Review of EIS

Client: Lue Action Group

Project No: P20022
DATE: 27 July, 2020
Final

Project: Bowdens Silver Project Environmental Impact Statement Review

PO Box 575

MUDGEE NSW 2850

Attention: Bron Wannan

CC: Mick Boller

RE: Technical Review of selected EIS reports in response to the Proposed Bowden's Silver Mine Development, State Significant Development No. 5765, Lue NSW

Dear Bron,

ABSolution Ecology and Stygoecologia were commissioned to provide a technical review of relevant Biodiversity and Aquatic Ecology reports within the Attachments of the EIS for the Proposed Bowden's Silver Mine, State Significant Development No. 5765. We understand the project is currently being displayed for public comment.

Our technical review was performed by two experienced scientists:

Dr Michael Aberton of ABSolution Ecology is an experienced ecologist having over 20 years field experience as both a researcher and consulting ecologist. He is BAM Accredited with BAAS Accreditation # 18181. He is also a Certified Environmental Practitioner through Environmental Institute of Australia and New Zealand (EIANZ) since 2013. Michael has many years' experience both as technical lead and technical review roles of linear assessments for large and small infrastructure projects throughout eastern Australia. He has led a multitude of targeted species surveys in flora and fauna assessments for various State and Federally Listed threatened species.

Dr Peter Serov of Stygoecologia is an experienced Aquatic Ecologist, and Invertebrate Taxonomist who has worked in a range of environments including surface aquatic ecosystems (Rivers, Wetlands), groundwater ecosystems, marine, and terrestrial ecosystems for over 30 years. Peter specialises in the identification of aquatic macroinvertebrates and stygofauna (groundwater fauna) with a particular interest in the ecological condition assessments and management of Aquatic Ecosystems including rivers, wetlands and Groundwater Dependent Ecosystems (GDE's). Peter has been a significant contributor in the early development of the NSW Sharing process and recognition of Groundwater Dependent Ecosystems in NSW government.

Scope: To review and comment on the BAR and Biodiversity Offset Assessments, Aquatic Ecology and Groundwater of the Bowden's Silver Mine, State Significant Development No. 5765 project EIS.

Based on the information provided, the following reviews were carried out:

- Review of the following EIS documents, they are:

-Volume 3 Part 9a Biodiversity Assessment Report prepared by Enviro Key reviewed by ABSolution Ecology
-Volume 3 Part 9b Biodiversity Offset Strategy prepared by Niche reviewed by ABSolution Ecology
-Volume 4 Part 10 Aquatic Ecology prepared by Cardno reviewed by Stygoecologia
-Volume 2 Part 5 Ground Water Assessment by Jacobs Group reviewed by Stygoecologia

- Other accompanying reports within the EIS and desktop assessments using relevant database searches where applicable.

Review of EIS

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Volume 3 Part 9a Biodiversity Assessment Report prepared by Enviro Key

The report adopted the previous NSW Biobanking Assessment Methodology (BBAM) format and therefore also the methodology to determine quantification of the vegetation quality which used assessments by EcoLogical Australia from 2014 and additional assessments by EnviroKey staff in 2019. Though the EcoLogical (ELA) data and plots are used the fauna assessments cared out by EcoLogical Australia are not cited (just as ELA previous studies). A flora assessment by Geoff Cunningham Natural Resource Consultants (GCNR) was carried out for the relocation of Mahoneys Road in 2014, however the results of this assessment don't appear to be referenced. Methodology and results of previous fauna assessments carried out by Biodiversity Monitoring Services 2012; and 2013 are not clearly defined but have apparently been considered within the mapping showing fauna records.

Threatened Fauna Species

Thirteen ecosystem species credits were identified by the site surveys. Of these species, many require hollow bearing trees for reproduction/shelter or as a source of food from fauna living within these hollows. However, the report does little to discuss the density and size of hollows which may also be suitable for species that were not identified during field survey assessments. In addition, there is a lack of information on the presence of hollows along the linear pipeline area and areas elsewhere nearby that are proposed to be retained. This is important as there is little to demonstrate the size and quality of hollows to be retained, and whether they are suitable for the species that require them. For example, Barking Owl was located within the impact area on 2 nights of survey. This species is likely to frequent tree hollows in the BAR impact area and prey on other hollow inhabitants. Given their presence on the BAR impact area and the fact that the extensive searches for the breeding site were outside the breeding season, it is reasonable to predict that breeding habitat is present in the study area. However, insufficient information is provided to determine size of hollows for availability across the entire study area. Multiple observations of the Greater Broad-nosed Bat were observed by ELA (reference not provided) within their previous studies of the BAR impact area and immediate surrounds. This is another example of a species that utilises tree hollows for roosting and maternity sites. The importance of tree hollows (particularly large hollows in old trees) should not be underestimated as the 2019-2020 bushfires throughout NSW has reduced habitat quality further, burnt many old, hollow-bearing trees needed as refuge by prey species and reduced the viability of some regional owl populations (Environment NSW 2020).

Squirrel Glider habitat was shown to occur across a large proportion of the study area on the mapping of Map 51. The use of spotlighting and scat/sign collection is suitable to determine the presence of this species. However, whilst the area around Maloneys Road appears to be thoroughly spotlighted over two occasions, there was a lack of spotlighting throughout the remainder of the proposed mine site disturbance and not much associated with the pipeline alignment indicated by Maps 12 and 13. Given that Maps 41-51 Species Polygons for Regent Honeyeater and Squirrel Glider in the Study Area shows other areas (particularly Tiles 9, 11, 12, 13, 14, 15, 16 and 18) perhaps spotlighting in these areas may have been assessed more thoroughly to enable the determination of presence or absence of this species. This species is one that depends on large hollow in old trees. Without detail it is difficult to comment on the impact placed on this species from the removal of vegetation (including hollows). Section 6.3.3 General Vegetation and Habitat Removal addresses protocol for hollow removal:
4. Implement a two-stage clearing protocol for all hollow-bearing trees.
5. Mark all hollow-bearing trees to be removed and catalogue their species and approximate dimensions so that hollows or nest boxes can be added to similar standing trees (i.e. 1 for 1).

However, the above does not take into account breeding time, reduced range and immediate or long-term impacts on the species present.

The recently released National Light Pollution Guidelines for Wildlife Including marine turtles, seabirds and migratory shorebirds (EEC 2020) notes that an appropriate assessment needs to take place to investigate impacts on fauna where outdoor lighting is present and/or indoor lighting is visible outside. In both cases it could be expected that these will be present during the mine production life. Where these do occur it is a requirement of the guideline to use best practice lighting design. However, because important habitat for listed species is located within 20km the Guidelines recommend an EIA for impacts from artificial light on wildlife. Nocturnal species such as Squirrel Glider, Owls, various microbats, Koalas and other species susceptible to predation by pest animals will be likely to be impacted upon by the lights. The Best Practice lighting design within the guidelines is not mentioned within the BAR in *Section 6.3 mitigation measures during operations* nor *7 Assessment of impacts* nor *7.4.9 Noise, Vibration and Lighting Impacts*. Though the BAR gives examples of

positives of artificial light, the negatives could provide adverse impacts on threatened species located within the vegetation that is retained adjacent to the mine. There is mention within the BAR that *lighting at the mine is unlikely to be directed toward vegetated areas, but rather at hardstand and active mining areas* however it does not adequately address the issue and impacts on threatened fauna. An Environmental Impact Assessment for Effects of Artificial Light on Wildlife should be carried out by appropriate personnel with the description of the project lighting requirements, the wildlife (including baseline surveys), a risk assessment, artificial light management plan and Biological and light monitoring and auditing followed by a review to mitigate any effects.

Conclusion:
More detail on the presence, size, distribution and type of tree hollows need to be detailed to address the impacts on threatened fauna from hollow removal. This is a Key Threatening Process. In addition, further consideration of the impacts of artificial lighting are required to determine the impacts to Matters of National Environmental Significance (MNES) of several EPBC Listed species.

Koala

The assessment of Koalas was insufficient to categorically determine their use and density within the study area. Koala transects performed in the February 2017 field survey, but only two Koala transects were carried out. Each transect was systematically searched for active and inactive Koalas, their signs (i.e. scratches on trees) and their scats. This was minimal assessment and potentially underestimates the frequency of use of the site as a corridor for movement passage. The survey effort was concentrated on a very small area within the centre of the BAR footprint only. Traffic Light Model in Map 64 shows impacts to both high and medium value habitat as a result of the disturbance. The report states that the proposed action would remove about 139.59 hectares of habitat that could be used by Koalas within the Study Area. Of this, considerable numbers of Koala habitat trees are presumed to be present and likely to be disturbed as a result of the works. The report mentions …..*numerous tree species as listed by Schedule 2 (SEPP) are located within the BAR footprint including Rough-barked, White Cypress Pine, White Box, Blakely's Red Gum, Ribbon Gum and Scribbly Gum*. It goes on to say ……*this represents only a small proportion of the same habitats that also occur within the Study Area which total 460.1 hectares, that would be retained as well as higher quality habitats to the north and east of the Study Area (in the wider locality) that would remain unaffected. For these reasons, the removal of the habitat required for the proposed action would not be considered critical to the survival of this species*. However, this does not take into account indirect impacts, the impact of mining and disturbance during construction and operations, such as increased lighting, noise, explosions and vibrations that could prevent Koala usage of the retained habitat adjacent to the mine within the 460.1 Ha. In addition, the report does not suitably take into account Koalas that may be impacted by fragmentation nor other impacts. The disturbance caused in the impact area has potential to stop passage as there will be pockets of suitable vegetation fragmented and from larger patches.

When considering the overall objectives of the NSW Koala Recovery Plan are to:
- Reverse the decline of Koala in NSW
- Ensure adequate protection, management and restoration of Koala habitat
- Maintain healthy breeding populations of Koala throughout their current range.

It has been acknowledged by EnviroKey that the proposed action would be in conflict with the second objective above by removing 139.59 hectares of habitat that is suitable for Koala…and that it would also provide adequate protection of the same vegetation types within the Mine Site. However, there is a high risk that due to the fragmentation and indirect impacts the impact areas would be higher, potentially extending into the 460.1Ha and to within other populations located east of the proposed mine. There is no mention of a buffer zone between the impact areas and the retained vegetation. Insufficient evidence has been proposed that will mitigate impacts to give confidence that both of the first two points of the NSW Koala Recovery Plan can be achieved. Given that Koalas have been heavily impacted by the 2019-2020 bushfires within NSW and a large proportion of their habitat was burnt with a large number estimated to have perished it seems that impacts from the mine and pipeline on habitat haven't been suitably addressed for EPBC purposes.

Conclusion:
The effect of the mine and pipeline on Koalas may be greater than the immediate impact areas, cause fragmentation and not be in line with the overall objectives of the NSW Koala Recovery Plan including:
- Reverse the decline of Koala in NSW; and
- Ensure adequate protection, management and restoration of Koala habitat

The cumulative and indirect impacts to Koala habitat as a result of the action make a higher proportion on current viable habitat remaining in NSW.

Herpetofauna Surveys

While herpetofauna surveys are generally numerous (85 sites across the Study Area) this number appears to be more suited to reptile habitat. This is emphasised by Map 12 which indicates reptile survey locations and is largely terrestrial. The method used to… *search fallen timber, loose bark, tree and ground hollows, and loose soil were extensively searched*. However, this does method not satisfy frog searches in an aquatic environment. From the report it appears that call playback for threatened frog species was not carried out and there is no evidence of suitable searches within aquatic vegetation and rocked areas. There appear to be no frog surveys along Lawsons Creek where it traverses the site in the southern section. Whether this be due to a lack of suitable habitat is not known. In addition, searches described are not always likely to locate cryptic species which are hard to find. Riparian habitat survey carried out also just appears to concentrate on fauna habitat searches rather than intensive species searches. It was noted the Aquatic ecology report (Volume 4 Part 10 of EIS, Cardno 2020) mentioned some frog habitat present.

The Booroolong Frog can be located in streams where cleared grazing land occurs in addition to within woodland and dry forest. In addition, microhabitat is described as under rocks or among vegetation near the ground along stream edges and active frogs may be on or near cobble banks or bedrock structures within stream margins, or near slow flowing connected or isolated pools. Either call playback or larvae assessments may have been more appropriate to assess for this species according to EPBC guidelines DEWHA (2010b). Not enough information is supplied within the report to determine the presence of all of this habitat but Plate 1 does show presence of rock, emergent aquatic plants and potential habitat. It's acknowledged these are associated with Stoney Creek and Moolarben Creek. If surveys were carried out in unusually dry periods (extended periods of low rainfall) there may be scope for this species to be present in optimal conditions when the streams have more water.

Reptile surveys were not suitable to detect some of the more cryptic species. For example, the Striped Legless Lizard *Delma impar* a cryptic species and may not be detected by surveys even when present at a site and requires more intensive targeted surveys to determine presence. Cooler months are more likely to locate this species from active searches but are less successful, however it doesn't appear these were performed in these cooler months. EPBC guidelines generally require the more intensive targeted technique utilising a grid of 50 artificial shelter sites (e.g. tiles) spaced 5m apart (5x10) in grassland between September-December) (DSEWPC 2010).

Conclusion:

Although reptile surveys appear to be quite numerous, methods of survey are not suitable to detect all of the threatened species that may occur on the study area or that are listed as MNES on the EPBC search. Amphibian survey in aquatic areas is not well distributed and was carried out in an extended period of low rainfall. Therefore, not all threatened reptile and amphibian species can be considered absent based on the information supplied.

Bird Surveys

A total of 137 diurnal bird surveys were completed guided by a standardised technique. The bird surveys across the survey extent appear to have been generally well represented between the months of October-April. However, given this timing of assessments there has been insufficient survey effort for EnviroKey to make broad conclusions regarding the Swift Parrot. In fact, appropriately timed targeted bird surveys were not carried out at all around the mine site to determine Swift Parrot presence. Commonwealth of Australia (DEWHA 2010a) Guidelines for threatened bird species require a Survey effort guide as follows:
Surveys on the mainland should be conducted between March and July and for areas >50Ha, the effort should be 20hrs over 8 days with Targeted assessment of areas of heavy flowering Eucalypts. In areas of less than 50 ha, 20hrs over 8 day (appropriate for pipeline alignment) is recommended. As there were no bird surveys carried out in appropriate seasonal timing for the Swift Parrot on the BAR impact area of the mine site (when they would be potentially present potentially feeding on winter flowering Eucalypts), the surveys are not adequate to make assumptions of absence from the mine site. The report shows the Swift Parrot has been found at Ulan in 2014 feeding in *Angophora floribunda* which is present amongst other suitable Eucalypts on the BAR mine site. As this species is highly nomadic and relatively large numbers can arrive at and vacate areas depending on local and regional flowering of favoured species (Mac Nally and Horrocks, 2000) it's

possible it uses the site and was not detected. In addition, it seems there could be potentially numerous hollow bearing trees (used for shelter) within the BAR impact area.

So, when answering the question within EPBC Significant Impact Criteria section: Will the action lead to a long-term decrease in the size of a population of a species? The answer provided by EnviroKey stated "Comprehensive field surveys detected no Swift Parrot within the Study Area" is misleading. Bird surveys and opportunistic data collection was not targeted at this species in the appropriate timing to be present. Given that this was a specific request within the SEARs by OEH 13/12/2016 under Relevant Requirements Nominated by Other Government Agencies, Impacts on the following species/populations/ecological communities will require further consideration and provision of the information specified in s9.2 of the Framework for Biodiversity Assessment it has not been addressed appropriately.

The Regent Honeyeater was not detected during the current assessment but the EnviroKey report indicates ……*it is probable that Regent Honeyeater uses the Study Area.* Maps 41-51 show extensive habitat for this species across Tiles 2,3,4,9,11,12-18 and on the mine site of Map 51. As the Regent Honeyeater was detected in a previous study of the site it is correctly assumed to be present. Importantly, Needle-leaf Mistletoe *Amyema cambagei* is considered a necessary requirement of the diet of the Regent Honeyeater. Although this species was not identified onsite there is a possibility it was missed and the presence of Family Casuarinaceae: Drooping Sheoak *Allocasuarina verticillata* is important as this can be the host for this species. There is no mention of Mistletoe within the report other than within the flora species list where *Amyema pendula* and Amyema sp. are located within the listed flora. It is recognised that due to its difficult and often inaccessible location, Mistletoe is often overlooked and not identified to species level and therefore there is potential that multiple species could occur within the study area, including *A. cambagei*. However, the report does not mention the location of the *Amyema* spp. nor the host tree species. In addition, other species that require Mistletoe were recorded within 4 of the 5 bird survey periods. Species include the Mistletoe bird and Listed Diamond Firetail (nesting), the majority of which are located within the BAR footprint within the mine area in addition to several locations along the Bara-Lue Road where the pipeline is proposed. Given its importance for the diet of the Regent Honeyeater, more comprehensive assessment would further identify habitat within the study area. It is noted that species credits have been applied for Regent Honeyeater but the presence of feed trees in the retained habitat is not known, nor the adverse (indirect) impacts of other mining practices.

Conclusion

The SEARS identified the Swift Parrot as one of the species requiring further consideration. However, there is insufficient survey effort to make the conclusion that Swift Parrot does not occur in the study area (particularly the mine site). Given the habitat values and potential for feeding (with flowering Eucalypts present), there is opportunity for this species to utilise the area and without evidence of its absence it should be assumed present. Therefore, this species hasn't been adequately considered. Species credits have been calculated for the removal of habitat for the Regent Honeyeater, and mention of a suitable biodiversity offset strategy must be considered for Regent Honeyeater. However, the impact of mining activities on habitat within the mine area "retained vegetation" is not known. There is risk that the Regent Honeyeater will lose more than the BAR footprint for mine site and pipeline of available habitat.

Box Grassy Woodland, Threatened and/or Endangered Ecological Communities (TEC's EEC's)
It has been shown in the report that three biometric vegetation types (BVT's) meet the definition of the Threatened Ecological Community (TEC) Box Grassy Woodland (BGW).

Table ES1 shows CW112, Blakely's Red Gum – Yellow Box Grassy Tall Woodland of the NSW South Western Slopes Bioregion (Moderate/Good_poor) (PCT 277) has 19.73Ha impacted by the mine site and relocation of Maloneys Road. However, the report body 4.1.2 shows the losses are 91.73Ha (perhaps this is an error but confirmation is required as the body report also shows 19.73Ha in Tables 6 and 30).

Two other TEC's will be directly impacted within the BAR footprint area, CW111 Rough-Barked Apple - red gum - Yellow Box woodland on alluvial clay to loam soils on valley flats in the northern NSW South Western Slopes Bioregion and Brigalow Belt South Bioregion losses will be incurred to over 159.23Ha. CW 216 White Box grassy woodland in the upper slopes sub-region of the NSW South Western Slopes Bioregion will also see the losses of 1.24Ha. The loss to CW111 is s a significant amount when considering both the community and losses to fauna species.

It is mentioned that a total of 673.2 hectares of BGW occurs within the Study Area and of that the proposed action would result in the removal of about 147.82 hectares of Box-gum Woodland that meets with the EPBC Act criteria leaving a remainder of 519.2Ha. These figures do not equate to the table in the Executive Summary TS1 but are shown in Table 22. There is a high risk that as a result of all of the mining activities including (change of groundwater hydrology) that impacts to the retained Box-gum Woodland may also occur. Without any buffer zone the edge effects of clearing are possible and this would likely reduce the remainder of 519.2Ha.

A few other points:

Given that these are Threatened Ecological Communities there is insufficient acknowledgement of their limited nature across NSW and Australia. With 95% clearance of Grassy Woodland Community in the central west, the importance of the remaining communities cannot be understated.

The report documents 7.4.4 Impact on relevant Key Threatening Processes .However, it does not look at the potential spread of the water borne oomycete plant pathogen *Phytophthora cinnamomi* "dieback" disease which was listed as a potential KTP in the area when ABSolution Ecology carried out an EPBC Protected Matters Search in 2020. Given that the mean annual rainfall at the nearest BOM weather station (Mudgee) is 668mm, this places the area within a high predictive zone for the presence of the disease (Commonwealth of Australia, 2017 and O'Gara et al. 2005). If dieback sensitive species are within the proposed BAR area, dieback caused by *P. cinnamomi* can cause severe decline in species diversity and impact threatened communities. The pathogen is often spread with disturbance of soils and gravel during earth movements and this could have drastic consequences to the vegetation communities adjacent to the pipeline works and mine site impact areas. However, appropriately timed assessment for the pathogen in susceptible species indicating disease can be carried out to determine the pathogen's presence. Without such susceptible species the pathogen can go undetected.

White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland is listed as a critically endangered ecological community under the Environment Protection and Biodiversity Conservation Act 1999. This is located within the Survey and BAR impact areas and significant amounts of this would be removed in the current plan**.**

Within EPBC Significant Impact Criteria to the question: Will the action reduce the extent of an ecological community?

This is not answered yes or no. The answer should be yes, regardless of the statement that 519.2Ha that also meets EPBC Act criteria will be retained with the study area, the majority of losses (147.82Ha) to this critically endangered Community falls in the mine site BAR impact area (138.13 Ha).

In addition, where questioned whether the action will modify or destroy abiotic factors necessary for an ecological communities survival there is insufficient evidence to suggest groundwater will not be affected. As species within this community are GDE's there is a likelihood some will be impacted resulting in an increased decline in BGW. GDE's are described further under Biodiversity -Section 3.5 Potential GDE's below in Dr Serov's section.

Within Annexure 6, the report correctly states that the proposed action would result in the fragmentation of some areas of BGW within the Study Area based on the BAR footprint.

The report does not adequately assess potential impacts from alterations of the impact and does not allow for edge effects. The impact on retained vegetation from changes to groundwater is unknown and cannot claim that the action won't cause a substantial change in species composition of an occurrence of an ecological community, including causing a decline or loss of functionality of important species. Though stating the BGW within the BAR footprint would be removed by the proposed action it cannot be just assumed there would be no modification to remaining BGW CEEC that would cause a decline in condition or composition (assuming mitigation measures include adequate weed control). As species within this community are GDE's there is a likelihood some will be impacted resulting in an increased decline in BGW. GDE's are described further under Biodiversity -Section 3.5 Potential GDE's below in Dr Serov's response.

Conclusion: The disturbance of impact areas is likely to cause fragmentation of this Critically Endangered Ecological Community in addition to potential indirect impacts that have not been adequately accounted for as a result of major changes to groundwater. Mitigation measures do not suitably address this risk and it is not

clear as to how the avoidance and minimisation of losses has been demonstrated through planning. There is no mention of edge effects nor the implementation of a buffer zone between the mine and the retained native vegetation. As Box Grassy Woodland provides habitat for threatened species (particularly flowering Eucalypts and presence of hollows) greater emphasis on its significance is warranted.

Overall:
It is claimed the applicant has made all reasonable efforts to avoid impacts to threatened species habitat where possible, through a substantial planning and design phase. This avoidance is not clearly demonstrated within the biodiversity assessment report and in the context of biodiversity protection. The mitigation measures proposed to minimise potential impacts are unclear and reliant on future work. Given that suitable biodiversity offset strategies and offsetting is proposed the direct impacts only have been considered, not indirect impacts of various species. The indirect impacts may be out of the control of the works and these will be only identified after the impact occurred.

Though the report mentions *…areas of potentially high biodiversity value were mapped as red, potentially medium ecological value were mapped as orange, and low ecological value were mapped as green. Should development occur in areas mapped as red, then it is likely that impacts to biodiversity would be greater than those in areas mapped as either orange or green…..* The Traffic light approach does not show how the red (high impact) will be avoided, particularly within the pipeline alignment and mine site BAR. For instance, the pipeline may be able to be manoeuvred in location to avoid 'high' areas but this level of planning has not been shown. While noise, vibration and lighting impacts are predicted and the example of the Grey Crowned Babbler colonising an area is documented this can't be expected of the same and or all species within the study area. Rather, there is likely to be a generally negative impact on retained habitat as many of the species to which habitat remains could be be spooked by the noise, vibration and lighting impacts. Lighting impacts need to be fully understood and any design requirements appropriately considered to eliminate the impacts to threatened species through the artificial light guidelines (DEE 2020). In addition, death to threatened species caused by road strike or predation in well-lit areas, changes to groundwater and vegetation can't be fully accounted for within the retained vegetation as these levels are unknown and cannot be accurately predicted.

References:
Commonwealth of Australia (2017) Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* March 2017 DRAFT FOR COMMENT Distribution of Pc in Australia, NSW

DEE (2020) National Light Pollution Guidelines for Wildlife Including marine turtles, seabirds and migratory shorebirds

DEWHA (2010a) Survey guidelines for Australia's threatened birds Guidelines for detecting birds listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999 Commonwealth of Australia

DEWHA (2010b) Survey guidelines for Australia's threatened frogs Guidelines for detecting frogs listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999, Commonwealth of Australia 2010

DSEWPC (2011) Survey guidelines for Australia's threatened reptiles Guidelines for detecting reptiles listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999

EEC (2020) National Light Pollution Guidelines for Wildlife Including marine turtles, seabirds and migratory shorebirds

Environment NSW 2020 https://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10561

Mac Nally and Horrocks (2000). Landscape-scale conservation of an endangered migrant: the Swift Parrot (*Lathamus discolor*) in its winter range. Biological Conservation, 92, 335-343.

O'Gara E, Howard K, Wilson B & Hardy GEStJ (2005), Management of *Phytophthora cinnamomi* for biodiversity conservation in Australia: Part 2—National best practice guidelines, a report funded by the Commonwealth Government Department of the Environment and Heritage by the Centre for Phytophthora Science and Management, Murdoch University, Western Australia.

Volume 3 Part 9b Biodiversity Offset Strategy prepared by Niche

It is understood that although the quantity of credits have been determined the location of these offsets is yet to be finalised. In addition, the report refers to the need for converting equivalence of offset credits from BBAM to BAM to suit the BC Act 2016. It is reasonable to conclude this will take some time.

Part 3. ON-SITE OFFSET SITES
3.1 OFFSET SITE DESCRIPTION AND LOCATION
A series of offset sites would be used to generate credits to satisfy the offset requirements for the Project. A summary of details for the on-site offset sites is provided in Table 4. Given that a large proportion of the offsets are already owned by the proponent, this is suitable for offset location if it can be proven that the effects of the mine do not have a broader impact on fringing vegetation and threatened species habitat. The close proximity to the proposed mine for these offsets may in fact be a problem if species are shy of the mine area. Ecosystem credits should be able to be offset appropriately with the native vegetation adjacent to the mine.

Three points that require contingency plans in the following events:
a) Land is not able to be purchased, or
b) Land does not meet the requirements of the remaining offsets, or
c) Conversion of BBAM to BAM credits BC Act is not what is hoped for in equivalence*.

* The credit requirement for the Project has been determined in Biobanking credits in accordance with the FBA requirements. Establishment of in-perpetuity offset sites (formally Biobanking sites but now Biodiversity Stewardship Sites) in NSW can now only be done using the Biodiversity Assessment Method (BAM) and therefore, a conversion from Biobanking credits to BAM credits would be required and would be conducted by DPIE.

Offsite offsets are reliant on the land being available for purchase, however, there appears to be many options. In addition, given the residual ecosystem credit requirement, it is predicted that between 850 and 1,000 hectares of off-site offset areas would be required.

A desktop assessment was carried out to determine value of potential offsets. The desktop assessment involved the following:
• *Analysis of vegetation mapping (DPIE, 2018) throughout the permissible offset areas comprising the IBRA subregions of Capertee Valley, Capertee Uplands, Wollemi and Inland Slopes.* Note: Biodiversity report by EnviroKey determined the mapping to be different from some of the mapping.

• *Identification of land holdings with large areas of mapped native vegetation (c.1000 ha) including large areas of Box Gum Woodland PCTs.*

• *After consideration of the above, properties that were in close proximity to Regent Honeyeater, Koala and Squirrel Glider records according to the NSW Wildlife Atlas were prioritised.*

These appear to be appropriate rationale. However, minimising the risk of fragmentation and effect on individual species by a 'hot' fire should also be considered.

It's documented that 7 of 10 short-listed potential landholders showed an EOI in the creation of a stewardship site which would be facilitated by the Applicant. Table 9 summarises the offset site and species credits where land is available. Generally, the purchased properties should contain Box Gum Woodland (incorporating EPBC listed qualities and all of the species credit requirements).

The Backup Plan encompasses the purchase of credits from relevant owners. However, it should be noted that this amount fluctuates significantly and fire and demand from other projects can alter availability.

Species Credits

Evidence of consultation between the NSW BCD and (then) Commonwealth DoEE in regard to the process for credit conversion for the Regent Honeyeater should be supplied. Although it is discussed that under the new

BAM the Regent Honeyeater only requires credits where important habitat is impacted by development. Does this consider other in-direct impacts caused to the species where important habitat is affected ?

Koala and Squirrel Glider credits
Koala credits will be created after survey of on-site and off-site offset areas. Any shortfall in the number of credits required will be addressed through purchase of credits from the market (biobanking or BAM credits). These are readily available and Niche has received a number of EOIs from credit holders for these species.

There is no discussion of Squirrel Glider credits under this section. This is an omission that needs rectification.

It is acknowledged that further field survey is required to determine ecosystem and species credits within proposed offset sites. This information will be included in a final BOS, with an accompanying management plan for the on-site and off-site offset areas. However, there needs to be some certainty that the mine will not have any indirect effects on the proposed offset sites, including that of lighting to ensure the offset sites are appropriate.

Other reports and components of the EIS

TSF and WRE Closure Cover Design

After mine closure there are plans to revegetate tailings storage facility (TSF) and waste rock emplacement (WRE) areas with carefully selected vegetation to ensure the integrity of the cover is maintained after closure.

How can Bowdens Silver guarantee the prevention of colonisation of trees and shrubs associated with both native vegetation and introduced species with potential to penetrate roots deep into the TSF and WRE in the long term after the project has been completed ?

Generally, it is expected that poor growth media in capping and assorted shallow planting would prevent establishment of trees in the short term. However, the Long term (1000's of years) success of encapsulating the TSF and WRE areas cannot be guaranteed and woody plants and trees have the potential to become established and penetrate these surfaces. Therefore, long term there are no guarantees the capping will not be permeated and could result in leakage of contaminants well after the project has closed.

Bowdens Silver Mine: EIS Review Comments

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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.

Overview

1) Groundwater

- 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 regards 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 below or under 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. It is obvious 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.

- These findings that stygofauna are present within and adjacent to the mine is very important and needs to be examined in more detail as changes to the groundwater levels, quality and flow direction will potentially impact on local endemic communities. 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;
- Develop specialised morphological and/or physiological adaptations to survive in groundwater environments; and
- 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; Serov et al. 2009, 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 and 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 take into account 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.

2 Aquatic Ecology
Section 3.2.9 – Stygofauna
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:
- There is no discussion on hydrological connectivity issue between the aquifers;
- 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' permanence are indicators of definite groundwater connectivity and are again aquatic refugia. Again, 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. 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 an 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 taxon that indicates the possible presence of a greater biodiversity. It is 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 that will not be restored following mine closure and rehabilitation because there would be no area it 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).

Section 3.5 Potential GDE's part of Biodiversity Assessment Report prepared by Enviro Key
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; and
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 mountain-sides, 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.

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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.

A secondary effect on terrestrial ecosystems and other GDE's from the alteration of groundwater levels is the mobilisation and transport of salts. 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.

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