Independent Desktop Review of the Bowdens Silver Pty Limited for the proposed Bowdens Silver Mine: EIS Review Updated February 2023 for the Lue Actions Group

by

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Documents Reviewed

This review was conducted for the Lue Action Group. The documents reviewed were:

1) Part 5 – Groundwater Assessment. State Significant Development No. 5765.

2) Part 10 – Aquatic Ecology Assessment. . State Significant Development No. 5765.

3) FDP, (2022). Review of Bowden's Response to Groundwater Questions: Bowdens' March 2022. Amendment Report Version: 4.0, 04 July 2022.

4) Baguley, S. (2022). Independent Review of the Bowdens Silver Pty Limited Surface Water Assessment – Updated May 2022.

Summary of Significant Points of Concern from Additional Documentation

1. Potential groundwater and surface water contamination from waste rock emplacement (WRE) designed to flow to a leachate dam located north of Lue. (FDP, 2022). There is potential for leakage into groundwater and spillage into the downstream waterways such as Lawsons Creek that flow through the townships of Lue and Mudgee. (FDP, 2022).

2. Potential groundwater and surface water contamination from acid leachate from the tailings storage facility (TSF) located to the west above a Lawsons Creek tributary that will flow into Lawsons Creek and through the townships of Lue and Mudgee. (FDP, 2022). Contamination of groundwater and surface waters would result in the subsequent and permanent reduction of catchment biodiversity and availability of water for community stock and domestic usage.

3. The underlying aquifer is unconfined with highly heterogenous; fractured rock and the proposed tailings storage facility (TSF) lies on mapped faults with one fault trending southeast through Lawsons Creek. (FDP, 2022). Therefore, there is a high probability of connectivity between the groundwater and surface water resulting in a high probability of impact exchange both between the water sources but also a considerable distance downstream of the proposed facility. This has serious, long-term implications for human and ecosystem health.

4. No predevelopment groundwater monitory of groundwater levels or water chemistry has been conducted between the edge of the proposed site and Lue village bores, therefore there is no understanding of natural groundwater level and water chemistry fluctuations to determine future changes in these parameters as result of the proposed mine and contaminated water storage facilities.

5. Proposed increase in reliance on local surface and groundwater supplies to meet all project demands thus increasing the potential drawdown of groundwater and a reduction in streamflow downstream that would reduce or eliminate permanent, relictual aquatic habitats with a subsequent

reduction of catchment biodiversity and availability of water for community stock and domestic usage.

6. Mine weather data (rainfall) significantly and incorrectly demonstrates higher rainfall predictions than the BOM and local authorities suggesting surface water and groundwater levels will be higher than in reality. The environmental implications of this is that with increased usage of local water sources by the mine will increase the depth and longevity of drawdowns on groundwater and reductions in flow and permanence of surface waterways with reduced availability to the community and environment. (Baguley, 2022).

7. Baguley, (2022) reports that there is a high number of springs, peatlands, bogs, and montane mires adjacent and within and adjacent the Bowdens site as well as throughout the Upper Cudgegong and Upper Lawson Creek catchments. These are likely to listed under protected Montane Peatlands and Swamps Endangered Ecological Community (EEC) listing under the NSW Biodiversity Conservation Act 2016 and the Temperate Highland Peat Swamps on Sandstone EEC Commonwealth Environment Protection and Biodiversity Conservation Act 1999 listing. Under the current mine proposal, these EECs, and potentially other associated listed species such as habitat for the Listed Threatened Species *Petalura gigantea* or Southern Petaltail or Giant Dragonfly as well as the many short-range emndemic species that are associated with this wetalnds and subterranean environments have not been considered and are at high, potential risk of impact from the drawdown of groundwater and reduction in surface water from the proposed mine. It needs to be stated that although NSW government has legislation in place to supposedly protect all GDE's, including wetlands and subterranean ecosystems as well as aquatic ecosystems including invertebrates this has seldom if ever been actually done. I have worked on many EIS's for a range of government departments, develpment companies and Conservation action groups developments and in all cases where data identified rare, unique and endangered ecosystems and species, the decision was always in favour of the developer and no legislation was enacted to protect the surface and groundwater environments. This has to change.

Although these threatened communities have not been considered and the EIS states there are no listed High Priority GDE's in the area, the NSW Risk Assessment Guidelines (Serov et al 2012) states that if a GDE has not been listed and assessed as a formal High Priority by government but contains either previous conservation status such as being an obligate or entirely dependent ecosystem and/or species or occurs in a national reserve or has been recognised as a Listed threatened or endangered community, it qualifies as having High ecological Value (HEV) and therefore of High Conservation Value (HCV) and is open for consideration as a High Priority GDE. The Water sharing plans provide rules for the protection of GDE’s such as setback distances and no drawdown rules for water supply works from high priority GDEs, ie. those GDE’s of High Ecological Value (HEV) that have been selected by an interagency expert panel to be listed within water sharing plans. The provisions within Water sharing plans therefore protects both high ecological / conservation value GDEs from development and extraction as well as providing water for all (non-high value) GDEs in general (Serov et al, 2012). As the EIS does not recognise these ecosystems or species further identification of these EEC needs to be conducted as a matter of priority prior to any development of the mine proposal. The springs and other surface wetlands, stream fauna and subterranean ecosystem urgently needs to be resurveyed by an independently from the mine and by experts in the field who understand these environments and are able identify the fauna to species. Allowing mines to conduct these surveys themselves has, for many years, allowed for biased reporting by inexperienced companies and people. A new procedure needs to be urgently implemented to prevent this from occurring.

8. Inappropriate and outdated definition and understanding of groundwater and GDEs.

9. Misidentification of obligate GDE's, particularly among terrestrial vegetation species.

10. Incorrect conclusions on stygofauna significance and distributions based on poor identification and background knowledge.

11. Significant stygofauna diversity is recorded east in both streams (Hawkes and Lawsons Creeks) with the highest diversity recorded in Hawkes Ck;

12. There is little to no discussion of the ecosystem health significance of the fauna found which demonstrates the authors lack of knowledge on the subject:

13. There is no discussion on hydrological connectivity issue between the aquifers and surface water ecosystems;

14. There is no discussion of the significant stygofauna taxa recorded;

15. It is stated in Table 3.12 that stygofaunal are largely absent from the proposed open pit area even though Syncarida (significant stygofauna taxon) were recorded.

16. The listing and discussion of the potential threatened invertebrate species is inadequate as no taxa were identified to species.

Overview

<u>Groundwater</u>

- The section covering Groundwater Dependent Ecosystems (GDE's) has been relatively well considered and has covered the typical ecosystems that are considered as GDE's. The use of the reference "Dresel 2010" for defining the types of GDE's is outdated. Refer to Serov et al. 2012 and Serov and Kuginis 2017 instead. This has been done in the Aquatic Ecology section; therefore, the Groundwater section needs updating for consistency.

- One issue in this discussion is the lack of definition of what constitutes groundwater and therefore what is a GDE and what is not. In the section covering "Springs and Seeps" most of the springs and seeps are implied to not be groundwater dependent as the water chemistry analysis indicates that they are not using 'regional groundwater. They are instead inferred to be ephemeral as they use 'rainwater interflow' through the soils. The definition of groundwater as defined in Serov et al., 2012 and Serov and Kuginis 2017 is as follows: "Water occurring naturally below ground level, including the saturated zone and the unsaturated vadose zone". Therefore, the transient and shallow nature of the subsurface 'interflow' is immaterial. This subsurface flow that supports all of the springs and seeps is groundwater and these ecosystems need to be included as GDE's.

- In regard to comments on the terrestrial GDES an assertion is made that River Red Gums are not necessarily obligate phreatophytes as they "root below the watertable'. This assertion is incorrect as any vegetation that has its roots at or below the watertable are automatically considered as 'obligate'. There is also the assertion that if the floral species is not an obligate it is not a full GDE. This is completely wrong as the definition used in the EIS and within Serov et al. 2012 states that any species that utilises groundwater for any length of time i.e., continuously, or partially is still a GDE and removal of that water supply will impact on its survival. For a better understanding of terrestrial species and their groundwater needs refer to Kuginis. L, and Dabovic. J. (2016), Serov et al. (2012) and Stygoecologia (2013).

- The section on stygofauna is completely incorrect as it states that the stygofauna were not endemic to the area as they were typical of fauna found in alluvials. As there has been no stygofaunal officially described and officially named from this area it can be certain that they are new species and highly likely to be endemic as stygofauna species are typically short-range endemics entirely restricted to a hydrological unit. It is clear that Cardno do not have the expertise to identify or understand the significance of these species or they would not have dismissed this so quickly.

- The findings that stygofauna are present within and adjacent to the mine is very important and needs to be examined in far more detail as changes to the groundwater levels, quality and flow direction will potentially impact on local endemic communities and other communities downstream. In Australia, stygofauna are known from alluvial, limestone, fractured rock, and calcrete aquifers (Serov & Kuginis 2017; Hancock et al. 2005; Humphreys 2008). Many aquifers occur as confined aquifers and as such have very low dissolved oxygen, high salinity and have a general lack of connectivity with surface environments. Stygofauna require space to live, which is dependent on the porosity of the sediments, degree of fracturing, or extent of cavity development. These requirements must be sufficient to enable fauna to move through the substrate.

The most biodiverse subterranean ecosystems in Australia are recognised to occur within the alluvial aquifers. Alluvial aquifers are unconsolidated aquifers consisting of particles of gravel, sand, silt, or clay (Tomlinson & Boulton, 2008). Within alluvial aquifers, groundwater is stored in the pore spaces in the unconsolidated floodplain material. Shallow alluvial groundwater systems are associated with coastal rivers and the higher reaches of rivers west of the Great Dividing Range. These groundwater systems are often in direct connection with surface water bodies such as rivers and wetlands. Alluvial aquifers are generally shallower than sedimentary and fractured rock aquifers. Due to their shallow and unconfined nature, alluvial aquifers are highly susceptible to contamination/pollution and excessive drawdown of the watertable from pumping.

A literature review found that the most significant and potentially sensitive groundwater organisms are those in aquifers and cave GDEs (i.e., those that are totally dependent on groundwater). These invertebrate communities are intrinsically adapted to these very specialised environments.

These ecosystems and organisms have many values including the following:

- Most are rare or unique
- Retain phylogenetic and distributional relictual species and communities;
- And therefore, the ecosystems surviving in aquifers and caves are amongst the oldest surviving on earth.
- High proportion of short-range endemics.
- Develop or retain narrow range habitat requirements (i.e., narrow range endemic species). To survive, these species and communities continue to rely on the continuance of certain groundwater levels/pressure and water chemistry; and
- Develop specialised morphological and/or physiological adaptations to survive in groundwater environments.
- They have water quality functions, biodiversity value and add to the ecological diversity in a region.

The other important characteristic of alluvial aquifer communities is that their dispersal capabilities are entirely dependent on the subsurface hydrological connectivity of the aquifer with other aquifers and narrow physiological tolerance ranges in water chemistry. As this community is adapted with specialized morphological features, narrow environmental tolerances (Gibert, et al. 1994; Gibert & Deharveng, 2002; Marmonier et al. 1993; Rouch and Danielopol, 1997; Sket 1999b; Danielopol et al., 2000; Serov, 2002; Tomlinson & Boulton, 2008), and have no desiccation tolerant life stages (i.e., they cannot disperse via surface rivers and streams or via aerial dispersal of eggs). They are therefore, solely restricted to this environment. Tomlinson & Boulton (2008) outline the characteristics of subsurface aquifer communities. These communities can be isolated by a number of barriers including geological, hydrogeological, climatic and differences in water chemistry. As a result of these barriers to dispersal, subterranean communities in general have a high potential for speciation and very short-range endemism and are highly vulnerable to habitat change resulting in local or total extinction of species.

The shallow nature of the groundwater in all geological units suggests the potential of stygofauna to be present in all geologies if the fracturing is sufficient. Water quality and water levels in the alluvium and the fractured rock lithologies is generally within the limits of acceptance from a GDE species perspective and groundwater has been identified as a significant contributor to the streams, springs, and seeps as well as to the terrestrial vegetation communities.

- Although no high priority GDE's have been identified in the local area there are many unregistered GDE's identified that need to be considered. The term 'High Priority GDE' is quite a misnomer and does not mean high ecological value only. The term 'High Priority GDE' is a specific legislative management term used within The Water Management Act 2000 which has been developed and refined through the process of developing Water Sharing Plans. It was initially defined in the water sharing plan for the NSW Great Artesian Basin Groundwater Sources, 2008, Order Schedule 1, Dictionary as:

'Ecosystems which are considered high priority for management action.'.

This definition was further refined within the Greater Metropolitan Region Groundwater Source Water Sharing Plan (NOW, 2010d, p 31) by the addition of a number of provisions that were designed to protect environmental assets such as GDEs. These provisions include equating high priority with high conservation value (high ecological value) groundwater dependent ecosystems. Therefore, a High Priority GDE is one which has high ecological value (HEV). However, as mentioned earlier a HEV GDE is not considered a High Priority Ecosystem from the management perspective, until it has been assessed through an interagency expert panel which includes groundwater and ecology experts. Therefore, this simply means that the local GDE's have not been assessed yet and there may be GDE's present that could be assessed as being 'High Priority'. Therefore, in order to adequately represent the GDE's present each should be adequately assessed and ranked.

- **Drawdown levels**

The predicted drawdown levels of 1-2m at Hawkes Creek would have a significant impact on the baseflow streams and pools present along the watercourse and downstream convergent streams. It would also impact shallow rooted terrestrial vegetation within the riparian zones and surrounding hill slopes. The addition of extended droughts appears not to have been included in the calculations that could result in localised dieback within the sub-catchment. The predicted impact to terrestrial GDEs has not been sufficiently examined at all and assumes that the deficits in groundwater will be mitigated by rainfall and rainfall runoff. It also does not consider the species sensitivities to changing groundwater levels and flows. The statements in section 6.1.2 are entirely incorrect as they have misunderstood the definition of GDE and have made false assertions as indicated earlier. It is highly likely that the springs, seeps, wetlands, stream, and terrestrial vegetation GDE communities will all be impacted by the predicted conservative drawdown levels.

<u>Aquatic Ecology</u>

<u>Section 3.2.9 – Stygofauna</u>

This section describes the results of the stygofauna sampling in and around the proposed mining operation, including the catchments to the east encompassing the Hawkes Creek and Lawsons Creek, bores within the development area and springs to the west (downstream of the development). The results indicate the following:

- Significant stygofauna diversity is recorded east in both streams (Hawkes and Lawsons Creeks) with the highest diversity recorded in Hawkes Ck;

There is little to no discussion of the ecosystem health significance of the fauna found which demonstrates the authors lack of knowledge on the subject.

Australia is biogeographically distinct in its groundwater fauna (Humphreys, 2002) and the subterranean fauna of South East Australia is biogeographically distinct from other Australian 'hotspots' (Eberhard and Spate, 1995; Serov, 2002; Thurgate et al, 2001). In addition to the diversity aspect, our ecological perspective of groundwaters has broadened to consider the subsurface system as having a complex and interactive boundary with surface ecosystems at a range of scales. Groundwater fauna, especially stygofauna are extremely sensitive to the environmental characteristics of the water they inhabit and thus potentially are useful indicators of groundwater health (Tomlinson & Boulton, 2008, Serov et al, 2009).

The importance of aquifer ecosystems in terms of biodiversity is that groundwater environments within unconsolidated and fractured rock aquifers harbour a dynamic and diverse range of invertebrates. The community can be composed of many of the major invertebrate groups (i.e., Crustacea, Oligochaete, Mollusca, Insecta) found in the surface water habitats, however, it also contains many that are no longer occur in surface environments (Humphreys, 2002; Marmonier et al, 1993; Rouch and Danielopol, 1997; Sket 1999b; Danielopol et al., 2000). There is also a marked bias towards the crustacean and oligochaete groups (Marmonier e. al, 1993; Rouch and Danielopol, 1997; Sket 1999b; Danielopol et al., 2000 Tomlinson & Boulton, 2008). Most of these species are new to science.

Stygofauna are potentially threatened by activities that change the quality or quantity of groundwater, disrupt connectivity between the surface and aquifer, or remove subterranean living space. Aquifer contamination, drawdown and structural change resulting in connectivity changes are identified as the main risks to stygofauna associated with current and future developments. The potential impacts include changes to:

- ❑ water table levels;
- ❑ aquifer flow paths;
- ❑ aquifer discharge volume to off-site GDEs;
- ❑ the frequency/timing of water table level fluctuations;
- ❑ river base flow;
- ❑ spring water pressure;
- ❑ natural groundwater chemistry; and
- ❑ groundwater salinity levels.

The risks of the Bowden Mine proposal to the surface aquatic and terrestrial groundwater dependent ecosystems from the modelled changes in water levels and water chemistry are also regarded as high due to the predicted high risk of leakage from the tailings dam and waste rock storage facility into the alluvial aquifer and surface waters. The risk of impact from water quality changes is regarded as high to moderate as any change in water quality parameters outside of the natural range can adversely impact subterranean and surface aquatic communities in particular but can also impact other surface GDEs as well.

Syncarida

For example, the Syncarida, Psammaspididae has only been recorded twice in the Atlas of Living Australia in Wellington Caves to the North of Lue and Jenolan Caves and in each case, they are individual species that only occur in the boundaries of each cave. The current classification of the Syncarida is broken up into the minute, interstitial Bathynellacea, which have a world-wide distribution and are suggested to be the most primitive; the fossil Palaeocaridacea which were restricted to North

America and Europe during the Carboniferous to Permian (approximately 360-250mya) and the Anaspidacea. The Anaspidacea have a distinctly Gondwana distribution from NZ, Australia and South America and include the shrimp like *Anaspides* and *Allanaspides*, found only in Tasmania. The Psammaspididae, known currently from 10 undescribed species in caves in NSW (Eberhard and Spate, 1995) and one described hyporheic species *Psammaspides williamsi* Schminke 1974, near Manilla in northern NSW (Schminke, 1974) and one in Northern Tasmania. The Division Syncarida is one of the most common invertebrate groups found in Australian groundwaters. They are an ancient group that branched off from the main stream of the Eumalacostraca or higher Crustacea at a very early period perhaps as far back as the Late Devonian (about 400-380mya), with today's extant taxa still retaining a primitive body structure.

The syncarids have always been indicators of cool temperate permanently wet habitats as they have no stage in their life cycle that can tolerate desiccation. The syncarid fauna collected from the alluvial aquifer represent the main group of obligate groundwater fauna. All species collected will be undescribed as there have been no described species from this area.

The importance of the discoveries of this obligate groundwater fauna is that they represent relics of a bygone eras and give us a glimpse of another time before the browning of Australia, to a time when Australia was covered in lush, wet, rainforest with numerous waterways, alluviums, and deltas. The fact the groundwater habitats have served as refuges and centres of speciation in fluctuating environments of generally increasing and spreading aridity, particularly in the Pleistocene, provides tools for studying the past history of particular taxa. The syncarids, Isopoda and Amphipoda are some of these groups. They have a wide distribution at the family and generic level but appear to be highly restricted at the species level due to their inability to withstand any degree of desiccation in any stage of their life cycle and have narrow environmental requirements. In effect they represent biological time capsules and are very useful as bioindicators (Serov, 2002).

Oligochaeta

In Australasia, the Oligochaeta are represented in freshwaters by the families Haplotaxidae, Aeolosomatidae, Lumbriculidae, Phreodrilidae, Naididae, and Tubificidae (Brinkhurst 1971). Of these families, the Haplotaxidae has a Gondwana, South East Australia and New Zealand distribution but is poorly represented in Australia, (Pinder 2001) although increasingly prominent in groundwaters.

The obligate groundwater fauna is characterised by the two Oligochaete Families, the Enchytraeidae and Haplotaxidae. The Enchytraeidae are a small family of aquatic worms that are poorly known although they have been found in freshwater environments in Victoria, NSW and recently in groundwaters in Queensland. They are a poorly known group that requires further taxonomic work (Pinder & Brinkhurst, 1994. In terms of their use within current environmental sensitivity indices such as the SIGNAL Index ranking, they can only be assessed at the Order level of Oligochaeta which has a ranking of 2. This equates to a family which is quite tolerant of environmental disturbance. This, however, is misleading as the family is usually associated with high water quality environments.

In a review of the stygobitic oligochaete fauna of the world, Juget & Dumnicka (1986) noted 66 species in seven families (Aeolosomatidae, Potamodrilidae, Haplotaxidae, Lumbriculidae, Dorydrilidae, Tubificidae, and Enchytraeidae). More recently, Giani et al. (2001) reported 57 species that can be classified as stygobites in southern Europe alone, suggesting the global diversity far exceeds initial estimates (e.g., Juget & Dumnicka 1936). Indeed, Giani et al. (2001) estimated that, when records from other areas of the world (e.g., North America, Africa, Europe) are added, a total of 96 stygobitic freshwater oligochaetes are known in the world (they excluded Australasia from their estimate for some reason). It should be noted that it is often difficult to make a clear separation between stygobitic and stygophilic oligochaetes. For example, the features that distinguish stygobitic crustaceans from epigean forms, such as absence of eyes, lack of pigmentation, and elongation of body, do not distinguish between stygobitic and epigean oligochaetes. Giani et al. (2001) noted that very few species of Naididae are stygobites.

The presence of Oligochaete worms in bores indicates that the water quality is characterised by elevated organic carbon, and possibly high levels of dissolved iron. The presence of the Oligochaete (worm) species present indicates a moderate hydraulic connectivity within the river/aquifer environment. The shallow water table levels within the alluvial phreatic zone suggests a direct association/connectivity with a slow base flow river system with a shallow alluvial aquifer. There is very little known about the diversity and distribution of freshwater Oligochaeta, therefore the identification can only be given to the family level. Subterranean Oligochaetes are an increasingly important component of Australia's groundwater fauna that contain a large number of short-range endemic species with large faunas along the continental marginal areas, particular in the southwest and eastern seaboards.

Copepoda

The Copepoda are a subclass of Crustacea comprising over 10,000 known species (Williamson and Read 2001). Copepoda are predominantly marine, although 3 of the 10 orders are widespread and abundant in freshwater habitats. These are the Calanoida, Cyclopoida and Harpacticoida. The first order occurs in the water column as plankton only, whereas the latter two are common in benthic habitats of surface waters and are important components of many groundwater communities.

The Copepoda Cyclopidae is normally associated with fine to course sandy substrates of still water environments of rivers, wetlands, the hyporheic zone and shallow groundwaters. Although they are a ubiquitous component of these habitats, their small size means that they are often overlooked and undercounted. In terms of management, therefore, they are potentially very useful bioindicators, particular of base flow fed streams or alluvial aquifers or flow through wetlands, as they are sensitive to changes in the environment (Tomlinson & Boulton, 2008). The Cyclopidae were collected at 8 sites (bores P116, Well P31, Well No. 1, P104, P106, P110, GW16, P120) which are all located within the shallow alluvials. Sites P116 and Well No.1 are situated on the flood plain of Wollombi Brook and GW16 are located on North Wambo Creek while the others are located along Wambo Creek. These three sites are characterised as being shallow (7-14m), occurring within the alluvium and having neutral to slightly alkaline pH. The conductivity levels however vary considerably from low to high suggesting that the fauna is either very tolerant of salinity changes or composed or different taxa. It is suggested that fauna is composed of different species with differing salinity tolerance ranges.

- There is no discussion on hydrological connectivity issue between the aquifers. As mentioned above the presence and type of stygofauna can be di9rect indicators of surface water/groundwater connectivity;

- There is no discussion of the Amphipoda, Paramelitidae, which is a significant stygofauna taxon in NSW;

- It is stated in Table 3.12 that stygofaunal are largely absent from the proposed open pit area even though Syncarida (significant stygofauna taxon) were recorded. This is therefore an incorrect statement;

- It is stated that there is a diverse macroinvertebrate fauna in Hawkes and Lawsons Creeks with mainly disturbance tolerant species but does not mention the sensitive taxa that are strong indicators of persistent high-water quality and water levels. These are also indicators of water permanence within the pools and therefore a definite groundwater connectivity. If the proposed drawdowns of groundwater along each creek is realised these aquatic refugia will be lost and a significant component of biodiversity within the surrounding valleys will be lost.

- The family level of identification of the macroinvertebrates does not allow for any comment on the species distribution i.e., potential endemicity of the fauna, which is a major failing of the AUSRIVAS approach;

- Battery Creek spring and associated dams indicate water level permanence and are also indicators of definite groundwater connectivity and are again aquatic refugia. As well, there is no discussion on the significance of the macroinvertebrate species collected as the level of identification precludes this.

- The aquifers associated with the Hawkes and Lawsons Creek are stated to have two unique taxa. This is incorrect. They are two unique orders/families however if the identifications had been done to species for the fauna collected there are likely to be more 'unique or endemic' species;

- The same statement applies to the fauna found in the springs to the west of the open pit area;

- There is a statement quoting Dr Peter Hancock (Ecological) alluding that although Copepoda (alone apparently) can be endemic to an aquifer the fauna found here are "common" and "widespread" and therefore of no significance. This was repeated in the groundwater report as well. This statement is correct in that these **Orders** of stygofauna are commonly found in aquifers in eastern Australia. It is however a completely incorrect assertion to make that that they are common and widespread at the genus and particularly the species level, particularly without any identifications done to these levels . The fact is that all evidence has demonstrated that stygofauna in general are highly restricted in their distributions and the species are highly endemic to individual aquifers. The level of identification was completely inadequate to make these statements. The statements are an attempt to mislead the reader and completely downplay the significance of the findings.

Section 3.3.2 – Threatened Species

- The listing and discussion of the potential threatened invertebrate species is inadequate as the methods used (with the exception of the Murray Crayfish) to sample for macroinvertebrates i.e., the AUSRIVAS methodology is insufficient to collect the listed species as they have very specific habitat requirements that require more specialised collecting techniques. The authors therefore cannot make any assessment of their likely occurrences in the area.

Section 4.3.3.1

This section states that:

The creation of the pit will "displace" the stygofauna present and implies that the fauna is this area is the same as that in Hawkes Creek and Lawsons Creek, yet they have only identified the taxa to family. It is therefore too much of an assumption without having identified them to species. The one species collected (The Psammaspididae) is also considered as a flagship stygofauna taxon that indicates the possible presence of a greater biodiversity. It important to acknowledge that unless there is a direct hydrological connection between the aquifers on site associated with the pit and those associated with the alluvials once the groundwater has been removed there will be a complete loss of subterranean biodiversity within this hydrological un it and downstream of this unit, that will not be restored following mine closure and rehabilitation because there would be no area/habitat they could recolonise from. This report does not adequately confirm this connectivity either hydrologically or biologically.

Annexure E – Macroinvertebrate data

- The taxa listed under the Mollusca, Crustacea, and the insect Orders Trichoptera and Odonata are indicators of water permanence and therefore, groundwater connectivity.

Annexure H – Raw stygofauna data

- The following fauna listed as non-stygofauna should be changed to stygofauna using the precautionary principle as the identification was insufficient to determine these ranking: Oligochaeta, Acarina, Collembola, Cladocera, Nematoda and potentially the Hydrochidae (Coleoptera). All of these groups contain families, genera and species that have previously been identified as phreatobites (groundwater fauna).

Biodiversity

Section 3.5 Potential GDE's

This section describes the potential for terrestrial GDE's being present in the area. It states that terrestrial GDE communities are those that "form part of the riparian zone". This is not a correct statement as terrestrial GDE's occupy a range of landscape settings and other factors (see below) that have not been considered at all in this document. The critical issue for phreatophytic vegetation is the depth of the water table below ground surface, and its accessibility by roots. The root systems of woody trees and shrubs typically extend vertically and laterally into the soil for considerable distances, and in so doing, retrieve water and nutrients from both deep and shallow soil layers. Since the availability of water at different soil depths varies markedly with season, roots exhibit corresponding adaptive spatial and temporal patterns of uptake and redistribution of water (Burgess et al., 2000). The rooting depths can vary not only among plant types, but also among different soil types for the same plant. If roots can reach a source of fresh water, it is generally accepted that this water will be absorbed by the roots and transpired by the canopy (Eamus 2009). The shallower the water table the more likely it will be that the vegetation can access groundwater during dry periods. The deeper the water table the harder it will be for the vegetation to access that groundwater.

The importance of groundwater to plants will be determined by five factors:

1) The proximity of groundwater to plants (i.e., rooting depth vs water table depth);

2) The distribution of roots;

3) The availability of shallow soil water;

4) Aquifer type;

5) Landscape Setting.

Phreatophytic trees use soil water when supplies are non-limiting and may only revert to groundwater during prolonged drought (Dawson and Pate 1996). The hydrology of mountainous terrain is characterized by highly variable precipitation and water movement over and through steep land slopes. On mountain slopes, macropores created by burrowing organisms and by the decay of plant roots have the capacity to transmit subsurface flow downslope quickly. In addition, some rock types underlying soils may be highly weathered or fractured and may transmit significant additional amounts of flow through the subsurface. In some settings, this rapid flow of water can result in hillside springs. Near the base of some mountainsides, the water table can intersect the valley wall some distance up from the base of the slope, resulting in perennial discharge of ground water and, in many cases, the presence of wetlands.

Threatening Processes for Terrestrial GDES that have not been appropriately considered in relation to the potential drawdown of groundwater across the site as well as upstream and downstream of the potential operations.

a) Impact of Water Level Changes to Terrestrial Vegetation Ecosystems

Under natural conditions, water tables fluctuate both on a micro scale (daily fluctuations influenced by diurnal vegetation water uptake as well as by solar and lunar cycles) and a macro scale (monthly to seasonal fluctuations (depending on aquifer porosity) in response to seasonal rainfall patterns. Progressive reductions in the availability of groundwater may lead to a gradual decline in the health of an ecosystem and/or a reduction in its spatial extent. In more extreme cases, thresholds of environmental requirements may be exceeded, resulting in the ecosystem collapsing or sustaining irreversible damage, (Hatton and Evans, 1998). A change in groundwater level can lead to a loss of aquatic habitat at particular levels, for example, within wetlands with an open water body, the habitats are stratified by degree of saturation and depth of water where each habitat has a suite of dependent species. A drawdown of the water table can cause wetlands to become recharge instead of discharge zones, altering both the soil water regime, water chemistry, which then influences the vegetation and fauna communities, Le Maitre et al, 1999.

A decreasing water table often results in plant water stress and reduced live biomass. Phreatophytes depend on groundwater to prevent water stress. Water stress can lead to a change in plant condition and/or reduced vigour or mortality of leaves, branches, or the entire plant. Changes in the composition and/or structure of vegetation and animal communities in response to changes in groundwater availability or quality can be observed or measured (Froend, et al., 1993; Roberts et al., 2000). Measurable changes in the vigour of vegetation, associated with reduced water availability, are the precursor to changes in distribution and composition. As water requirements are not being met, the vigour of individuals within a population will decline (water stress, branch die-back, reduced growth, leaf shed, chlorosis), leading to loss of individuals at drier areas of the water availability gradient (altered distribution), or total loss of the local population. Any such changes provide an indication that the ecosystem under consideration is potentially groundwater dependent.

The lowering of the water table will have a significant impact on all GDE types but in particular those communities that are entirely dependent and have narrow environmental physiological tolerances such as ecosystems within karsts, baseflow and some wetland communities. The community response time to a significant drawdown event or period where the water table lowers below the threshold of the dependent communities' resilience may be immediate or be delayed until well after the event.

A community's response to an impact can be subtle. For example, excess lowering of water levels may prevent seedling recruitment and alter vegetation dynamics with little obvious impact in the short term, but which can completely change the vegetation community composition in the long term (Le Maitre et al, 1999). A drop in water table levels in disturbance sensitive ecosystems on the other hand may result in an immediate and complete collapse of that ecosystem, Le Maitre et al, 1999. The impacts may be rapid and dramatic, for example, rapid loss of water level in a permanent wetland such as a mound spring where the species are endemic, totally dependent, with no ability to withstand desiccation could mean the complete and irreversible loss of that community.

The degree to which GDEs are impacted by altered water regimes will depend on four factors.

1) The degree of groundwater dependence of the ecosystems.

Highly or totally dependent ecosystems and those that occupy a very narrow ecological range may be completely eliminated by even relatively small changes in the water regime.

Changes in the overlying vegetation can alter hydrological linkages and water levels in caves and their aquatic ecosystems with devastating impacts on their fauna. For example, the quantity of available water and the transport of dissolved and particulate organic matter, critical as an energy source for subterranean food webs, are impeded by changes in hydrological linkages and vegetation cover, Boulton et al, 2003.

2. The rate of water level change (rate of drawdown).

The disconnection of roots from its aquifer by a rapid drop in the water table can cause severe stress and partial or complete mortality in large trees which cannot grow their root systems rapidly enough to maintain adequate water supplies to their extensive canopies, (Le Maitre et al, 1999).

3. The length of time the alteration is in effect.

A prolonged period of drawdown can result in the disconnection of the root zone from the water table, resulting in the subsequent drying out of the ecosystem over time. The loss of species and changes in the vegetation community structure may have time lags of years to decades before becoming evident as different species of plants within a community have varying groundwater dependency and stress thresholds, Le Maitre et al, 1999.

4. The seasonal timing of the alteration.

The impact of a rapid or an extended drawdown is exacerbated if it occurs at particular times of the year for example during periods of environmental stress such as summer or drought.

As previously indicated, the condition or ‘health’ of a GDE relies on a combination of timing and availability of groundwater but the response functions of these ecosystems are seldom known, (Boulton, 2005). Although the health of some GDEs, such as alpine bogs, might show a linear response; i.e., as the water table drops the condition decreases relative to groundwater availability, other ecosystems such as salt marshes may respond in a stepped fashion with minimal change in condition until a threshold of water availability is reached, (Evans and Clifton, 2001). Inland, rising water tables and increased soil salinity have affected the health and distribution of native plants species, (Cramer and Hobbs, 2002). Secondary dryland salinity affects agricultural landscapes where native vegetation is often highly fragmented, of small size and already degraded by land use activities, (Hobbs 1993; Hobbs, 1998). The alteration of hydrological processes could force an ecosystem, already stressed, across a threshold resulting in its collapse.

Other Impactors

A secondary effect on terrestrial ecosystems and other GDE’s from the alteration of groundwater levels is the mobilisation and transport of salts and or contaminants. The ecosystems at most risk from saline discharge are those systems that occur in the lowest topographic positions in the landscape. These ecosystems include riparian zones, floodplains, and wetlands, both fresh and naturally saline. The risk to low lying vegetation beyond riparian zones is uncertain, Cramer and Hobbs, 2002. Wetland vegetation often relies on the regular flushing of salt from the root zone for continued survival. A change in hydrology that leads to the constant presence of a shallow saline water table could reduce the leaching of salt from the root zone and cause a decline in vegetation health, Cramer, and Hobbs, 2002.

The raising of groundwater levels by over irrigation can cause the transport of salt to the surface resulting in the development of shallow saline groundwater. This in turn, can cause salinisation of the plant root zone and subsequent collapse of the ecosystem. Diversions and/or impoundments of surface waters can change groundwater levels, particularly in near stream alluvial aquifers, SKM, 2001. Groundwater levels can increase if the post regulation stream flows exceed natural flows or they may be lower, particularly if river regulation is associated with out of basin transfers of water. Elevated groundwater levels may benefit some groundwater dependent species whilst detrimentally affecting others.

<u>Management Actions</u>

Recommendations from the desktop review includes:

- ❑ Continue conducting a baseline surveys for stygofauna within the Alluvial Aquifer and bores upstream and downstream of the proposed mine site and shallow bores (<100m) within the Fracture Rock Aquifer following BACI monitoring design i.e., Before, After, Control sites, Impact sites.
- ❑ As stygofauna have been found within the aquifers it will be necessary to establish an ongoing biannual biodiversity surveys in line with spring and autumn seasons in conjugation with a monthly water quality monitoring program to monitor potential changes/impacts to the stygofauna community as result of potential water quality change;
- ❑ Continue ongoing groundwater monitoring of water levels and water chemistry in the study area, with the addition of water temperature, dissolved Oxygen and Redox Potential (Eh) measurements.
- ❑ The exploration of more sites to gain a more complete understanding of stygofauna community composition and species distributions in the area, particular down gradient of shallow groundwater flow path.
- ❑ Identify stygofauna and macroinvertebrate taxa to species in order to determine the presence of short-range endemic species and to establish the distribution of the fauna in relation to

hydrological connectivity and faunal distribution ranges and conservation value individual species.

- Conduct aquatic biodiversity surveys of surrounding species, wetlands, peat swamps upstream and downstream of the proposed mine site with complimentary water quality and water level monitoring at each location.
- These recommendations are to be carried out within an adaptive management and monitoring program. Also identified is the inter-ecosystem risk of aquifer physicochemical parameter change to the other GDE types that are potentially supported by the shallow groundwater systems.

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