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 & L. Chandler

March 2007

Aquatic Research Laboratory
School of Animal Biology

THE UNIVERSITY OF WESTERN AUSTRALIA

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Aquatic Research Laboratory
School of Animal Biology M092, The University of Western Australia
35 Stirling Highway, Crawley, WA 6009, Australia
Ph: (61 8) 9655 1482, Fax: (61 8) 9655 1029, e-mail: awstorey@cyllene.uwa.edu.au

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Frontispiece: Egerton Spring, (photo: L. Chandler)

Study Team

Management:	Andrew Storey
Field Work:	Andrew Storey, Brenton Knott, Lisa Chandler, Danny Tang
Invertebrate Identification:	Lisa Chandler, Brenton Knott
Report:	Lisa Chandler, Andrew Storey, Brenton Knott
Photographic Voucher	Lisa Chandler, Danny Tang

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EXECUTIVE SUMMARY

Eleven caves in the Yanchep area were visited in spring 2006 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, Boomerang Cave, Mire Bowl and Fridge Grotto were dry, and therefore no samples were collected. Twilight Cave and Spillway Cave were considered unsafe and therefore not entered. Two springs on the Gnangara Mound were also sampled; Egerton and Edgecombe Springs. Caves were sampled on 8th & 9th November, and the springs were sampled on 9th October 2006.

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. Elevated nutrient levels may indicate anthropogenic influence on groundwater entering this cave, or a high organic (detritus) load. A trend indicating that the sulphate levels in YN555 increase with elevated salinity levels was noticed in the data this year.

Water levels in the springs were variable. Egerton Spring was flowing, although not as strongly as the previous year, and had more water near the base of the mound; however, Edgecombe Spring had only a very thin film of water running near the discharge point. Water quality of the springs was generally indicative of good quality, fresh water and was relatively constant over time. However, a downward trend in pH levels was evident at Egerton Spring. This decrease is of concern as low pH is detrimental to aquatic fauna, and as Egerton Spring appears to be in a zone of high risk of acid sulphate soils (ASS) 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 system resulting in observable improvement in the condition of the remaining tree root mats. The fauna of Cabaret Cave appears to be becoming more 'terrestrial' in composition, with the exposed root mats being colonised by species more characteristic of dry caves.

Caves recently added to the monitoring program, including Orpheus Cave (YN256) and the cave on Lot 51 (YN555) exhibited a decline in species diversity this sampling period and the significant ancient cavernicole taxa first recorded in spring 2002 were notably absent. However, an amphipod was observed in Orpheus Cave a few weeks prior to the sampling period (L. Bastion, pers. comm.).

Results continue to cause concern, particularly as a result of declining water levels. Hydrographs for caves which have had AHD surveyed, and have a bore in close proximity, indicate a continuing reduction 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 where 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 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.

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

The fauna sampled from Edgecombe Spring was characterised by the juvenile stages of insects with highly mobile adult phases (e.g. ceratopogonids, anisopterans): only three specimens of ostracod, and two specimens of copepod crustaceans were collected. This indicates that generally, the crustacean fauna, for which the Edgecombe Spring was noteworthy, is in decline.

Recommendations

Based on these results, the following recommendations were made:

- The caves identified by Lex Bastion in his commissioned review of all known caves in the area, which formerly contained water but for which the current status is 'unknown', should be revisited as soon as possible to document their current hydrological regime.
- Encourage local speleologists to continue looking for additional caves with root mats/water.
- Permanent water flows must be restored to the cave streams, and maintained at a level whereby the majority of the root mats are submerged.
- 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 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.
- The risk to the TECs through mixing of populations and genetic 'dilution' of extant cave stream populations through the introduction of fauna in recharge waters should be assessed.
- Boomerang Cave, which dried in 2003 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 this site.
- A gauge for measuring flows should be established on Egerton 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 and 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.
- Resample Egerton early in 2007 to determine the extent of the influence recent development to the west and south of the spring has on the water levels.

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 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 Conservation and Land Management's (CALM) WA Threatened Species and Communities Unit and the Swan-Goldfields District of the Department of Environment (nee Water & Rivers Commission).

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 to historical (1998) and more recently collected data (November 2000, September 2001, January 2002, September 2002, September 2003, October 2004 and November 2005).

1.3 Scope

1. In spring 2006 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)
   - Twilight Cave (YN194)

   Sampling is to provide an indication of the status of the invertebrate communities compared against historical data. Of caves previously 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 2006, monitor spring 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 Environment prior to undertaking fieldwork and then with the two property owners.

   Sampling is to provide an indication of the status of the invertebrate communities compared against historical data. It is critical that the macroinvertebrate fauna be sampled from runnels before the discharge point and at the point of spring discharge, 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.

2 METHODS

2.1 Study Sites

2.1.1 Caves

All caves were sampled on 8th and 9th November 2006. All were within the area of the Gnangara Mound Groundwater Resources study area, and with the exception of the cave on Lot 51, all the study sites were within the Yanchep National Park (Figure 1).

The ecological value of the caves is considered to be dependant on 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 (TEC's). 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 these were used to relate changes in groundwater levels to cave stream water levels (Table 2).

A total of eleven caves were considered for sampling in 2006, with nine caves visited and five caves actually sampled. As anticipated, Fridge Grotto (YN81) and Gilgie Cave (YN27) contained no water and were not sampled. Mire Bowl (YN61) and Boomerang Cave (YN99) were also dry during this period. Following a recent assessment of the safety of all caves, conducted by DoW, Twilight and Spillway caves 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 their GPS location and sample date, if visited.

Table 1. Names and codes of caves visited in 2006 and whether sampled.

Cave	Code	Easting	Northing	Visited	Date Visited	Sampled	Nearest Bores[1]
Cabaret Cave	(YN30)	37565	650960	Yes	8 November 2006	Yes	YN4 (100m SE)
Boomerang Cave	(YN99)	37566	650952	Yes	8 November 2006	No (dry)	YN4 (100m SE)
Carpark Cave	(YN18)	37525	650844	Yes	8 November 2006	Yes	YN3 (300m NE) YN2 (400m SE)
Water Cave	(YN11)	37499	650864	Yes	8 November 2006	Yes	YN7 (1100m SSE) YN5 (1500m NE)
Cave on Lot 51	(YN555)	376921	6505901	Yes	9 November 2006	Yes	YN8 (~910m NW) GNM9 (~820 NNW) GNM10 (~960 NNW) JP23 (~600m NE)
Gilgie Cave	(YN27)	375714	6506702	Yes	9 November 2006	No (dry)	-
Twilight Cave	(YN194)	375778	6506788	No	9 November 2006	No (unsafe)	-
Spillway Cave[2]	(YN565)	374404	6509263	No	9 November 2006	No (unsafe)	-
Orpheus Cave	(YN256)	373673	6512354	Yes	9 November 2006	Yes	-
Fridge Grotto	(YN81)	373844	6511733	Yes	9 November 2006	No (dry)	-
Mire Bowl	(YN61)	374254	6511387	Yes	9 November 2006	No (dry)	-

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

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

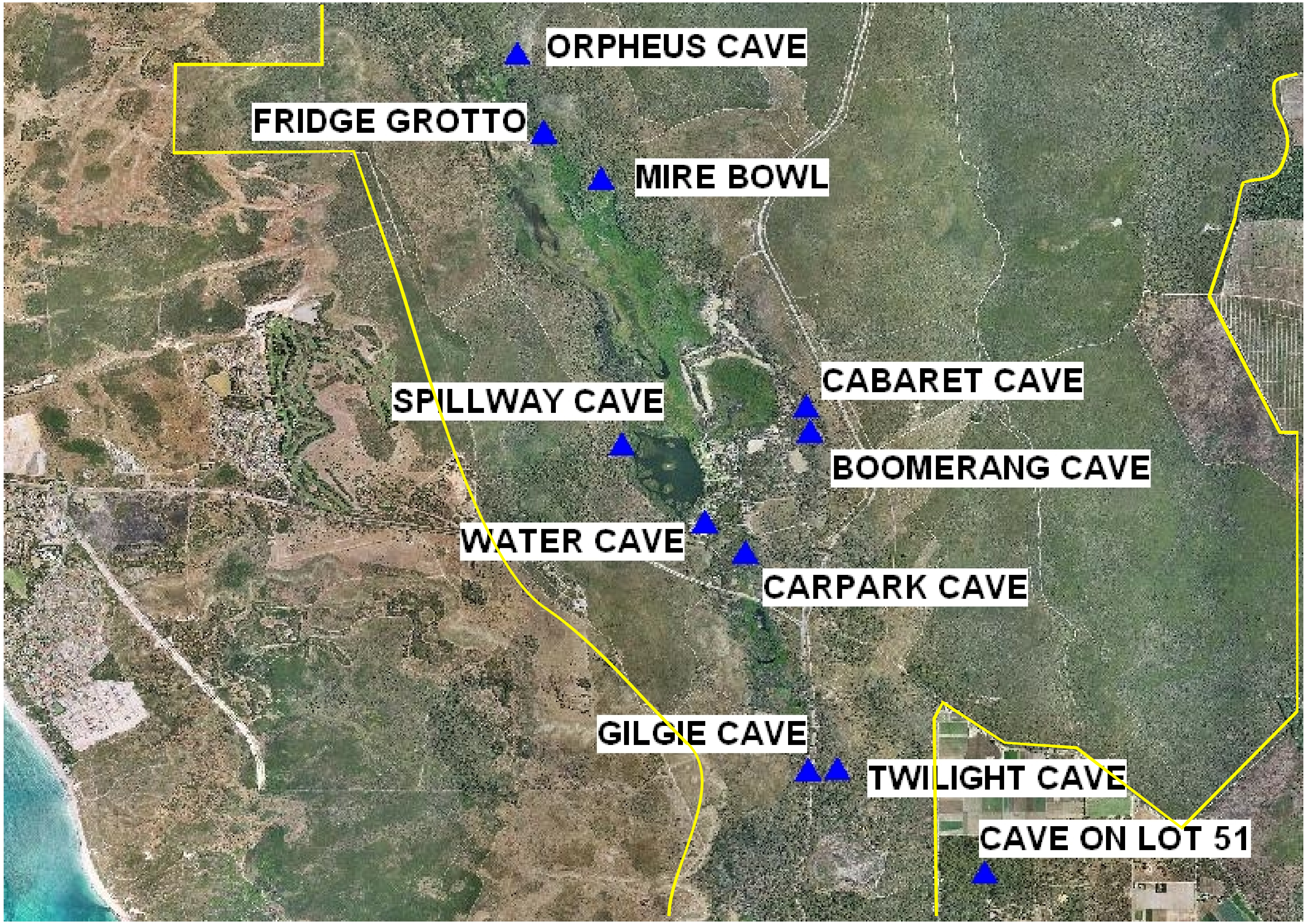


Figure 1. Aerial showing location of Yanchep caves. Yellow outline indicates border of Yanchep National Park

2.1.2 Springs

Both Egerton and Edgecombe springs were sampled on 9th October 2006. The ecological value of the springs is considered to be dependant 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 Egerton Stud, Ellenbrook. 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 was noticed to the west and south of the spring during the current study.

Edgecombe Spring

The 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.

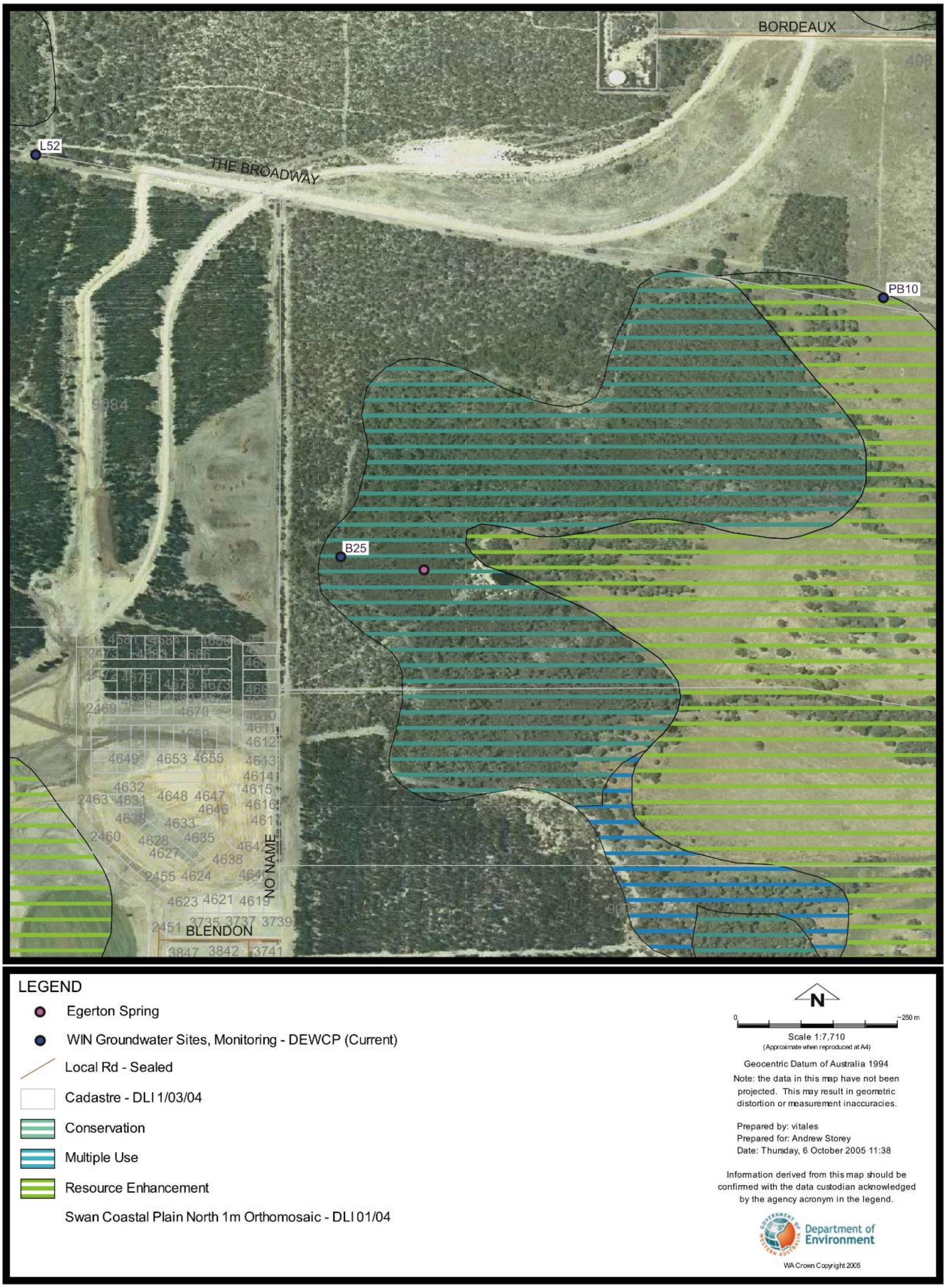


Figure 2. Aerial photo showing location of Egerton Spring.

Figure 3. Aerial photo showing location of Edgecombe Spring.

2.2 Water Quality

2.2.1 Caves

In-situ measures of water quality were made at each site using a Yeo-Kal Model 611 multiprobe water quality meter (Table 3). 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 3). Laboratory analyses were conducted by the Natural Resources Chemistry Laboratory, Chemistry Centre (WA), a NATA accredited laboratory.

Table 3. *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)
Dissolved Oxygen (% sat.)	Potassium (K)
Turbidity (NTU)	Magnesium (Mg)
Salinity (ppt)	Nitrate and nitrite (N_NO3)
Conductivity (µS/cm)	Sodium (Na)
pH	Soluble reactive phosphorus (P_SR)
Redox	Sulphate (SO4_S)
Water Temperature (˚C)	

2.2.2 Springs

In-situ measures of water quality were made at each site using a Yeo-Kal Model 611 multiprobe water quality meter (Table 4). To obtain sufficient water depth at Edgecombe Spring, a small hole was dug near the point of discharge (Plate 1) and water samples were taken from this area, once the sediments had settled. 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 4). Laboratory analyses were conducted by the Natural Resources Chemistry Laboratory, Chemistry Centre (WA), a NATA accredited laboratory.

Plate 1. Hole dug at Edgecombe Spring for sampling purposes.

Table 4. *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)
Turbidity (NTU)	Magnesium (Mg)
Salinity (ppt)	Calcium (Ca)
Conductivity (µS/cm)	Total Iron (Fe)
pH	Chloride (Cl)
Redox	Nitrate and nitrite (N_N03)
Water Temperature (˚C)	Sulphate (SO4_S)

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.

The Egerton Spring fauna were collected approximately 20 metres downstream from the point of the spring discharge, along the runnels before they exit from the mound. Access to the actual point of discharge was made 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. At Edgecombe Spring, sampling for fauna was difficult due to low flows. Five samples were taken from the point of discharge using a ~ 2.5 m long hose and bulked in a sealed, labelled plastic bag. The hole dug for water quality measurements was also sampled using a 500 μm mesh sieve and added to the bulked sample.

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

Sampling was timed to take place when water levels were expected to have been at their highest (*i.e.* mid spring). However, water levels were very low when compared to historical levels (*cf* 1990s) and no surface water flow was evident. 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 cave was dry. The water levels in the sumps were low, with pumps struggling for water at a time of year when levels should be at their highest. External bores were not working at the time of sampling, though red-oxide stains were evident from when they had been trialled. Water levels in each cave at the time of sampling are summarised below:

- *Cabaret Cave* – there was no natural surface flow in this cave, with the only water present being in the liners. The only water of sufficient depth to measure water quality was in the sump well, so measurements were taken on the assumption that the water present was representative of the water in the cave. The root mats in this cave appeared healthy where water was available.
- *Boomerang Cave* – the cave and root mats were dry as the pump system was broken.
- *Carpark Cave* – the entrance stream was dry and the water in the cave was confined to the liners. The root mats were relatively healthy where water was available.
- *Water Cave* – this cave still contained a relatively deep pool, however water levels were down from last year and all accessible root mats were exposed and dry, well above the water table. The organic layer at the bottom of the pool was sampled for fauna.
- *Cave YN555 on Lot51* – the water levels were approximately ¾ m lower than the previous year, with the main pool sampled last year dry this sampling period (see Plates 2 & 3). No isopods were observed this year. A goldfish (*Carassius auratus*) was observed in the pool; attempts to catch and remove it from the cave were unsuccessful.
- *Twilight Cave* – the roof of the cave was considered unstable, therefore access was deemed unsafe.
- *Spillway Cave (YN565*) – this cave was considered unsafe to enter this year.
- *Mire Bowl (YN61)* – the cave and sump well were dry.
- *Orpheus Cave* – water level appeared to be half the level of previous years. The water did not appear to be flowing. An amphipod was recently sighted (Lex Bastion pers. comm. 2006); however none were observed during the current sampling period.
- *Fridge Grotto* – this cave was dry.

3.1.2 Water Levels

Comparison of water levels in groundwater bores with the surveyed AHD (Table 2) of the caves indicated the maximum winter water level was below the AHD of Cabaret and Boomerang Gorge caves (Figure 4). The minimum summer water level in the bore closest to Carpark Cave (Figure 4) was at least 3 m above the AHD of the cave, suggesting the cave always contains water. However, the stream in Carpark Cave dries in summer 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.

Water levels in four groundwater bores near the cave on Lot 51 (YN555) show a steady decline for the past ten years (Figure 5). The maximum winter water levels for 2006 were almost half a metre lower than the average for the previous 5 years at each of the four bores. The water levels in JP23 indicate almost a four metre drop over the past 30 years.

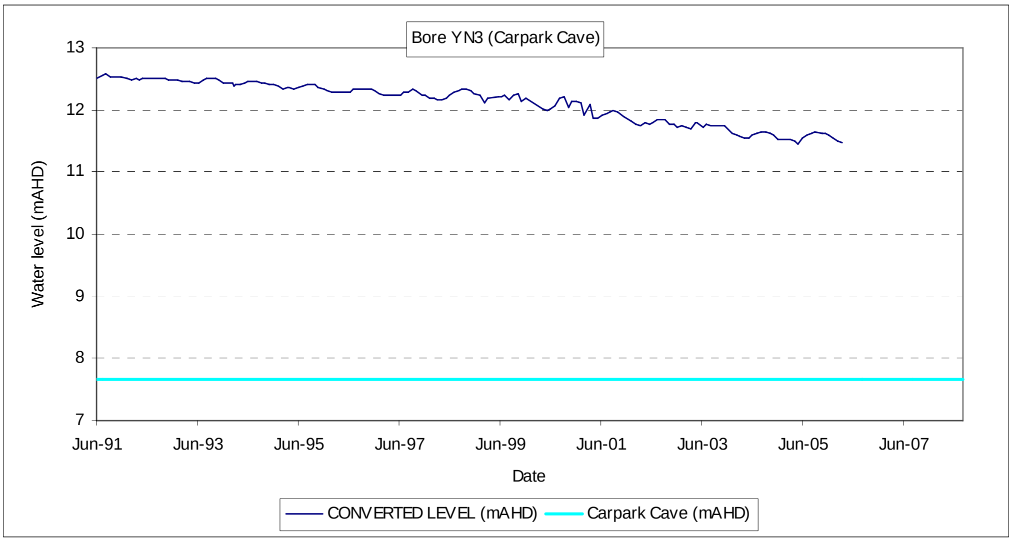
Relating AHD in bores to AHD of the floor of the caves assumes that flows in the caves directly reflect a relationship between the AHD of the bores and that of the cave floor. Some attribute of the hydrostatic head of the groundwater mound upstream of the caves may also play a role in determining the water regime of the caves.

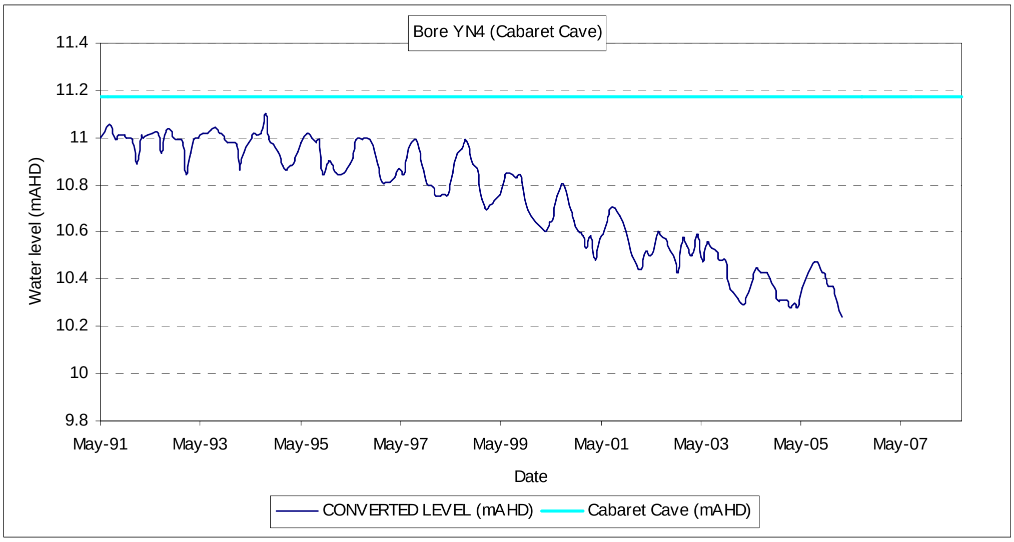
Plate 2. Sampling a pool in the cave on lot 51 (YN555), in 2005.

Plate 3. Showing extent of water loss in pool in the cave on lot 51 (YN555), in 2006.

Plate 4. Pool in Orpheus Cave, 2005. Arrow indicates water level.

Plate 5. Pool in Orpheus Cave, 2006. Arrow indicates water level.





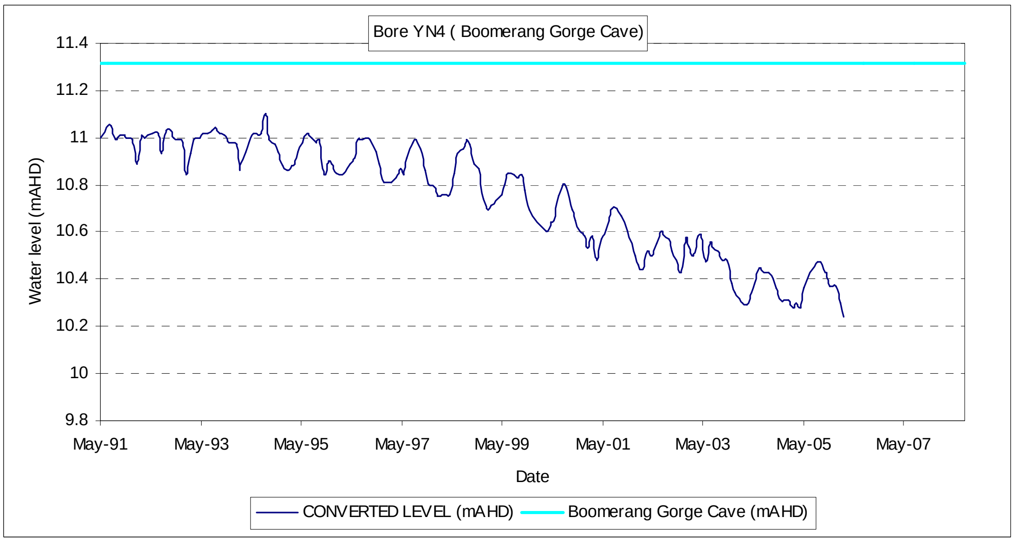


Figure 4. Temporal changes in water levels (mAHD) in monitoring bores YN3 and YN4 against surveyed bed levels (mAHD) of adjacent caves in Yanchep National Park.

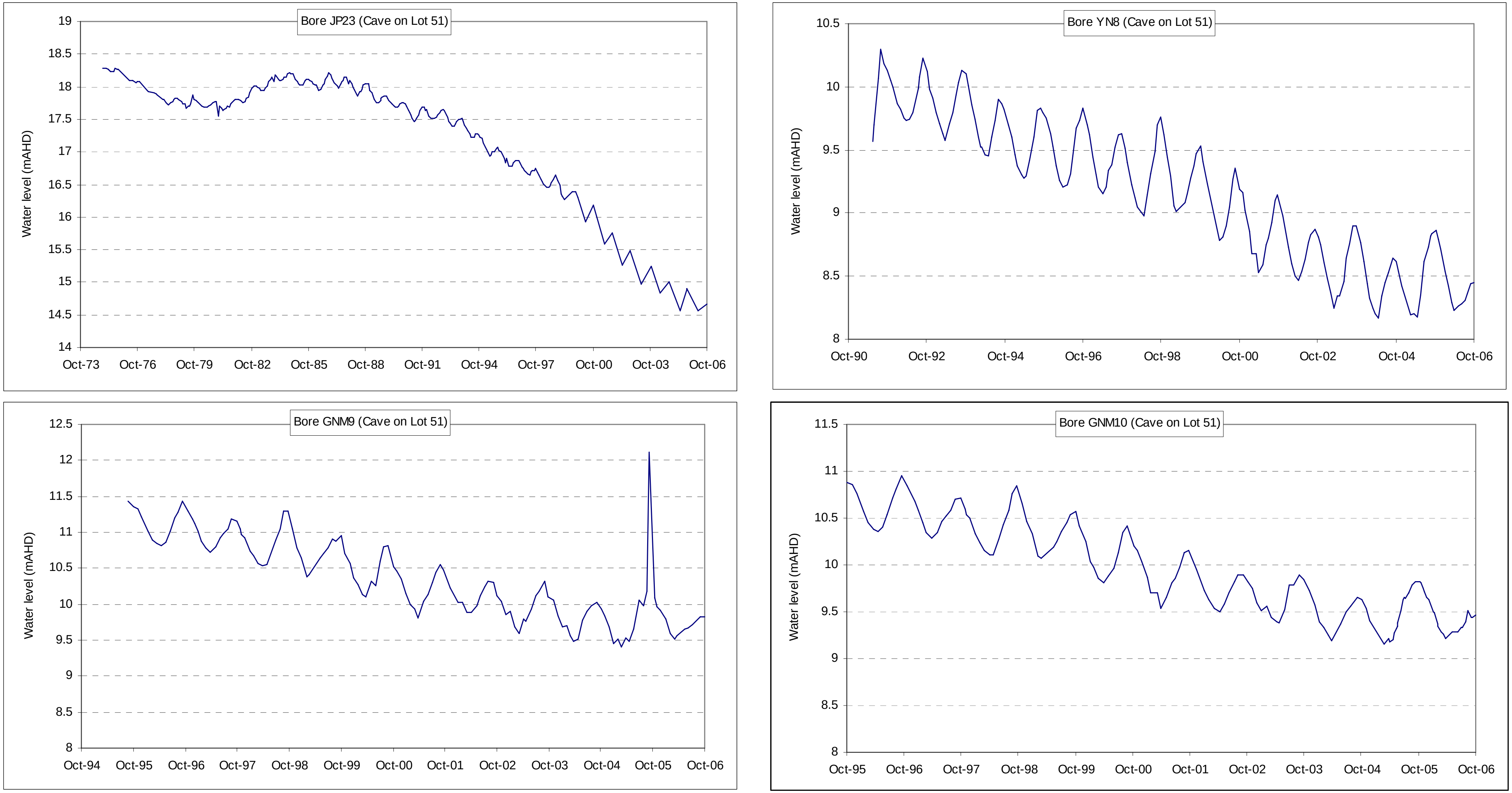


Figure 5. Temporal changes in water levels (mAHD) in monitoring bores JP23, YN8, GNM9 and GMN10 near the cave on Lot 51 (YN555).

3.1.3 Water Quality

As in previous reports (Knott & Storey 2001, 2002, 2003, 2004; Cook & Janicke 2005; Knott *et al.* 2006), *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 6). Values in those caves sampled for the first time in 2002 and again this year (Spring 2006) were relatively constant across years and comparable to levels in caves previously sampled (Table 6).

Dissolved oxygen (DO) levels varied over time. Levels in caves sampled this year were within the range measured on previous occasions (Table 6, 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 less than 0.5 ppt, during the current sampling period. 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 6) which may reflect some evapoconcentration of salts in the waterbody in the cave on Lot 51.

All caves had neutral to slightly alkaline water (pH 7 – 8), 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.* Water and Orpheus caves). The cave on Lot 51 had slightly higher pH (8.56), which may reflect the supersaturation of calcium carbonate crystals noticed in the pool (Lex Bastion, pers.comm., 2007). This could reflect the lower water levels in this pool and some effect of evapoconcentration.

Water temperatures were consistent and less than 20 °C in most caves, with the exception of Orpheus Cave which had a temperature of 22.2 °C.

Concentrations of laboratory-determined parameters also were relatively consistent across caves and years (Table 6). The composition of cations was dominated by calcium (Ca) and sodium (Na), with lower levels of potassium (K) and magnesium (Mg). YN555 on Lot 51 had the highest Na concentrations (85.9 mg/L), which correlated with the higher conductivities/salinities 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) (Table 5). The exception was again YN555 on Lot 51 where 0.99 mg/L of nitrogen (nitrate + nitrite) was recorded in November 2006. 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 into the caves given their proximity to the surface.

Concentrations of soluble reactive phosphorus were generally low in all caves (≤ 0.01 mg/L) and fell below the recommended guideline concentrations for protection of aquatic ecosystems (ANZECC/ARMCANZ 2000) (Table 5).

Sulphate levels were low in most caves; with YN555 having the highest level (18.2 mg/L). This level was considerably lower than those recorded in previous years (Appendix 1). A trend of increased sulphate levels with increased conductivity has also become apparent in YN555 (Figure 6). 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)). However, 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 6, 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.

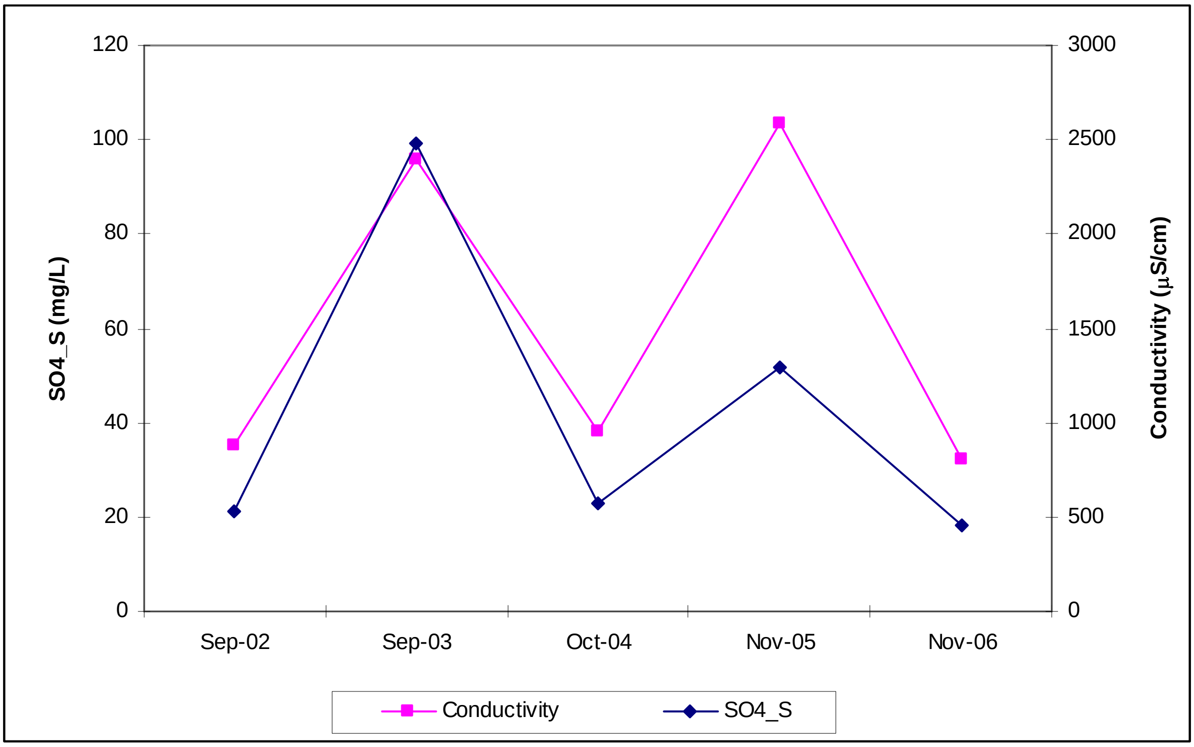


Figure 6. Conductivity (µS/cm) and sulphate (SO4_S, mg/L) over a four year sampling period for the cave on Lot 51 (YN555).

Table 5. 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 6. *In-situ* and analytically-determined water quality parameters measured in 2006. 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	**%**	68.5	66.5	60.5	78.5	82.4
Dissolved Oxygen	**mg/L**	6.8	6.7	5.6	7.2	7.1
Conductivity	**μS/cm**	440	685	508	810	636
Salinity	**ppt**	0.17	0.29	0.2	0.36	0.28
pH		7.37	7.69	7.29	8.56	7.33
Temperature	**˚C**	15.74	18.03	19.07	19.4	22.2
Turbidity	**NTU**	52.5	44.1	246		
Redox		149	137	151	134	95
Laboratory determined						
Calcium (Ca)	**mg/L**	32.9	63.9	44.6	75.6	65.2
Potassium (K)	**mg/L**	2.2	2.2	3.3	2	2.3
Magnesium (Mg)	**mg/L**	5.6	6.4	5.4	6.2	6
Sodium (Na)	**mg/L**	51.8	69.1	54.1	85.9	67.7
Conductivity	**mS/m**	48.4	72.8	56.8	86.5	70.1
Nitrate/nitrite (N_NO3)	**mg/L**	0.07	0.03	0.12	0.99	0.05
Total reactive phosphorus	**mg/L**	<0.01	<0.01	0.01	<0.01	<0.01
Sulphate (SO4_S)	**mg/L**	10.3	10.6	6.4	18.2	16.1

3.1.4 Aquatic Fauna

Species richness recorded from root mat samples taken in November 2006 ranged from zero in Orpheus Cave to eight in Carpark Cave (Table 7). Abundance of each species was very low, generally consisting of one specimen of each of the forms listed in Table 7. The specimens collected comprised, three widespread marine and freshwater interstitial species, one species sourced from Loch McNess, one insect species with terrestrial adult and aquatic larval stages and six unclassified species (Table 7).

The fauna of Cabaret Cave was dominated by Oribatida (mites) and Nematoda (round worms). The presence of these acarines as the most abundant element of fauna may be indicative of deteriorating conditions.

Carpark Cave yielded eight taxa; turbellarians (flat worms), nematodes, ostracods (seed shrimps), acarines, oligochaetes (aquatic worms) and empidids (dance fly larvae). The acarines were identified as Oribatida and a specimen of the suborder Mesostigmata (Dr. M. Harvey, pers. comm., 2007). Of the oligochaetes collected, one species of *Aelosoma* was recorded from the cave. These particular specimens were identified as being similar to specimens collected from the Pilbara (A. Pinder, pers. comm., 2006). The other oligochaetes were identified as enchytraeids, which will be sent to Dr. Emilia Rota (University of Siena, Italy) for further taxonomic work. In general terms enchytraeids are not of specific biogeographic significance.

Water Cave yielded three taxa; nematodes, oligochaetes, and acarines (the latter are being identified as Oribatida by Dr. Mark Harvey). The oligochaetes were identified as enchytraeids.

YN555 on Lot 51, outside Yanchep National Park yielded three taxa; nematodes, copepods, and ostracods. The isopods and gastropods recorded in previous years were not recorded or observed.

No live specimens were recovered from Orpheus Cave. Empty ostracod valves and long dead snail shells were noted from the sample. The amphipods observed, and taken in low numbers in previous years were not observed during sampling, although an individual was observed several weeks prior (Lex Bastian, pers comm.).

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 Crustacea specimens from the caves is currently being undertaken by Dr. Danny Tang (UWA), and results will be produced in a separate report, and paper. The species so far identified are listed in Table 8, along with the site and dates collected. Future reports will include the updated species list. Of interest were a new species (*Australoeucyclops* sp. nov.) currently being described by Dr. T Karanovic (WAM) and specimens of *Mixocylops crozetenis* a freshwater species previously only found on Crozet Island (however the Yanchep caves specimens exhibit some morphological differences which at this stage have been attributed to damage of the specimen, rather than species differentiation).

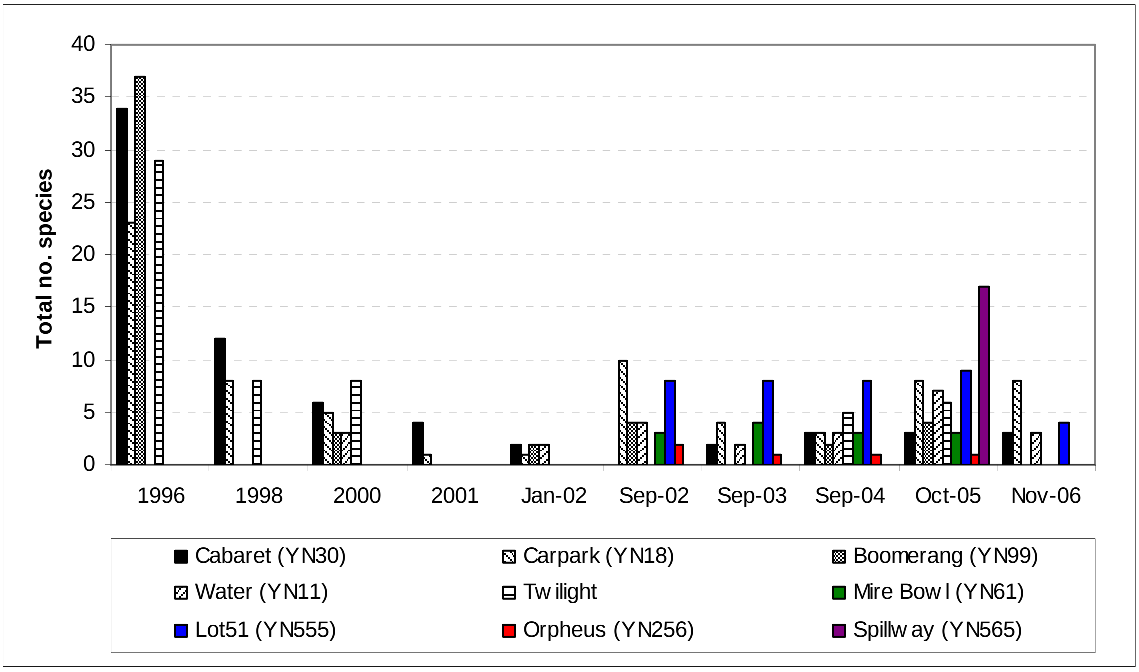


Figure 7. Total number of taxa over the entire sampling period.

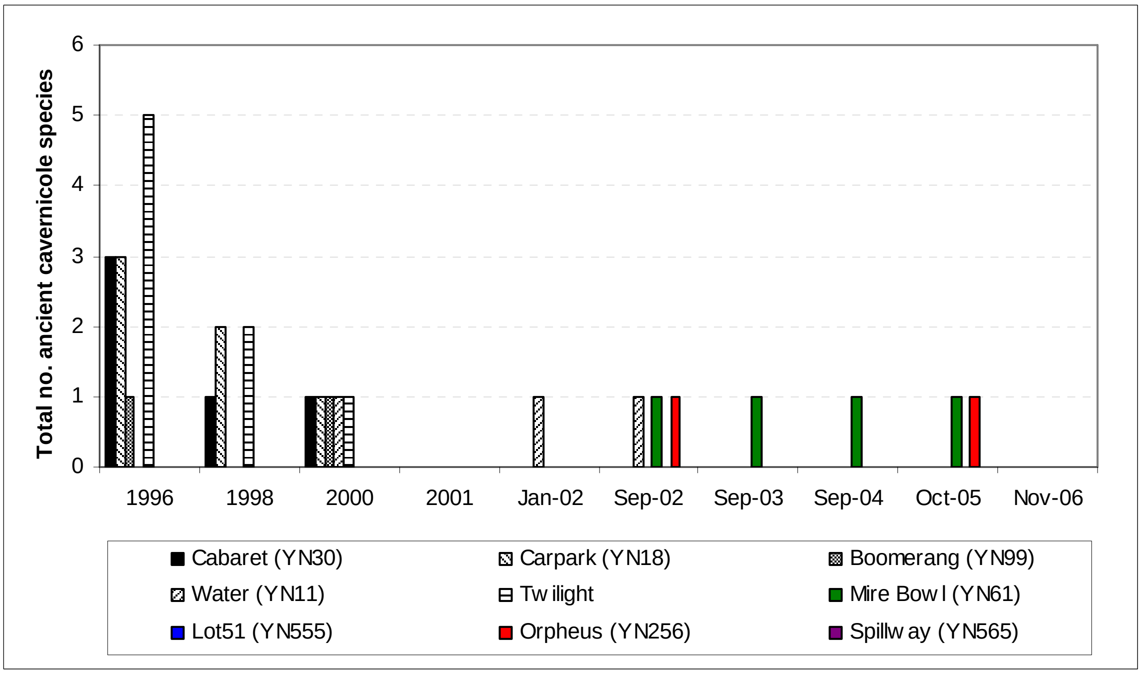


Figure 8. Total number of ancient cavernicole (stygofauna) taxa over the entire sampling period.

Table 7. Systematic list of aquatic invertebrates recorded from Yanchep Caves in November 2006. The source of each taxa, 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. Taxa present are highlighted.

			TAXON	Source of fauna	Cabaret (YN30)	Carpark (YN18)	Water (YN11)	Lot51 (YN555)	Orpheus (YN256)
PLATYHELMINTHES									
	TURBELLARIA		Turbellaria spp.	I	0	1	0	0	0
NEMATODA			Nematoda spp.	U	1	1	1	1	0
ANNELIDA									
	APHANONEURA	**Aeolosomatidae**	*Aeolosoma* sp.	I	0	1	0	0	0
	OLIGOCHAETA	**Enchytraeidae**	Enchytraeidae UWA1	I	0	1	1	0	0
CRUSTACEA									
	COPEPODA								
	Cyclopoida		Cyclopoida copepodite	U	0	0	0	1	0
	OSTRACODA	**Darwinulidae**	*Gomphodella* sp.	U	0	0	0	1	0
			Candona sp.	U	0	1	0	1	0
ARACHNIDA									
	ACARINA								
	Acariformes								
	Oribatida		Oribatida spp.	U	1	1	1	0	0
	Parasitiformes								
	Mesostigmata		Mesostigmata spp.	U	0	1	0	0	0
INSECTA									
	COLEOPTERA	**Curculionidae**	Curculionidae spp. (L)	S	1	0	0	0	0
	DIPTERA	**Empididae**	Empididae spp.	T	0	1	0	0	0
			Total number of taxa recorded		**3**	**8**	**3**	**4**	**0**
			No. taxa in each group recorded						
			Ancient cavernicoles (stygofauna)	A	0	0	0	0	0
			Widespread marine & freshwater interstitial fauna	I	0	3	1	0	0
			Surface waters of Loch McNess	S	1	0	0	0	0
			Insects with terrestrial adult and aquatic larval stages	T	0	1	0	0	0
			Unclassified[3]	U	2	4	2	4	0

[3] Unclassified refers to taxa which could not be assigned to any of the above categories through lack of taxonomic discrimination and/or life history information

Table 8. 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)			Mire Bowl (YN61)		Lot51 (YN555)			Orpheus (YN256)	Twilight			Spillway (YN565)	Gilgie Cave (YN27)		Fridge Grotto (YN81)
TAXON	**Source of fauna**	1/06/1990	19/06/1990	27/01/1991	5/02/1992	29/07/1993	?	?	17/07/1992	28/08/1994	14/11/1996	17/07/1992	2005	2004	2005	2006	17/07/1992	2/06/1996	27/11/1996	2005	2005	17/03/1993	28/08/1994	17/07/1992
Cyclopoida copepodites	U	1								3	2				1	1				1				
Cyclopidae: Eucyclopinae																								
Macrocyclops albidus	S																				24			
Paracyclops chiltoni	S	1	3								1								5		2			
Australoeucyclops sp.nov.	S[4]	15		16	10	15	15	4				2	4	5			1	1	4		2	8	11	3
Cyclopidae: Cyclopinae																								
Mesocyclops brooksi	S													4							1			
Mixocyclops crozetensis	S[4]								3													1		

[4] 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

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 and B25 are presented in Figure 9. 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 directly to flow from the springs.

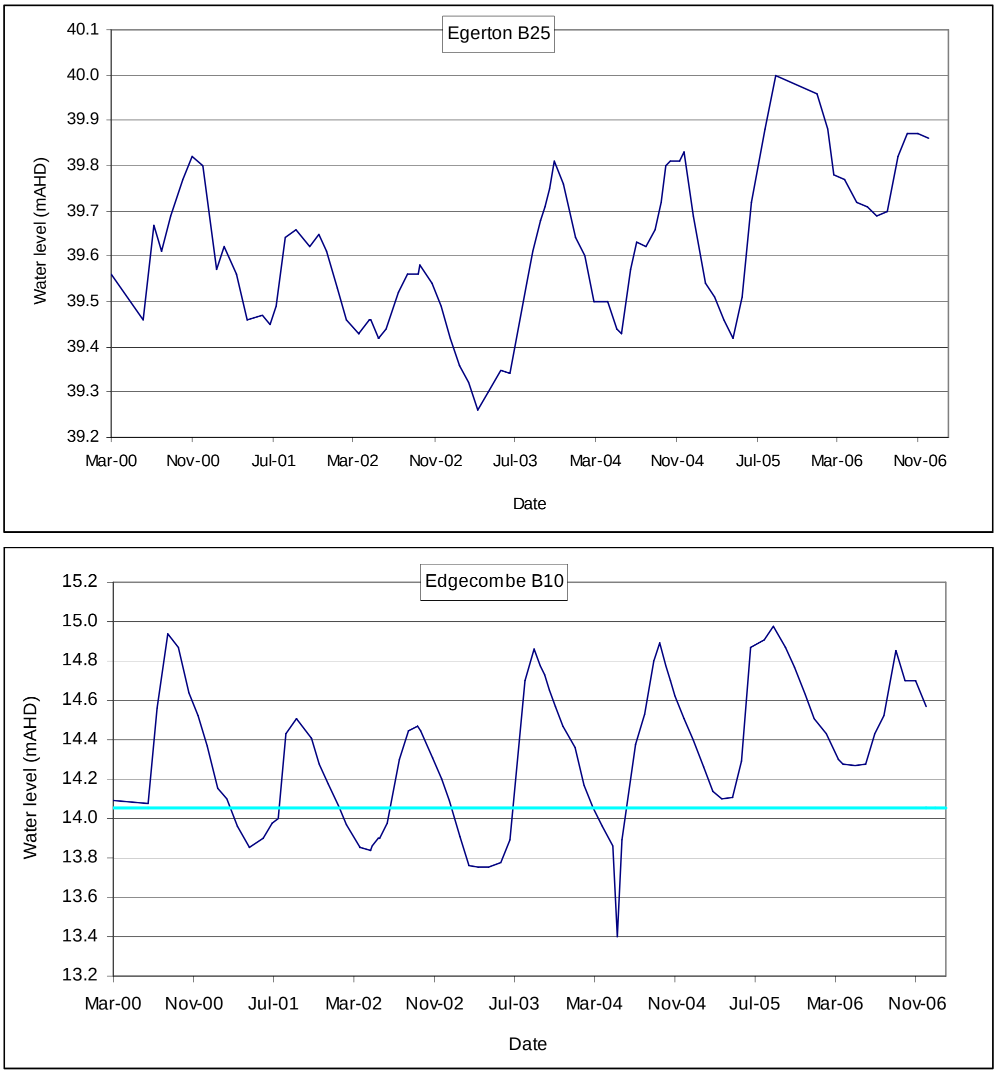


Figure 9. Temporal changes in water levels in Bores B10 and B25. Estimated bed level (m AHD) of Edgecombe Spring is illustrated, based on drying in spring/summer 1999.

3.2.2 Water Quality

Water levels were very low at Edgecombe Spring, but water levels in Egerton Spring appeared to have been maintained, however the water in the runnels did not appear to be flowing as strongly as last year, and there was more water near the base of the mound (pers obs. B. Knott, UWA).

As in previous reports (Horwitz & Knott 2002, 2004; Cook & Janicke 2005; Knott *et al.* 2006) *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[5] while pH ranged from mildly acidic (pH 5.72) at Edgecombe to more strongly acidic (5.07) at Egerton Spring. Data collated over the past three sampling periods shows an upward trend in salinity at Edgecombe Spring (Figure 10) and a downward trend in pH at Egerton Spring (Figure 11).

Concentrations of other water quality parameters were relatively consistent over time (Table 8, 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 8). In contrast Ca was sub-dominant in waters at Edgecombe Spring (Table 8). Levels of nitrogen (as nitrate + nitrite, NO_X) exceeded ANZECC/ARMCANZ guidelines (Table 5, Figure 12) at both springs; however levels were lower than those recorded during the last sampling period (Knott *et al.* 2006). Levels of sulphate at both springs appear to be increasing over time (Figure 13).

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

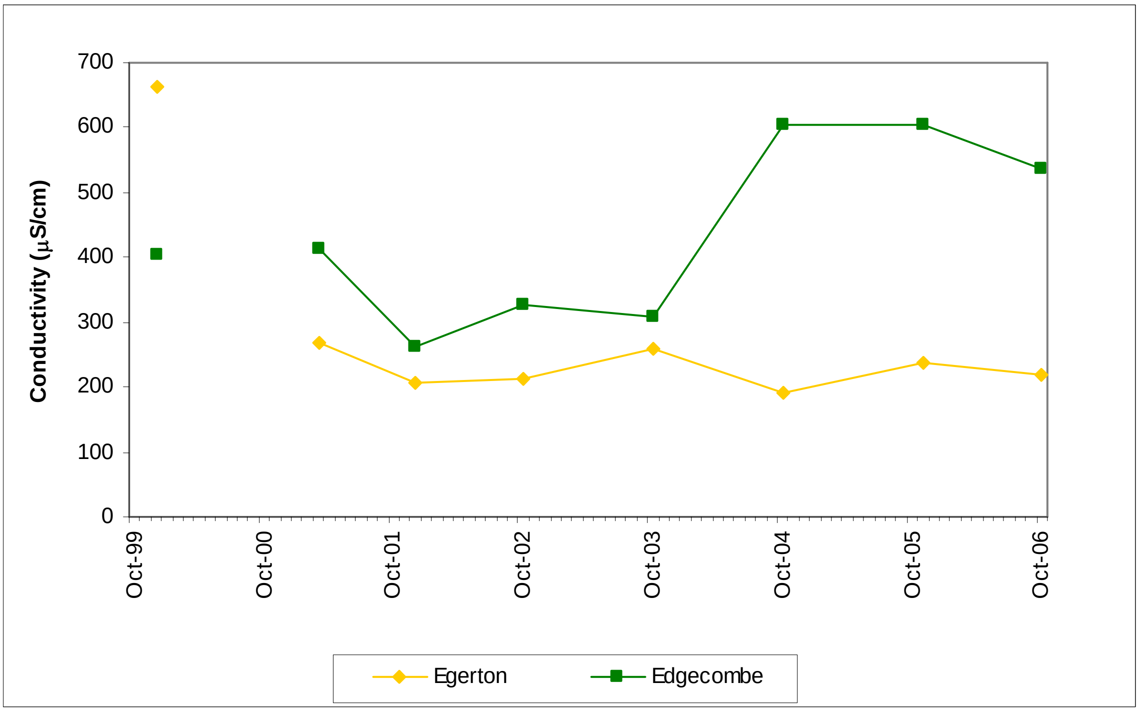


Figure 10. Salinity (ppt) over time for Egerton and Edgecombe Springs.

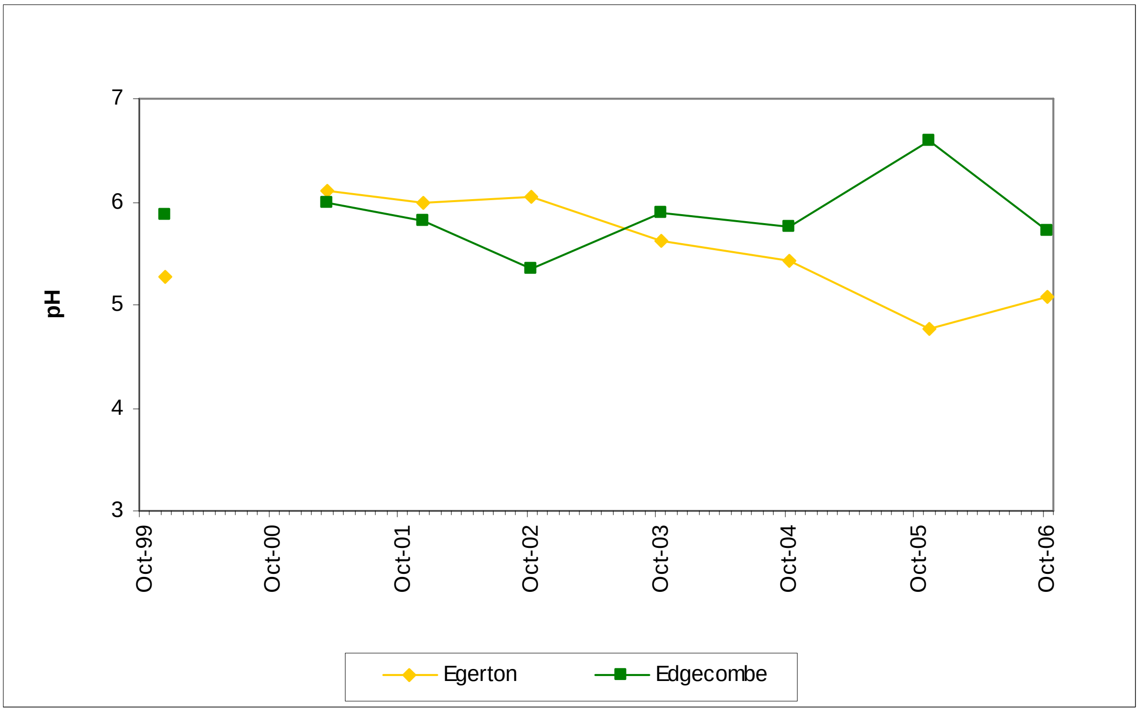


Figure 11. pH over time for Egerton and Edgecombe Springs.

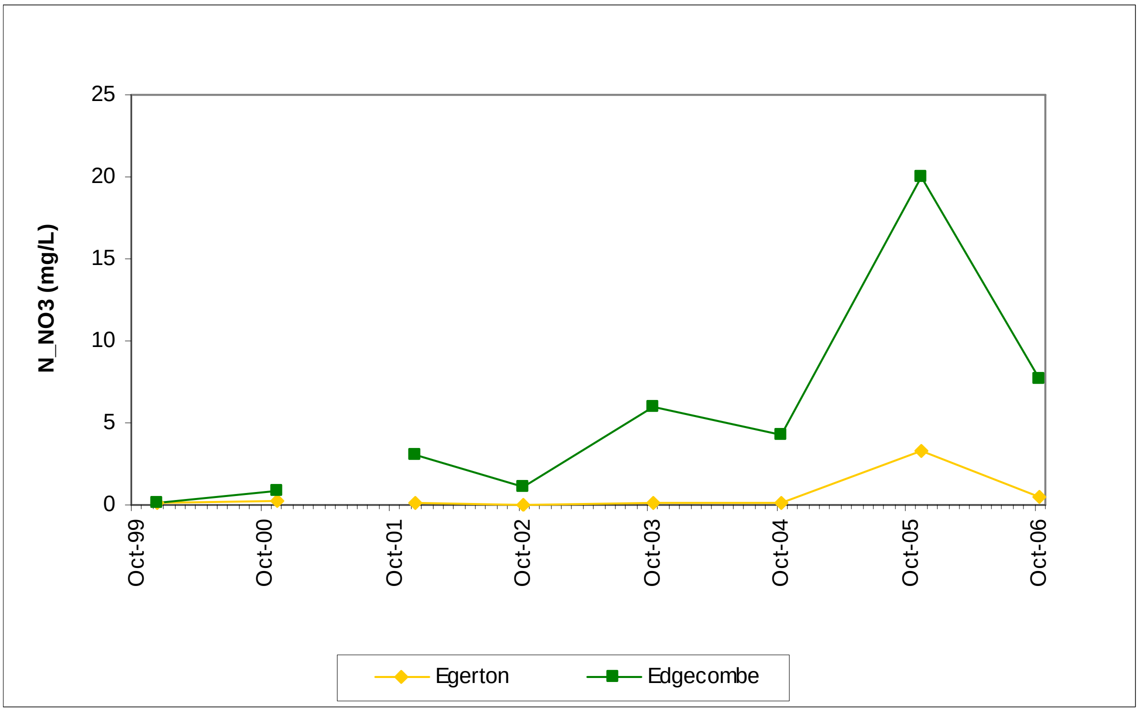


Figure 12. Nitrate and nitrite levels (mg/L) over time for Egerton and Edgecombe Springs.

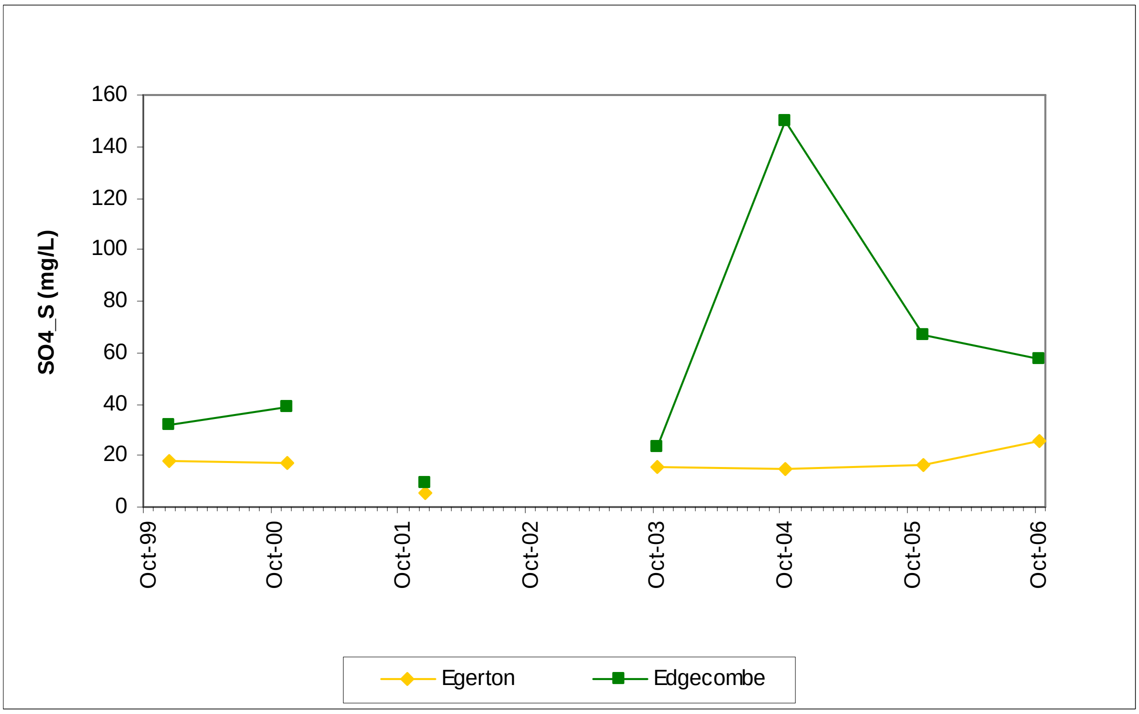


Figure 13. Sulphate (SO4_S mg/L) over time for Egerton and Edgecombe Springs.

Table 9. *In-situ* and analytically-determined water quality parameters measured in 2006. Levels of concern are indicated by shading.

		Egerton Spring	Edgecombe Spring
In-situ			
Dissolved Oxygen	%	89.5	92
Dissolved Oxygen	mg/L	8.85	8.5
Conductivity	µS/cm	220	537
TDS	mg/L	113	277
pH		5.07	19.6
Temperature	˚C	15.1	5.72
Turbidity	NTU	ns	ns
Redox		ns	ns
Laboratory determined			
Calcium (Ca)	mg/L	2.8	33.8
Potassium (K)	mg/L	4	10.5
Magnesium (Mg)	mg/L	5.6	7.5
Sodium (Na)	mg/L	34.7	43.7
Chloride (Cl)	mg/L	45	81
Conductivity	mS/m	25.6	53.8
Total iron6	mg/L	4.7	6.4
Nitrate/Nitrite (N_N03)	mg/L	0.43	7.7
Sulphate (SO4_S)	mg/L	25.4	57.5

3.2.3 Aquatic Fauna

Species richness at Egerton Spring was again high (Table 9), with all crustacean groups (Amphipoda, Cladocera, Copepoda, Ostracoda) represented and most in relatively high abundance. Fauna of note included a purple mite that is considered to be a new species of the subfamily Anisitsiellinae (Limnesiidae) (M. Harvey, pers. comm., 2007). The specimens had no visible eyes or eyespots and are therefore considered to be a stygal species (M. Harvey pers. comm., 2007).

The fauna sampled from Edgecombe Spring was characterised by the juvenile stages of insects with highly mobile adult phases (e.g. ceratopogonids, anisopterans): and immature crustaceans (Copepods and Ostracods).

[6] Includes the deposit and in solution iron.

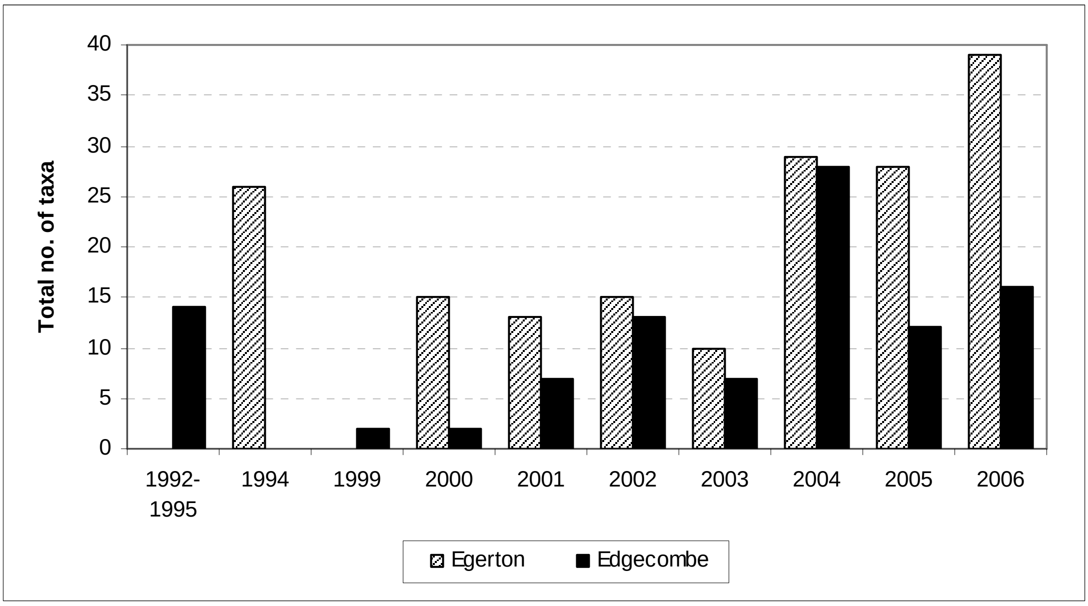


Figure 14. Total number of taxa recorded at the springs over the entire sampling period.

Table 10. Systematic list of aquatic invertebrates recorded from sites at Egerton and Edgecombe Springs in October 2006.

			TAXON	Egerton	Edgecombe
TURBELLARIA			Turbellaria spp.	1	1
NEMATODA			Nematoda spp.	1	1
ANNELIDA					
OLIGOCHAETA	**Tubificidae**				
		Naidinae	*Pristina aequiseta*	1	1
			Pristina leidyi	1	0
			Pristina cf osborni	1	0
	Phreodrilidae		*Insulodrilus bifidus*	0	1
			Insulodrilus lacustris s.l (form WA28)	1	0
			immature Phreodrillidae with similar ventral chaetae	0	1
ARTHROPODA					
CRUSTACEA					
Cladocera	**Ilyocryptidae**		*Ilyocryptus* sp.	1	0
COPEPODA					
Calanoida					
Cyclopoida			Cyclopoida spp. (copepodites)	1	1
	Cyclopidae				
		Eucyclopinae	Eucyclopinae spp.		
			Eucyclops sp.	1	0
		Cyclopinae	Cyclopinae copepodite	1	0
			Diacyclops sp.	0	1
Harpacticoida			Harpacticoida spp.	1	1
Ostracoda					
	Darwinulidae		*Darwinula sp.*	1	0
	Candonidae		*?Candona* sp.	1	1
Amphipoda	**Paramelitidae**		Paramelitidae gen. nov.	1	0
CHELICERATA					
ACARINA					
Oribatida			Oribatida spp.	1	1
Prostigmata	**Hygrobatidae**		Hygrobatiidae spp.	1	0
	Limnesiidae		Anisitsiellinae *sp. nov.*	1	0
	Trombidioidea		Trombidioidea spp.	1	0
INSECTA					
ODONATA					
Zygoptera	**Megapodagrionidae**		*Archiargiolestes* sp.	1	0
Anisoptera	**Synthemistidae**		*Archaeosynthemis occidentalis*	1	1
HEMIPTERA	**Hebridae**		*Hebrus* sp.	1	0
COLEOPTERA	**Dytiscidae**		*Sternopriscus* sp. (L)	1	0
	Hydrophilidae		*Enochrus ?peregrinus*	1	0
			Enochrus sp. (L)	1	0
	Scirtidae		Scirtidae spp. (L)	1	1
DIPTERA	**Chironomidae**				
		Chironominae	*Polypdedilum ?oresitrophus*	1	0
			Riethia sp. (V4)	1	0
			Riethia sp. (V5)	1	0
			Stempellina ?australiensis	1	0

		Tanytarsus sp.	1	0
	Orthocladiinae	Orthocladiinae sp, V31	1	0
	Tanypodinae	*Apsectrotanypus ?maculosus*	1	0
		Paramerina levidensis	1	1
		Pentamura sp.	1	0
		Chironomidae spp. (P)	1	0
	Ceratopogonidae	Ceratopogoniinae spp.	1	1
	Empididae	Empididae spp.	1	0
	Tipulidae	Tipulidae spp.	1	1
TRICHOPTERA	**Hydroptilidae**	*Oxyethira* sp.	0	1
	Leptoceridae	*Notalina* sp.	1	0
		Total no. of species	**39**	**16**

4 DISCUSSION

4.1 Water Quality

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). 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 generally were above levels likely to pose a threat to fauna. Dissolved oxygen concentrations may be influenced by local factors such as the degree of mixing of the water, particularly with surface waters, the length of time the water has been underground and the levels of biological respiration. Because the water flows through the superficial aquifer and then across the floor of the caves, it is assumed that most aeration occurs via physical processes (i.e. turbulence and riffles), and biological activity (photosynthesis) is absent. The most critical area is the microhabitat occupied by the cave fauna at the interface between the roots and the water body. The absence of flowing water, combined with respiration by the microbial (bacterial/fungal) community coating the roots, upon which the cave fauna grazes, may well result in reduced DO levels in this critical habitat. Under normal conditions, the flowing water would replenish the oxygen at this interface (and potentially remove any waste products). The absence of flow could fundamentally alter this microhabitat and would likely be detrimental to the survival of the cave fauna. Measuring DO levels in this microhabitat is desirable, but would be technically difficult. As a way of counteracting this potential localised oxygen depletion, reticulation lines, sprays and drips have been installed above the root mats to deliver water across the root mats and hopefully generate localised water movement that will minimise any potential depletion at the root surface. The fresh growth of root material following installation of these drips is encouraging, and indicates better conditions for root mat growth, which may also enhance conditions for the fauna.

Cave YN555 on Lot 51 continued to exhibit elevated concentrations of nitrogen (nitrate + nitrite) and sulphate, however levels of sulphate were lower than 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 appears to indicate there is a relationship between elevated levels of sulphate and conductivity in YN555 (Figure 6).

Previous sampling has determined water quality parameters from the springs were generally indicative of good quality, fresh water and were relatively constant over time. In general terms the water had a low salinity, pH < 7.0, with medium to low dissolved oxygen levels, consistent with groundwater from the Gnangara Mound. A low pH was again recorded from Egerton spring, possibly reflecting the extensive cover of emergent aquatic vegetation and associated detritus, and groundwater conditions. However, such levels are exceptionally low to result from humic influences alone. The decreases in pH at Egerton are of concern, as low pH is detrimental to aquatic fauna. Egerton Spring appears to be in a zone of high risk (Figure 15) of acid sulphate soils (ASS) and potential acid sulphate soils (PASS), therefore the possibility of the influence of ASS on this site should be investigated.

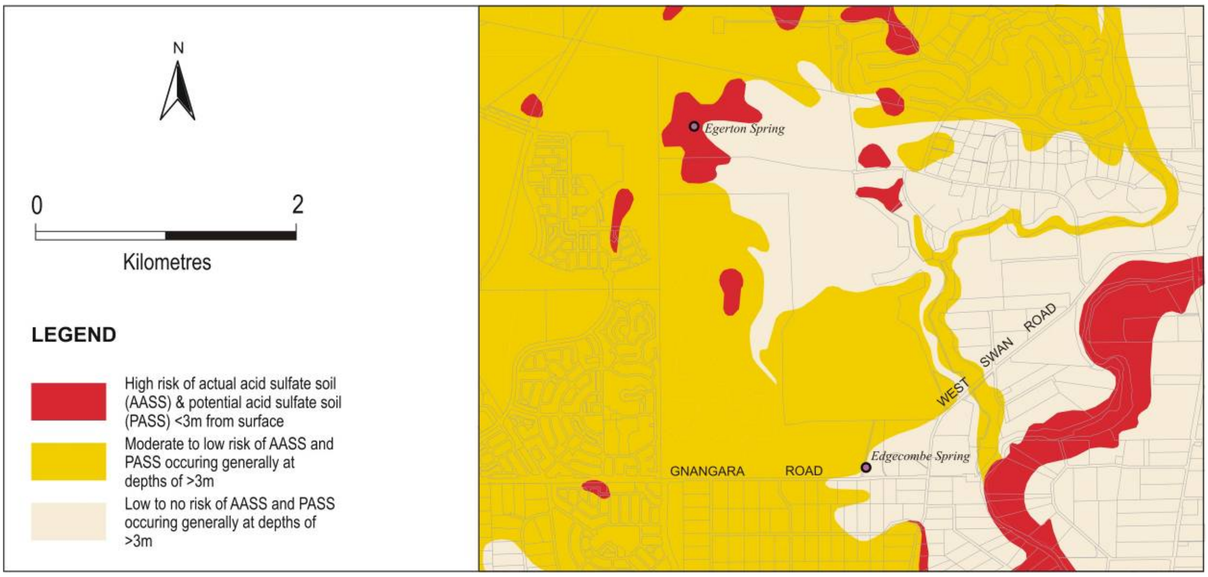


Figure 15. Study area, with areas of acid sulphate soil indicated. Taken from Figure 2, (**http://www.wapc.wa.gov.au/Publications/213.aspx**).

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 was 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), 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, in particular the amphipods from Orpheus Cave, and the isopods and hydrobiid snails from YN555, could be attributed to this decline in water levels. However a more immediate threat in YN555 would be the presence of a goldfish, 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.

In view of the continuing high faunal diversity and abundance, there is no evidence of degradation of the Egerton tumulus spring resulting from the clearing of vegetation to the west (the major recharge area), and particularly to the north, of the spring, observed in January, 1999. New clearing was observed this year just to the west and south of the spring and it is recommended that a visual reconnaissance of the area be undertaken in early 2007 to determine if this new development has any influence on the water levels of the spring. Edgecombe Spring however, continues to have low diversity and the main discharge channel no longer appears to be operating. For these reasons we again recommend that the status of the Edgecombe Spring Threatened Ecological Community (TEC) should be re-assessed.

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.

The higher diversity recorded from Egerton Spring this year (2006) may be considered a factor of the increased diversity of chironomid species recorded, and increased taxonomic resolution, when compared to previous years.

5 RECOMMENDATIONS

- The caves identified by Lex Bastion in his commissioned review of all known caves in the area, which formerly contained water but for which the current status is 'unknown', should be revisited as soon as possible to document their current hydrological regime.
- Encourage local speleologists to continue looking for additional caves with root mats/water.
- Permanent water flows must be restored to the cave streams, and maintained at a level whereby the majority of the root mats are submerged.
- 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 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.
- The risk to the TECs through mixing of populations and genetic 'dilution' of extant cave stream populations through the introduction of fauna in recharge waters should be assessed.
- Boomerang Cave, which dried in 2003 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 this site.
- A gauge for measuring flows should be established on Egerton 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 and monitoring should cease.
- Setting traps in the cave on Lot 51 (YN555) for the goldfish is of high priority.
- Continued monitoring YN555 to determine if the isopod and hydrobiid snail populations return.
- Resample Egerton early in 2007 to determine the extent of the influence recent development to the west and south of the spring has on the water levels.

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APPENDICES

Appendix 1: Water Quality 1998 – 2006

Table A1-1. Caves water quality for the total sampling period 2000 - 2006. 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 (°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	**Nov-06**	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
	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	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
	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	**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
Water	**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	**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
	Nov-06	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
	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
Mire Bowl	**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
	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**
Lot 51	**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
	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
Orpheus	**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
	Nov-06	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
	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
Twilight	**Sep-03**	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
	Sep-02	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
	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)	**Nov-06**	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
	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 – 2006. "-" indicates parameters not measured. Levels of concern are highlighted in bold.

		Egerton Spring									Edgecombe Spring								
Parameter	**units**	**Dec-99**	**Nov-00**	**Mar-01**	**Dec-01**	**Oct-02**	**Oct-03**	**Oct-04**	**Nov-05**	**Oct-06**	**Dec-99**	**Nov-00**	**Mar-01**	**Dec-01**	**Oct-02**	**Oct-03**	**Oct-04**	**Nov-05**	**Oct-06**
In situ parameters																			
Dissolved Oxygen	(mg/L)	-	-	-	7.41	8.3	8.5	9.55	3.9	8.85	-	-	-	5.48	8.4	9.4	6.4	4.3	8.5
Dissolved Oxygen	(% sat.)	-	-	-	77.4	82	84	98	38.3	89.5	-	-	-	61.8	82	94	68	45.2	92
Turbidity	(NTU)	-	-	-	-	-	-	-	185	-	-	-	-	-	-	-	-	0	-
Salinity	(ppt)	-	-	-	-	-	-	-	0.12	-	-	-	-	-	-	-	-	0.32	-
TDS	(mg/L)	350	-	134	-	126	131	140	120	113	194	-	212	-	192	156	360	320	277
Conductivity	(μs/cm)	662	-	269	206	214	258	192	236	220	405	-	413	261	327	307	604	604	537
pH		5.27	-	6.11	6	6.04	5.63	5.42	**4.76**	**5.07**	5.87	-	6	5.81	5.35	5.9	5.76	6.59	5.72
Redox	(mV)	-	-	-	87	121	-	-	60	-	-	-	-	171	123	-	-	269	-
Water Temperature	(^{o}C)	-	-	-	-	15.8	15	17.95	14.86	15.1	19.4	-	20.8	22	17.1	17.5	19.1	18.3	19.6
Laboratory determined parameters																			
Ca	mg/L	1	1	-	-	-	1.8	2	1.3	2.8	13	16	-	-	-	20.3	63.6	42.9	33.8
Cl	mg/L	93	46	-	-	-	54	52	51	45	28	31	-	-	-	43	65	78	81
Econd	mS/m	-	-	-	-	-	-	-	23.5	25.6	-	-	-	-	-	-	-	59.2	53.8
Fe	mg/L	-	-	-	-	-	-	-	0.33	-	-	-	-	-	-	-	-	0.026	-
Fe_total	mg/L	-	-	-	0.97	-	0.18	0.54	0.49	4.7	-	-	-	10	-	0.11	0.42	**200**	6.4
K	mg/L	1	<1	-	-	-	0.8	0.85	1	4	<1	<1	-	-	-	1.5	6.3	11.6	10.5
Mg	mg/L	5	5	-	-	5	5	5.45	4.7	5.6	5	5	-	-	-	6.3	15.4	8.3	7.5
Na	mg/L	32	32	-	-	-	30.5	32.65	33.1	34.7	21	20	-	-	-	17.7	37	44.3	43.7
N_NO3	mg/L	0.13	0.27	-	0.15	0.047	0.1	0.095	3.3	0.43	0.07	0.82	-	**3**	**1.1**	**6**	**4.3**	**20**	**7.7**
SO4_S	mg/L	18	17	-	5.5	-	15.2	15.05	16.4	25.4	32	39	-	9.1	-	23.2	**150**	**66.9**	**57.5**
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	-	-	-	-
O_3	mg/L	3	3	-	-	-	-	-	-	-	18	3	-	-	-	-	-	-	-

Appendix 2: Aquatic Macroinvertebrates 1996-2006

Table A2-2. Egerton Spring macroinvertebrates 1994-2006. 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	2000	2001	2002	2003	2004	2005	2006
TURBELLARIA								
Turbellaria spp.	1	1	1	1	0	0	1	1
NEMATODA								
Nematoda spp.	1	1	1	1	1	0	1	1
ANNELIDA								
OLIGOCHAETA								
Oligochaeta spp.	1	1	1	1	1	1	0	0
immature with all bifid chaetae	0	0	0	0	0	0	1	0
Pristina aequiseta	0	0	0	0	0	0	0	1
Pristina leidyi	0	0	0	0	0	0	1	1
Pristina cf osborni	0	0	0	0	0	0	1	1
?Nais communis	0	0	0	0	0	0	1	0
Insulodrilus lacustris s.l (form WA28)	0	0	0	0	0	0	0	1
immature Phreodrillidae with similar ventral chaetae	0	0	0	0	0	0	1	0
CRUSTACEA								
Chydoridae: *?Alona* sp.	0	0	0	0	0	0	1	0
Ilyocryptidae: *Ilyocryptus* sp.	1	1	1	1	1	0	0	1
COPEPODA								
Cyclopoida: Cyclopoida spp.	0	0	0	0	0	1	0	1
Cyclopidae: Eucyclopinae spp.	0	0	0	0	0	0	1	0
Eucyclops sp.	0	0	0	0	0	0	0	2
Microcyclops sp 5	1	1	1	1	1	0	0	0
Microcyclops sp 6	1	0	0	0	0	0	0	0
Mixocyclops sp 4	1	0	0	0	0	0	0	0
Paracyclops sp 5	1	1	1	1	1	0	0	0
Paracyclops sp 6	1	0	0	0	0	0	0	0
Paracyclops sp 7	1	0	0	0	0	0	0	0
Paracyclops sp 8	1	0	0	0	0	0	0	0
Cyclopinae copepodite	0	0	0	0	0	0	0	1
Harpacticoida								
Harpacticoida spp.	1	1	1	1	1	1	1	1
OSTRACODA								
Ostracod spp	0	0	0	0	0	1	0	0
Darwinulidae: *Darwinula* sp.	1	1	0	1	1	0	1	1
n.sp	0	0	0	0	0	0	1	0
Candonidae: *?Candona* sp.	0	0	0	0	0	0	0	1
Paramelitidae: Paramelitidae gen. nov.	1	1	1	1	1	0	1	1
Perthiidae: *Perthia branchialis*	0	0	0	0	0	1	0	0
DECAPODA								
Parastacidae: *Cherax quinquecarinatus*	1	1	0	0	0	1	0	0
CHELICERATA								
ACARINA								
Oribatida: Oribatida spp.	1	1	1	1	0	0	4	1
Hygrobatidae: Hygrobatiidae spp.	0	0	0	0	0	0	0	1
Limnesiidae: *Anisitsiellinae sp. nov.*	0	0	0	0	0	0	0	1
Limnesia sp nov	1	0	0	0	0	0	0	0
Trombidioidea: Trombidioidea spp.	0	0	0	0	0	0	0	1
Acarina sp. 3	0	0	0	0	0	1	0	0
Acarina sp. 4	0	0	0	0	0	1	0	0
Acarina sp. 5	0	0	0	0	0	1	0	0

COLLEMBOLLA								
Sminthuridae: Sminthuridae spp.	0	0	0	0	0	1	0	0
INSECTA								
ODONATA								
Megapodagrionidae: *Archiargiolestes* sp.	0	0	0	0	0	0	0	2
Anisoptera spp.	1	1	1	1	0	0	0	0
Gomphidae: *Austrogomphus lateralis*	0	0	0	0	0	1	0	0
Austrocorduliidae: *Lathrocordula metallica*	0	0	0	0	0	1	0	0
Synthemistidae: Synthemistidae spp. (imm.)	0	0	0	0	0	0	1	0
Archaeosynthemis occidentalis	0	0	0	0	0	0	0	1
Archeosynthemis ?leachii	0	0	0	0	0	1	0	0
HEMIPTERA								
Hemipteran sp.	0	0	0	0	0	1	0	0
Hebridae: *Hebrus* sp.	0	0	0	0	0	0	0	1
Veliidae: Veliidae spp.	1	0	0	1	0	0	0	0
COLEOPTERA								
Dytiscidae: Dytiscidae spp. (L)	1	1	1	1	1	0	0	0
Necterosoma sp.	0	0	0	0	0	1	0	0
Sternopriscus brownii	0	0	0	0	0	1	0	0
Sternopriscus marginatus (A)	0	0	0	0	0	0	1	0
Sternopriscus sp. (L)	0	0	0	0	0	0	1	1
Hydrophilidae: *Enochrus ?peregrinus*	0	0	0	0	0	0	0	1
Enochrus sp. (L)	0	0	0	0	0	0	0	1
Scirtidae: Scirtidae spp. (L)	0	0	0	0	0	1	1	1
DIPTERA								
Culicidae: *Anopheles* sp.	0	0	0	0	0	0	1	0
Chironomidae: Chironomidae spp.	1	1	1	1	1	0	0	1
Polypedilum sp.	0	0	0	0	0	0	1	0
Polypdedilum ?oresitrophus	0	0	0	0	0	0	0	1
Riethia sp. (V4)	0	0	0	0	0	0	0	1
Riethia sp. (V5)	0	0	0	0	0	0	1	1
Stempellina ?australiensis	0	0	0	0	0	0	1	1
Tanytarsus sp.	0	0	0	0	0	0	1	1
Chironominae spp.	0	0	0	0	0	1	0	0
Limnophyes pullulus	0	0	0	0	0	0	1	0
Orthocladiinae sp, V31	0	0	0	0	0	0	0	1
Apsectrotanypus ?maculosus	0	0	0	0	0	0	0	1
Paramerina levidensis	0	0	0	0	0	0	1	1
Pentamura sp.	0	0	0	0	0	0	0	1
Tanypodinae spp.	0	0	0	0	0	1	0	0
Ceratopogonidae: Ceratopogoniinae spp.	0	0	0	0	0	0	1	1
Ceratopogonidae spp.	0	0	0	0	0	1	0	0
Empididae: Empididae spp.	0	0	0	0	0	1	0	1
Simulidae: Simuliidae spp.	0	0	0	0	0	1	0	0
Tipulidae: Tipulidae spp.	0	0	0	0	0	1	0	1
TRICHOPTERA								
Ecnomidae: *Ecnomina D group* sp.	0	0	0	0	0	1	0	0
Hydroptilidae: *Oxyethira* sp.	0	0	0	0	0	1	1	0
Leptoceridae: Leptoceridae spp.	1	1	1	1	0	0	0	0
Notalina sp.	0	0	0	0	0	1	1	1
LEPIDOPTERA								
Unidentified lepidopteran	0	0	0	0	0	1	0	0
Total no. of species	**22**	**15**	**13**	**15**	**10**	**27**	**28**	**39**

Table A2-3. Edgecombe Spring macroinvertebrates 1992-2006. 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
TURBELLARIA									
Turbellaria spp.	0	0	1	0	1	0	1	0	1
NEMATODA									
Nematoda spp.	1	1	1	0	0	0	1	1	1
ROTIFERA									
Rotifera spp.	1	0	0	0	0	0	0	0	0
ANNELIDA									
OLIGOCHAETA									
Oligochaete sp. 3	0	0	0	0	0	0	1	0	0
Oligochaete sp. 6	0	0	0	0	0	0	1	0	0
Oligochaete sp. 7	0	0	0	0	0	0	1	0	0
Tubificidae: *Pristina* sp.	1	0	0	0	0	0	0	0	0
Pristina aequiseta	0	0	0	0	0	0	0	0	1
Naidinae spp.	0	0	0	0	1	0	0	0	0
Phreodrilidae: *Insulodrilus bifidus*	0	0	0	0	0	0	0	1	1
Insulodrilus lacustris s.l (form WA28)	0	0	0	0	0	0	0	1	0
immature Phreodrillidae with similar ventral chaetae	0	0	0	0	0	0	0	1	1
CRUSTACEA									
COPEPODA									
Cyclopoida: Cyclopoida spp.	0	0	0	0	0	0	1	0	1
Cyclopidae: *Microcyclops* sp.1	1	0	0	1	1	1	0	0	0
Mixocyclops sp.1	1	0	0	0	0	0	0	0	0
Paracyclops sp.1	1	1	0	0	0	0	0	0	0
Diacyclops sp.	0	0	0	0	0	0	0	0	1
Harpacticoida									
Harpacticoida spp.	1	0	0	0	1	0	1	0	1
OSTRACODA									
Ostracoda spp.	0	0	0	0	0	0	1	0	0
Candona sp.	1	0	0	1	1	1	0	1	1
Cypridopsidae: *Darwinula* sp.	1	0	0	0	0	0	0	1	0
SYNCARIDA									
Bathynellacaea spp.	1	0	0	0	0	0	0	0	0
ISOPODA									
Paramphisopus ?palustris	0	0	0	0	0	0	1	0	0
Unidentified isopod	0	0	0	0	0	0	1	0	0
DECAPODA									
Parastacidae: *Cherax quinquecarinatus*	0	0	0	0	0	0	0	1	0
CHELICERATA									
ACARINA									
Acarina sp. 1	0	0	0	0	0	0	1	0	0
Acarina sp. 2	0	0	0	0	0	0	1	0	0
Acarina sp. 6	0	0	0	0	0	0	1	0	0
Acarina sp. 7	0	0	0	0	0	0	1	0	0
Hydracarina spp.	0	0	0	0	1	0	0	0	0
Limnohalacarida: *Lobohalacarus* sp.	1	0	0	0	0	0	0	0	0
Oribatida spp.	1	0	0	0	0	0	0	1	1
COLLEMBOLLA									
Hypogasturidae: Hypogastruridae spp.	0	0	0	0	0	0	1	0	0
INSECTA									

ODONATA									
Anisoptera: Anisoptera spp.	0	0	0	0	1	0	0	0	0
Synthemistidae: Synthemistidae spp. (imm.)	0	0	0	0	0	0	0	1	0
Archaeosynthemis occidentalis	0	0	0	0	0	0	0	0	1
Archeosynthemis ?leachii	0	0	0	0	0	0	1	0	0
HEMIPTERA									
Hemipteran sp.	0	0	0	0	0	0	1	0	0
Veliidae: Veliidae spp.	0	0	0	0	1	0	0	0	0
COLEOPTERA									
Dytiscidae: *Liodessus ornatus*	0	0	0	0	0	0	1	0	0
Rhantus suturalis	0	0	0	0	0	0	1	0	0
Georissidae: *Georissus* sp.	0	0	0	0	0	0	1	0	0
Scirtidae: Scirtidae spp. (L)	0	0	0	0	0	1	1	1	1
DIPTERA									
Culicidae: *Anopheles* sp.	0	0	0	1	1	1	0	0	0
Chironomidae: Chironominae spp.	0	0	0	0	0	0	2	0	0
Paramerina levidensis	0	0	0	0	0	0	0	0	1
Chironomus sp.2	1	0	0	1	1	1	0	0	0
Tanypodinae spp.	0	0	0	1	1	0	2	0	0
Ceratopogonidae: Ceratopogoniinae spp.	0	0	0	1	1	1	2	1	1
Tipulidae: Tipulidae spp.	1	0	0	1	1	1	1	1	1
Psychodidae: Psychodidae spp.	0	0	0	0	0	0	1	0	0
Tabanidae: Tabanidae spp.	0	0	0	0	0	0	2	0	0
Stratiomyidae: Stratiomyidae spp.	0	0	0	0	0	0	1	0	0
TRICHOPTERA									
Hydroptilidae: *Oxyethira* sp.	0	0	0	0	0	0	0	0	1
Total no. of species	**14**	**2**	**2**	**7**	**13**	**7**	**28**	**12**	**16**

Appendix 3: Photographic Voucher