	0	1	0	0	0	0	1	1	1	1	0	1
Eucyclops sp. nov.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mesocyclops brooksi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mixocyclops sp. nov.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitocra lacustris pacifica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitocrella sp. nov.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Attheyella (Chappuisiella) hirsuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Australocamptus hamondi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elaphoidella bidens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parastenocaris eberhardi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXON	Lot51 (YN555) Sep-02	2003	2004	2005	2006	2007	2008	Orpheus (YN256) 1992	Dec-02	2003	2004	2005	2006	2007	2008	Twilight (YN194) 1992	1994	1996	1998	2000	2001	2004	2005
CNIDARIA																							
Hydra sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydra sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PLATYHELMINTHES																							
TURBELLARIA																							
Turbellaria spp.	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Stenostomum sp. or spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0
Macrostomum sp. or spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0
RHABDOCOELA: *Temnocephala*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dalyellioida sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Gyratrix hermaphroditus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Typhloplanidae spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ROTIFERA																							
Rotifera spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
NEMATODA																							
Nematoda spp.	1	0	0	1	1	0	1	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	1
Sp. 1 (hooks present)	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
Sp. 2 (hooks absent)	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
MOLLUSCA																							
GASTROPODA																							
Hydrobiidae: *Westrapyrgus* sp. nov.	1	1	50	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glacidorbidae: *Glacidorbis sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANNELIDA																							
APHANONEURA																							
Aeolosomatidae: Aeolosomatidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aeolosoma sp.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aeolosoma sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aeolosoma aff. *leidyi*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Aeolosoma tracanvorense	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Aeolosoma sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
OLIGOCHAETA																							
Oligochaeta spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oligochaete sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oligochaete sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Oligochaete sp. 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oligochaete sp. 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tubificidae: Tubificidae sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tubificidae sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ainudrilus nr WA14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
immature tubificid with all bifid chaetae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dero digitata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pristina longiseta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pristina aequisita	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pristina sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pristina sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pristina sp. 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pristina sima	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enchytraeidae: Enchytraeidae sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Enchytraeidae sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enchytraeidae sp.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enchytraeidae sp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enchytraeidae UWA1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Phreodrilidae: *Insulodrilus lacustris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Phreodrillidae sp.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phreodrillidae sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0
Phreodrillidae sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
immature Phreodrilidae with similar ventral chaetae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
immature Phreodrilidae with dissimilar ventral chaetae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HIRUDINEA																							
Erpobdellidae: Erpobdellidae spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TARDIGRADA																							
EUTARDIGRADA																							
Hypsibiidae: *Hypsibius* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA																							
COPEPODA																							
Tropocyclops confinis	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macrocyclops albidus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paracyclops chiltoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Australoeucyclops sp. nov.	0	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Eucyclops sp. nov.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mesocyclops brooksi	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mixocyclops sp. nov.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitocra lacustris pacifica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitocrella sp. nov.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Attheyella (Chappuisiella) hirsuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Australocamptus hamondi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Elaphoidella bidens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Parastenocaris eberhardi	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0

Yanchep Caves, Egerton and Edgecombe Springs Invertebrate Monitoring

TAXON	Source of fauna	Cabaret (YN30)																	Carpark (YN18)													Boomerang (YN99)									Water (YN11)										Mire Bowl (YN61)					Lot51 (YN555)							Orpheus (YN256)								Twilight (YN194)							
		?	1990	1991	1992	1993	1996	1998	2000	2001	Jan-02	Sep-02	Sep-03	2004	2005	2006	2007	2008	?	1996	1998	2000	2001	Jan-02	Sep-02	2003	2004	2005	2006	2007	2008	1992	1996	2000	2001	Jan-02	Sep-02	2004	2005	2007	2000	2001	Jan-02	Sep-02	2003	2004	2005	2006	2007	2008	1992	Sep-02	2003	2004	2005	Sep-02	2003	2004	2005	2006	2007	2008	1992	Dec-02	2003	2004	2005	2006	2007	2008	1992	1994	1996	1998	2000	2001	2004	2005
OSTRACODA	
Darwinulidae: *Darwinula* sp.	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gomphodella sp.	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gomphodella aff *maia*	U	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0
Candoniidae: Candoniidae sp. 1	U	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Candona sp.	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
?*Candona* spp.	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Candonopsis sp.	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ISOPODA	
Janiridae: Janiridae spp.	A	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0
Phreatoicidae: *cf. Paramphisopus palustris*	S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	50	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AMPHIPODA	
Ceinidae: *Austrochiltonia subtenuis*	S	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Perthidae: *Perthia* sp. 1	A	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Perthia sp. 2	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Paramelitidae: Paramelitidae gen. nov.	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0
Paramelitidae Gen 1.	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paramelitidae Gen 2	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paramelitidae Gen 3	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hurleya sp.	A	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
DECAPODA	
Parastacidae: *Cherax quinquecarinatus*	S	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
ARACHNIDA	
ACARINA	
Acariformes	
ASTIGMATA	
Acaridae: Acaridae spp.	U	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sp1 (Acaridae)	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sp8 (Acaridae)	U	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORIBATIDA	
Oribatida spp.	U	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oribatid sp. 1	U	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Oribatid sp. 2	U	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oribatid sp. 3	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrozetidae: *Hydrozetes* sp.	S	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Malaconothridae: *Trimalaconothrus* sp.	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trhypochthoniidae: *Trhypochthoniellus* sp.	U	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
PROSTIGMATA	
Halacaridae: *Lobohalacarus weberi*	I	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Soldanellonyx monardi	I	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0
Unionicolidae: *Unionicola* sp.	S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arrenurus: *(Truncaturus) sp.*	S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mideopsidae: *Tillia* sp.	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parasitiformes	
MESOSTIGMATA	
Mesostigmata spp.	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ENTOGNATHOUS HEXAPOD	U	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COLLEMBOLLA	
Hypogastruridae: Hypogastruridae spp.	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
INSECTA	
ODONATA	
Anisoptera: Anisopteran spp.	S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
COLEOPTERA	
Dytiscidae: *?Liodessus dispar affinis*	S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sternopriscus sp.	S	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Sternopriscus marginatus (A)	S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sternopriscus sp. (L)	S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tribe Bidessini spp. (L)	S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Curculionidae: Curculionidae spp. (L)	S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DIPTERA	
Diptera larva	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Culicidae: Culicidae spp.	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anopheles sp.	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Culicinae spp.	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironomidae: *Corynoneura* sp.	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironomus aff. alternans	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Paramerina levidensis	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Polypedilum sp.	T	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceratopogonidae: Ceratopogonidae spp.	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Empididae: Empididae spp.	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tipulidae: Tipulidae spp.	T	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
TRICHOPTERA	
Leptoceridae: Leptoceridae spp.	T	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VERTEBRATA	
OSTEICHTHYES:	
Bostockia porosa	S	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of taxa recorded		1	2	1	1	2	32	11	5	4	2	0	2	3	3	3	4	0	1	24	7	4	1	1	9	4	3	8	8	0	2	4	39	3	0	2	3	3	4	1	2	0	2	4	2	2	7	3	1	5	1	3	4	3	3	7	10	9	9	4	3	4	2	2	1	1	1	1	1	0	4	1	31	7	7	0	5	5
																																																			(+ 2 acarines)				
No. taxa in each group recorded on each occasion	
Ancient cavernicoles (stygofauna)	A	0	0	0	0	1	3	1	1	0	0	0	0	0	0	0	0	0	0	3	2	1	0	0	0	0	0	0	0	0	0	2	1	1	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	1	1	0	0	1	1	1	0	2	1	5	2	1	0	0	0
Widespread marine & freshwater interstitial fauna	I	0	1	0	0	0	7	2	1	2	0	0	0	0	1	0	1	0	0	7	2	2	0	0	4	0	0	1	3	0	0	1	8	0	0	0	1	0	2	0	1	0	0	0	2	1	2	1	1	2	0	1	0	0	1	0	1	1	3	0	0	2	0	0	0	0	0	0	0	0	2	0	11	4	4	0	0	2
Surface waters of Loch McNess	S	0	0	0	0	0	6	4	4	0	0	0	0	0	0	1	0	0	0	2	1	0	0	0	1	0	0	1	0	0	0	0	4	1	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1?	0
Insects with terrestrial adult and aquatic larval stages	T	0	0	0	0	0	3	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	4	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
Unclassified1	U	1	1	1	1	1	14	5	0	1	1	0	2	3	2	2	3	0	1	11	3	2	1	1	4	3	3	5	4	0	2	1	17	1	0	1	3	2	1	1	1	0	1	2	0	1	4	2	0	3	1	1	3	2	1	8	6	4	2	4	3	2	1	1	1	1	0	0	0	0	0	0	9	2	3	0	4	2

Table A2-2. Egerton Spring macroinvertebrates 1994-2008. Taxa recorded new in 2008 are given in green lettering. Taxa recorded new in 2007 are given in orange lettering. Taxa recorded new in 2006 are given in khaki lettering. Taxa from 2005 are indicated in blue lettering. Taxa from 2004 are indicated in red lettering.

TAXON	1994	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
TURBELLARIA											
Turbellaria spp.	1		1	1	1	0	0	1	1	1	1
NEMATODA											
Nematoda spp.	1		1	1	1	1	0	1	1	1	1
ANNELIDA											
OLIGOCHAETA											
Oligochaeta spp.	1		1	1	1	1	1	0	0	0	0
immature with all bifid chaetae	0		0	0	0	0	0	1	0	0	0
Pristina aequiseta	0		0	0	0	0	0	0	1	1	1
Pristina leidyi	0		0	0	0	0	0	1	1	0	0
Pristina cf osborni	0		0	0	0	0	0	1	1	0	0
?Nais communis	0		0	0	0	0	0	1	0	0	0
Insulodrilus lacustris s.l (form WA28)	0		0	0	0	0	0	0	1	0	1
immature Phreodrillidae with similar ventral chaetae	0		0	0	0	0	0	1	0	0	1
CRUSTACEA											
Chydoridae: *?Alona* sp.	0		0	0	0	0	0	1	0	0	0
Ilyocryptidae: *Ilyocryptus* sp.	1		1	1	1	1	0	0	1	0	1
COPEPODA											
Eucyclops edytae	0	1	0	0	0	0	0	1	1	1	0
Paracyclops chiltoni	0	1	0	0	0	0	0	0	0	0	0
Paracyclops intermedius	0	1	0	0	0	0	0	0	1	1	0
Mixocyclops sp. nov.	0	0	0	0	0	0	0	0	1	0	0
Cyclopinae copepodite	0	0	0	0	0	0	0	0	1	0	0
Attheyella (*Chappuisiella*) *hirsuta*	0	1	0	0	0	0	0	0	1	1	1
Australocamptus hamondi	1	0	0	0	0	0	0	0	0	0	0
Canthocamptid sp.	0	0	0	0	0	0	0	0	0	1	0
OSTRACODA											
Ostracod spp	0		0	0	0	0	1	0	0	0	0
Darwinulidae: *Darwinula* sp.	1		1	0	1	1	0	1	1	0	0
n.sp	0		0	0	0	0	0	1	0	0	0
Candonidae: *?Candona* sp.	0		0	0	0	0	0	0	1	1	1
Perthiidae: *Perthia branchialis*	1		1	1	1	1	1	1	1	1	1
DECAPODA											
Parastacidae: *Cherax quinquecarinatus*	1		1	0	0	0	1	0	0	0	0
CHELICERATA											
ACARINA											
Oribatida: Oribatida spp.	1		1	1	1	0	0	4	1	0	0
Hygrobatidae: Hygrobatiidae spp.	0		0	0	0	0	0	0	1	0	0
Limnesiidae: *Anisitsiellinae sp. nov.*	0		0	0	0	0	0	0	1	1	0
Limnesia sp nov	1		0	0	0	0	0	0	0	0	0
Trombidioidea: Trombidioidea spp.	0		0	0	0	0	0	0	1	0	0
Acarina sp. 3	0		0	0	0	0	1	0	0	0	0
Acarina sp. 4	0		0	0	0	0	1	0	0	0	1

TAXON	1994	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
Acarina sp. 5	0		0	0	0	0	1	0	0	0	0
COLLEMBOLLA											
Sminthuridae: Sminthuridae spp.	0		0	0	0	0	1	0	0	0	0
INSECTA											
ODONATA											
Megapodagrionidae: *Archiargiolestes* sp.	0		0	0	0	0	0	0	1	0	0
Anisoptera spp.	1		1	1	1	0	0	0	0	1	0
Gomphidae: *Austrogomphus lateralis*	0		0	0	0	0	1	0	0	0	0
Austrocorduliidae: *Lathrocordula metallica*	0		0	0	0	0	1	0	0	0	0
Synthemistidae: Synthemistidae spp. (imm.)	0		0	0	0	0	0	1	0	0	0
Archaeosynthemis occidentalis	0		0	0	0	0	0	0	1	0	0
Archeosynthemis ?leachii	0		0	0	0	0	1	0	0	0	0
HEMIPTERA											
Hemipteran sp.	0		0	0	0	0	1	0	0	0	0
Hebridae: *Hebrus* sp.	0		0	0	0	0	0	0	1	0	1
Veliidae: Veliidae spp.	1		0	0	1	0	0	0	0	1	0
COLEOPTERA											
Dytiscidae: Dytiscidae spp. (L)	1		1	1	1	1	0	0	0	0	0
Necterosoma sp.	0		0	0	0	0	1	0	0	0	0
Sternopriscus brownii	0		0	0	0	0	1	0	0	0	0
Sternopriscus marginatus (A)	0		0	0	0	0	0	1	0	0	0
Sternopriscus sp. (L)	0		0	0	0	0	0	1	1	0	1
Hydrophilidae: *Enochrus ?peregrinus*	0		0	0	0	0	0	0	1	0	0
Enochrus sp. (L)	0		0	0	0	0	0	0	1	0	0
Scirtidae: Scirtidae spp. (L)	0		0	0	0	0	1	1	1	1	1
DIPTERA											
Culicidae: *Anopheles* sp.	0		0	0	0	0	0	1	0	0	0
Chironomidae: Chironomidae spp.	1		1	1	1	1	0	0	1	1	0
Polypedilum sp.	0		0	0	0	0	0	1	0	0	0
Polypdedilum ?oresitrophus	0		0	0	0	0	0	0	1	0	1
Riethia sp. (V4)	0		0	0	0	0	0	0	1	0	1
Riethia sp. (V5)	0		0	0	0	0	0	1	1	0	0
Stempellina ?australiensis	0		0	0	0	0	0	1	1	0	0
Tanytarsus sp.	0		0	0	0	0	0	1	1	0	0
Chironominae spp.	0		0	0	0	0	1	0	0	0	0
Limnophyes pullulus	0		0	0	0	0	0	1	0	0	0
Orthocladiinae sp, V31	0		0	0	0	0	0	0	1	0	0
Apsectrotanypus ?maculosus	0		0	0	0	0	0	0	1	0	0
Paramerina levidensis	0		0	0	0	0	0	1	1	0	0
Pentamura sp.	0		0	0	0	0	0	0	1	0	0
Tanypodinae spp.	0		0	0	0	0	1	0	0	1	0
Ceratopogonidae: Ceratopogoniinae spp.	0		0	0	0	0	0	1	1	1	1
Ceratopogonidae spp.	0		0	0	0	0	1	0	0	0	0
Empididae: Empididae spp.	0		0	0	0	0	1	0	1	0	0
Simulidae: Simuliidae spp.	0		0	0	0	0	1	0	0	0	0
Tipulidae: Tipulidae spp.	0		0	0	0	0	1	0	1	0	0
TRICHOPTERA											

TAXON	1994	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
Ecnomidae: *Ecnomina D group* sp.	0		0	0	0	0	1	0	0	0	0
Hydroptilidae: *Oxyethira* sp.	0		0	0	0	0	1	1	0	0	1
Leptoceridae: Leptoceridae spp.	1		1	1	1	0	0	0	0	1	1
Notalina sp.	0		0	0	0	0	1	1	1	0	0
LEPIDOPTERA											
Unidentified lepidopteran	0		0	0	0	0	1	0	0	0	0
Total no. of species	**15**	**4**	**12**	**10**	**12**	**7**	**25**	**30**	**40**	**17**	**20**

Table A2-3. Edgecombe Spring macroinvertebrates 1992-2007. Taxa recorded new in 2008 are given in green lettering. Taxa recorded new in 2007 are given in orange lettering. Taxa recorded new in 2006 are given in khaki lettering. Taxa from 2005 are indicated in blue lettering. Taxa from 2004 are indicated in red lettering.

TAXON	1992-1995	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
TURBELLARIA											
Turbellaria spp.	0	0	1	0	1	0	1	0	1	0	1
NEMATODA											
Nematoda spp.	1	1	1	0	0	0	1	1	1	0	1
ROTIFERA											
Rotifera spp.	1	0	0	0	0	0	0	0	0	0	0
ANNELIDA											
OLIGOCHAETA											
Oligochaete sp. 3	0	0	0	0	0	0	1	0	0	0	0
Oligochaete sp. 6	0	0	0	0	0	0	1	0	0	0	0
Oligochaete sp. 7	0	0	0	0	0	0	1	0	0	0	0
Tubificidae: *Pristina* sp.	1	0	0	0	0	0	0	0	0	0	0
Pristina aequiseta	0	0	0	0	0	0	0	0	1	1	1
Naidinae spp.	0	0	0	0	1	0	0	0	0	0	0
Phreodrilidae: *Insulodrilus bifidus*	0	0	0	0	0	0	0	1	1	0	0
Insulodrilus lacustris s.l (form WA28)	0	0	0	0	0	0	0	1	0	0	0
immature Phreodrillidae with similar ventral chaetae	0	0	0	0	0	0	0	1	1	0	1
CRUSTACEA											
COPEPODA											
Paracyclops chiltoni	1	0	0	0	0	0	0	0	0	0	0
Mixocyclops sp. nov	0	0	0	0	0	0	0	0	1	0	0
Elaphoidella bidens	1	0	0	0	0	0	0	0	0	0	0
Australocamptus sp.	0	0	0	0	0	0	0	0	0	0	1
Parastenocaris eberhardi	1	0	0	0	0	0	0	0	0	0	0
OSTRACODA											
Ostracoda spp.	0	0	0	0	0	0	1	0	0	0	0
Candona sp.	1	0	0	1	1	1	0	1	1	1	1
Cypridopsidae: *Darwinula* sp.	1	0	0	0	0	0	0	1	0	0	0
SYNCARIDA											
Bathynellacaea spp.	1	0	0	0	0	0	0	0	0	0	0
ISOPODA											
Paramphisopus ?palustris	0	0	0	0	0	0	1	0	0	0	0
Unidentified isopod	0	0	0	0	0	0	1	0	0	0	0
DECAPODA											
Parastacidae: *Cherax quinquecarinatus*	0	0	0	0	0	0	0	1	0	0	0
CHELICERATA											
ACARINA											
Acarina sp. 1	0	0	0	0	0	0	1	0	0	0	0
Acarina sp. 2	0	0	0	0	0	0	1	0	0	0	0
Acarina sp. 6	0	0	0	0	0	0	1	0	0	0	0
Acarina sp. 7	0	0	0	0	0	0	1	0	0	0	0
Hydracarina spp.	0	0	0	0	1	0	0	0	0	0	0
Limnohalacarida: *Lobohalacarus* sp.	1	0	0	0	0	0	0	0	0	0	0
Oribatida spp.	1	0	0	0	0	0	0	1	1	0	0
COLLEMBOLA											
Hypogasturidae: Hypogastruridae spp.	0	0	0	0	0	0	1	0	0	0	0

TAXON	1992-1995	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
INSECTA											
ODONATA											
Anisoptera: Anisoptera spp.	0	0	0	0	1	0	0	0	0	0	0
Synthemistidae: Synthemistidae spp. (imm.)	0	0	0	0	0	0	0	1	0	0	0
Archaeosynthemis occidentalis	0	0	0	0	0	0	0	0	1	0	0
Archeosynthemis ?leachii	0	0	0	0	0	0	1	0	0	0	0
HEMIPTERA											
Hemipteran sp.	0	0	0	0	0	0	1	0	0	0	0
Veliidae: Veliidae spp.	0	0	0	0	1	0	0	0	0	0	0
COLEOPTERA											
Dytiscidae: *Liodessus ornatus*	0	0	0	0	0	0	1	0	0	0	0
Rhantus suturalis	0	0	0	0	0	0	1	0	0	0	0
Georissidae: *Georissus* sp.	0	0	0	0	0	0	1	0	0	0	0
Scirtidae: Scirtidae spp. (L)	0	0	0	0	0	1	1	1	1	0	0
DIPTERA											
Culicidae: *Anopheles* sp.	0	0	0	1	1	1	0	0	0	0	0
Chironomidae: Chironominae spp.	0	0	0	0	0	0	2	0	0	0	1
Paramerina levidensis	0	0	0	0	0	0	0	0	1	0	0
Chironomus sp.2	1	0	0	1	1	1	0	0	0	0	0
Tanypodinae spp.	0	0	0	1	1	0	2	0	0	0	0
Ceratopogonidae: Ceratopogoniinae spp.	0	0	0	1	1	1	2	1	1	0	0
Tipulidae: Tipulidae spp.	1	0	0	1	1	1	1	1	1	0	0
Psychodidae: Psychodidae spp.	0	0	0	0	0	0	1	0	0	0	0
Tabanidae: Tabanidae spp.	0	0	0	0	0	0	2	0	0	0	0
Stratiomyidae: Stratiomyidae spp.	0	0	0	0	0	0	1	0	0	0	0
TRICHOPTERA											
Hydroptilidae: *Oxyethira* sp.	0	0	0	0	0	0	0	0	1	0	0
Total no. of species	**14**	**2**	**2**	**7**	**13**	**7**	**28**	**12**	**16**	**3**	**7**

7.3 Appendix 3: Photographic Voucher

- New species and cavernicole and interstitial species are given in detail where possible. If only one specimen was available only whole body images were taken as detailed photographs of diagnostic features often involved dissection which destroys the specimen.
- Photographs taken by L. Chandler and D. Tang unless otherwise indicated.
- Taxonomic confirmation of cladoceran specimen identifications was sought from Dr. Russell Shiel of the University of Adelaide, for this photographic voucher.

OLIGOCHAETA (AQUATIC WORMS)

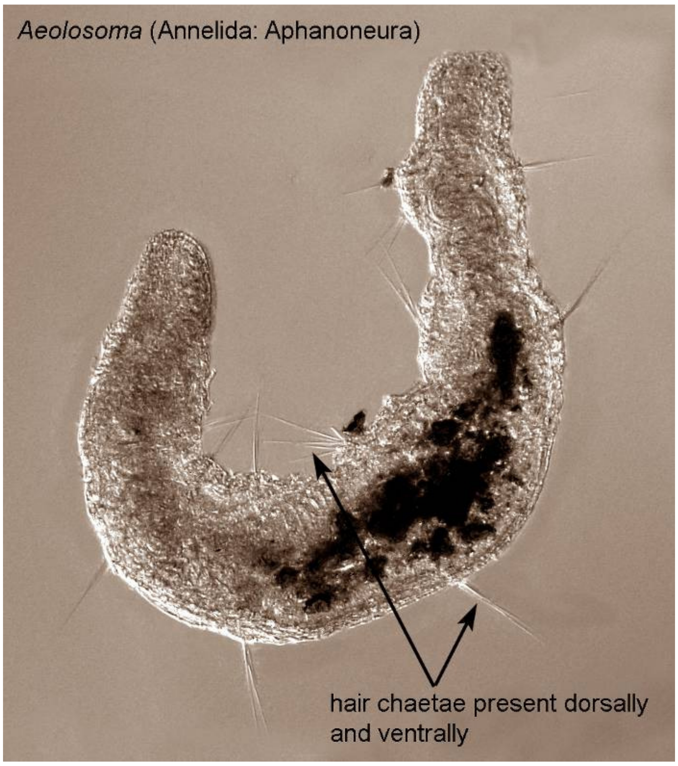

Plate A4. 1. Aeolosoma sp. (Photo: A.W. Pinder).

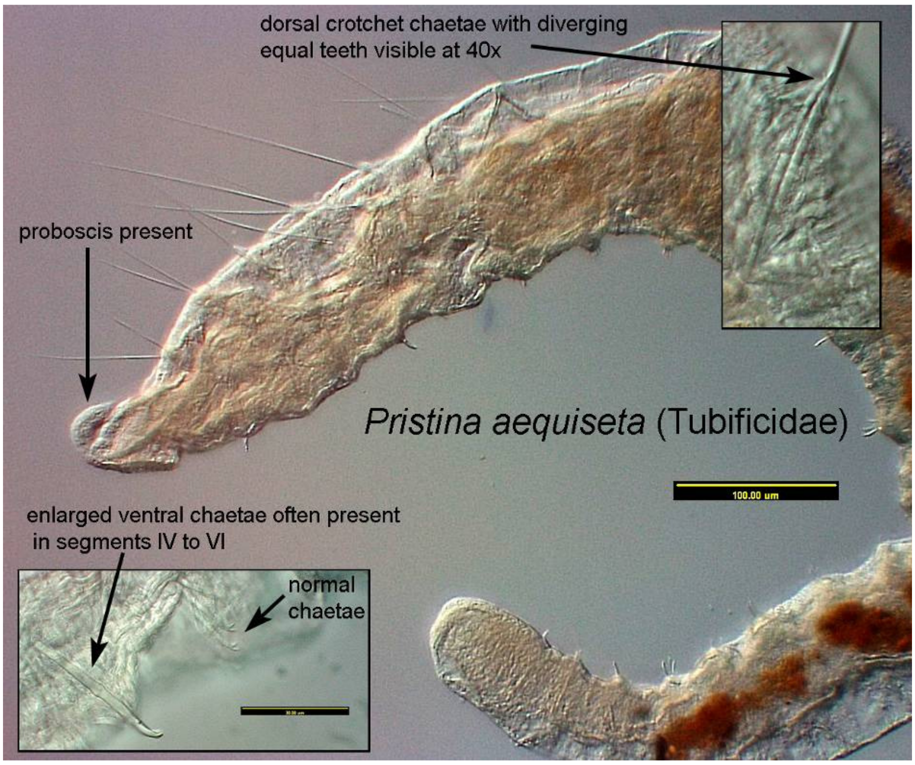

Plate A4. 2. *Pristina aequiseta.* (Photo: A.W. Pinder).

ACARINA (MITES)

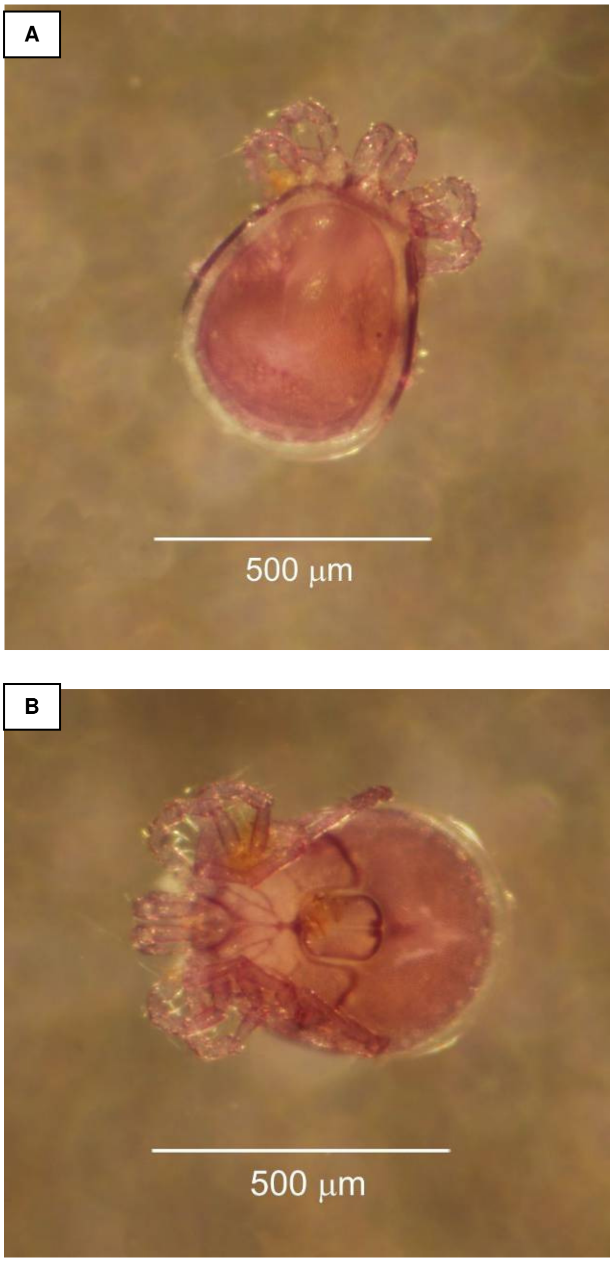

Plate A4. 3. Anisitsiellinae spp. (Limnesiidae) specimen collected from Egerton Spring a) dorsal view, and b) ventral view.

CRUSTACEA

Copepoda

Australoeucyclops sp.

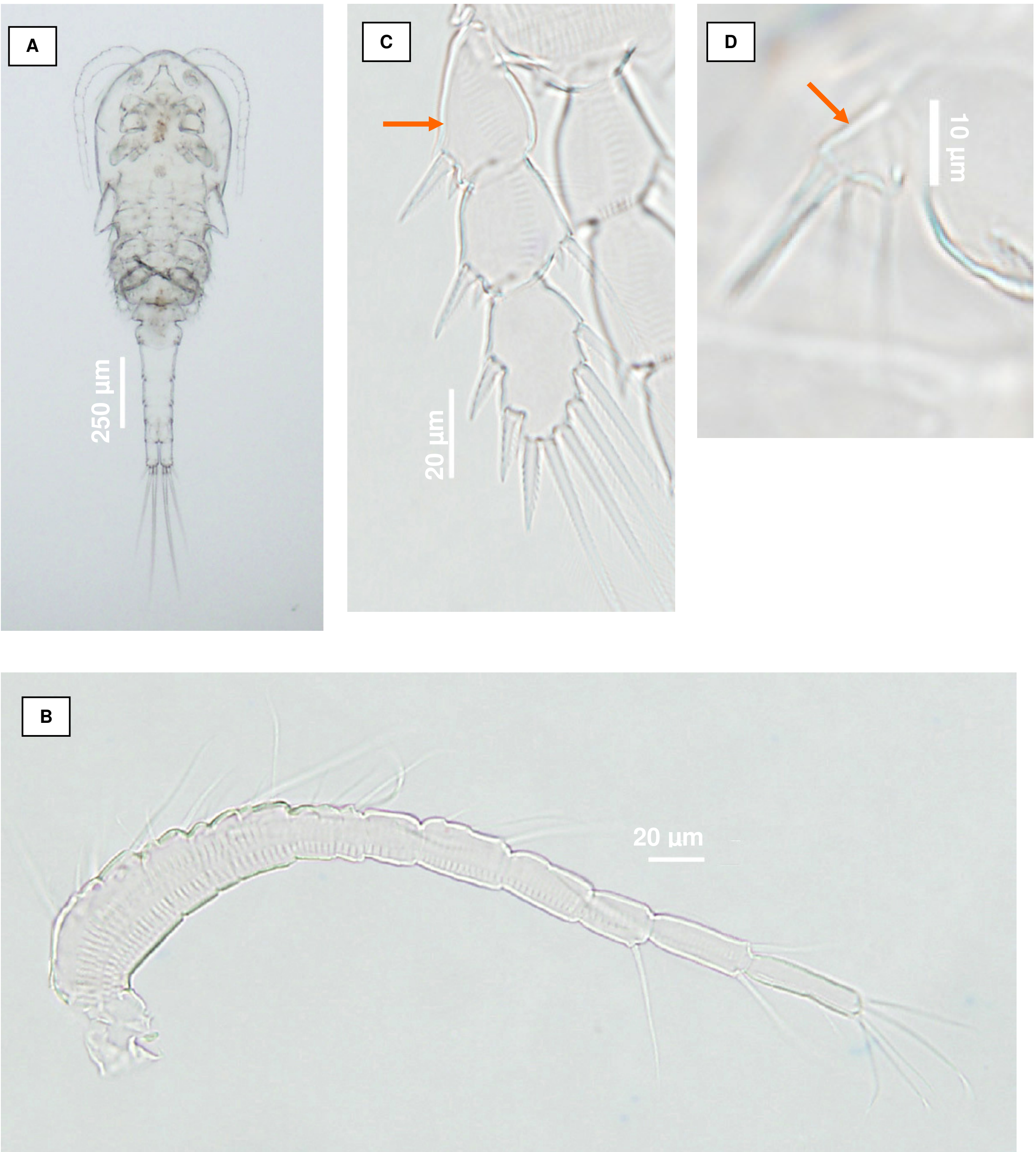

Plate A4. 4. *Australoeucyclops* sp., adult female. a) habitus; b) 12-segmented antennule; c) exopod of fourth leg showing absence of inner seta on proximal segment (arrowed); d) 1-segmented fifth leg (arrowed) showing 3 distal setae/spines.

Eucyclops edytae.

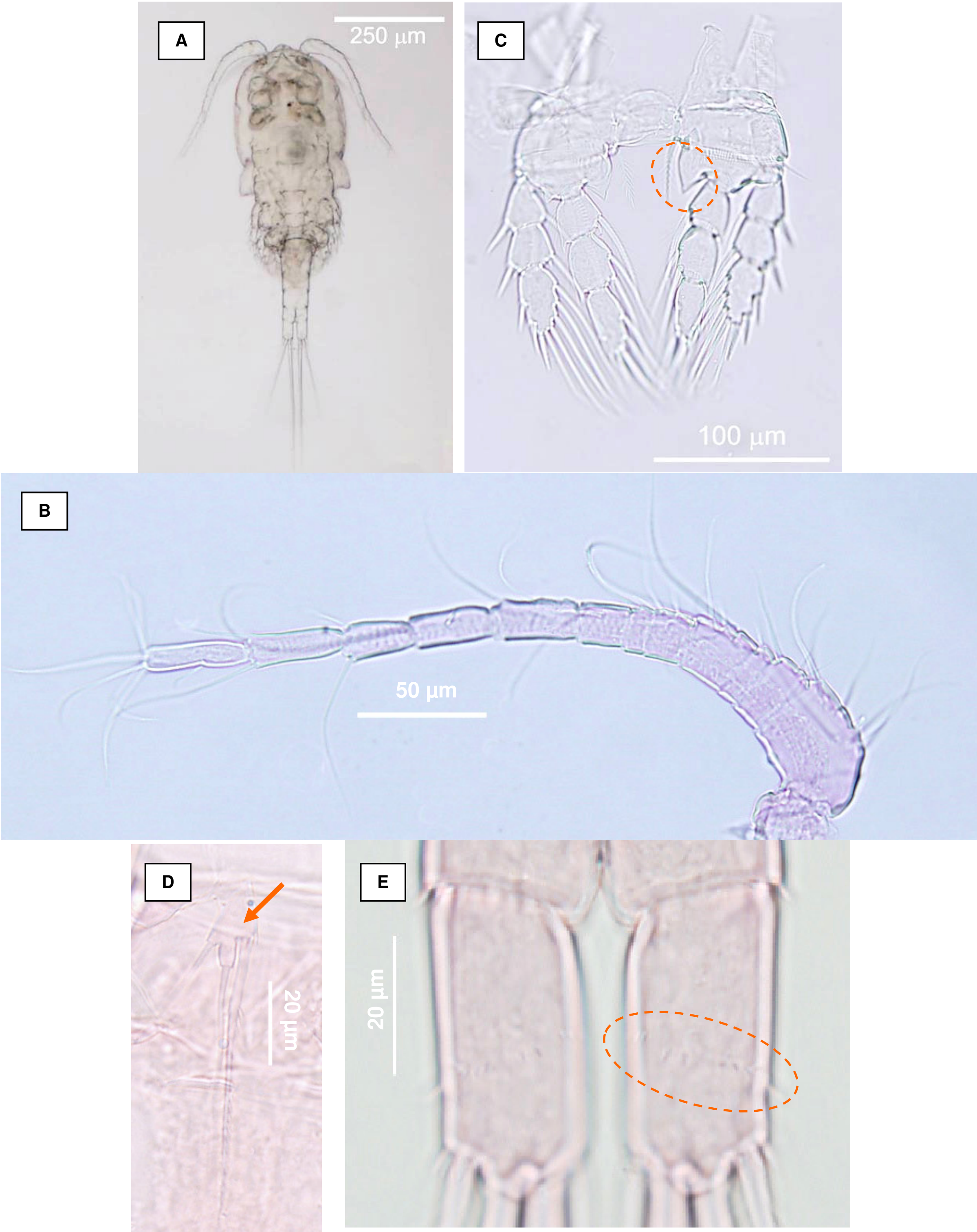

Plate A4. 5. *Eucyclops edytae*., adult female. a) habitus; b) 12-segmented antennule; c) fourth leg showing inner distal angle of basis produced into acute process (circled); d) 1-segmented fifth leg (arrowed) showing 3 long setae/spines; e) caudal rami showing small spinules (circled) on ventral surface.

Macrocyclops albidus (Jurine, 1820)

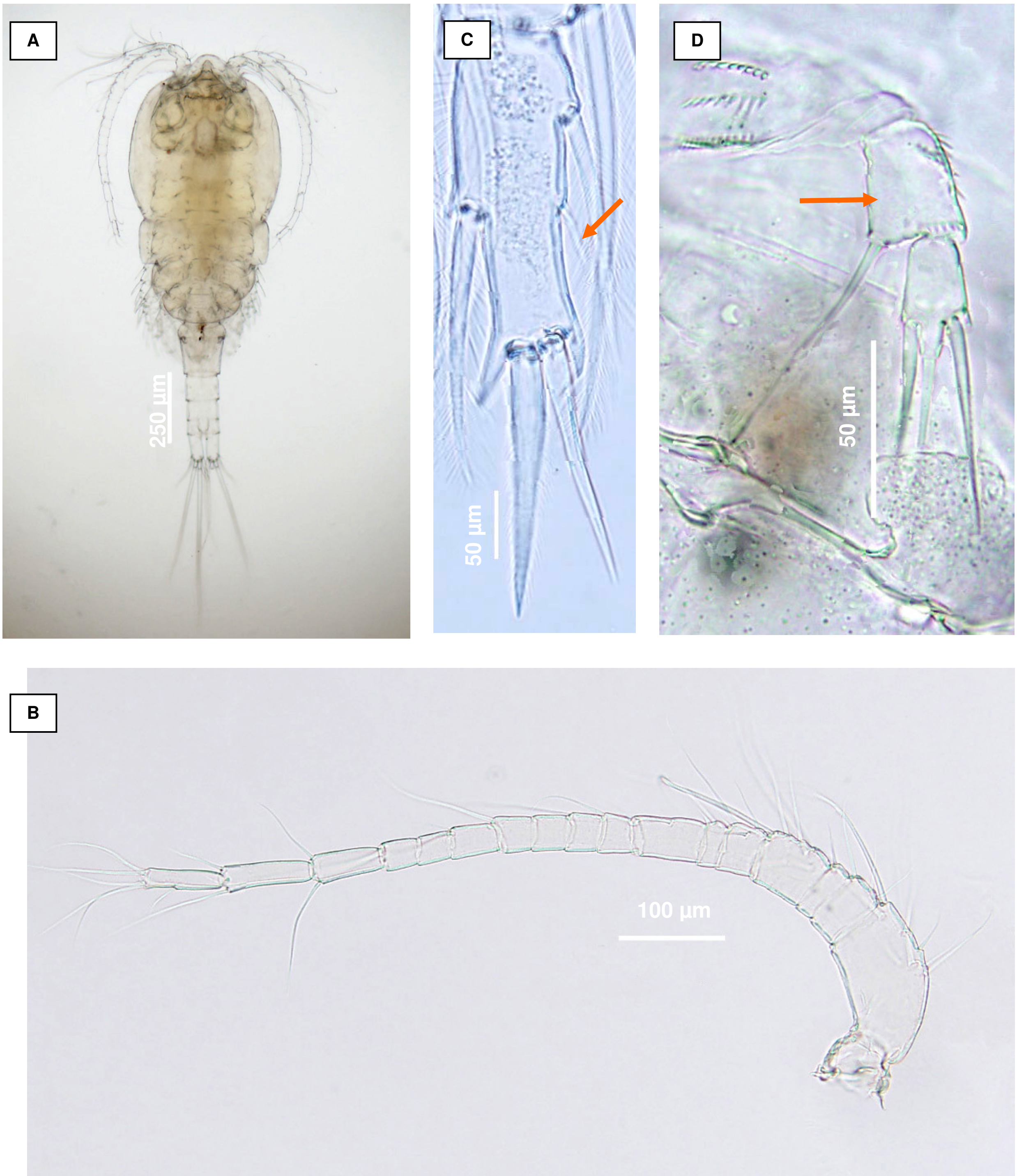

Plate A4. 6. *Macrocyclops albidus* (Jurine, 1820), adult female. a) habitus; b) 17-segmented antennule; c) terminal endopodal segment of leg 4 showing highly reduced inner seta (arrowed); d) 2-segmented fifth leg (arrowed) showing 3 setae/spines on distal segment.

Paracyclops chiltoni (Thomson, 1882)

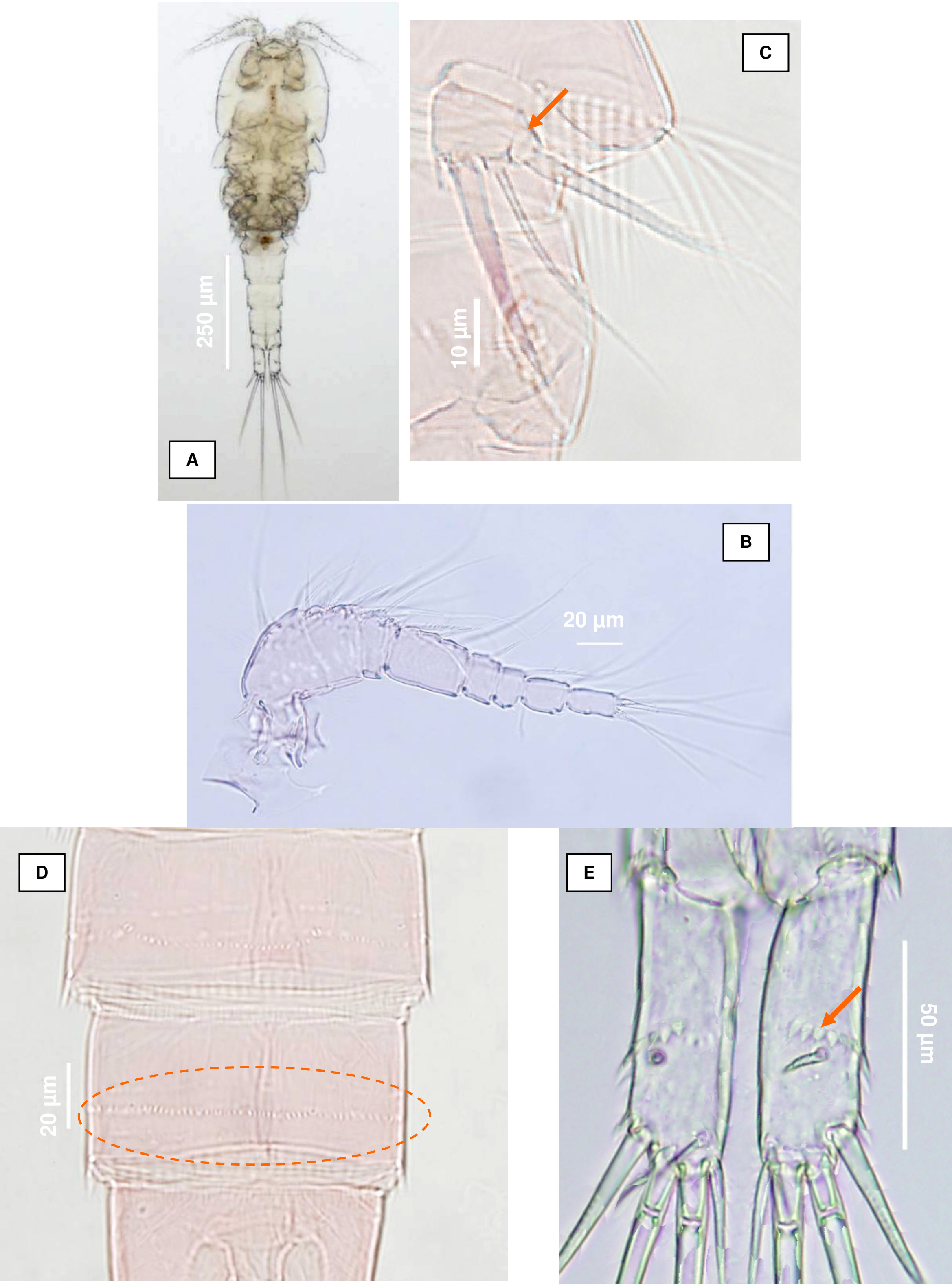

Plate A4. 7. *Paracyclops chiltoni* (Thomson, 1882), adult female. a) habitus; b) 8-segmented antennule; c) 1-segmented fifth leg (arrowed) showing 3 setae/spines; d) cuticular pores (circled) on postgenital somites 1 and 2; e) caudal rami showing large spinules (arrowed) on mid-dorsal surface.

Attheyella (Chappuisiella) hirsuta Chappuis, 1950

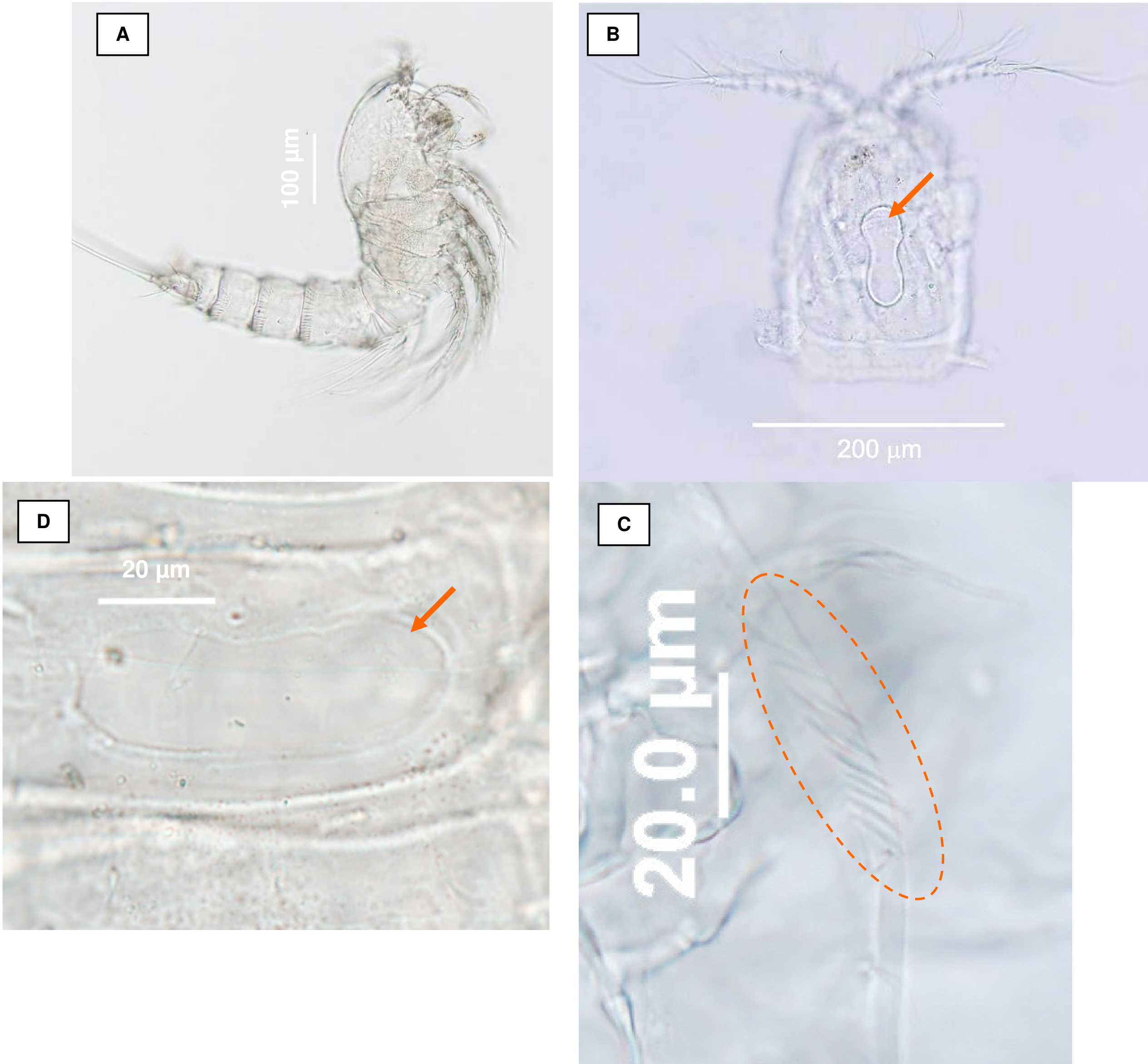

Plate A4. 8. *Atthyella* (*Chappuisiella*) *hirsuta* Chappuis, 1950, adult female. a) habitus, lateral view; b) dorsal view of cephalothorax showing nuchal organ (arrowed); c) spinules (circled) on mid-ventral margin of cephalothorax; d) integumental window (arrowed) on lateral surface of first pedigerous (= second leg-bearing) somite.

Cladocera

Plate A4. 6. *Ilyocryptus* sp. (Ilyocryptidae) collected from Egerton Spring.