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Memorandum Report

To: Michael Ruane / Dan Tenardi (Reward Minerals)

From: Phil Whittle (contributors – Plaxy Barratt, Dustin Hobbs)

Date: 2/9/2016

Re: **Lake Disappointment – Ecotoxicity Hazard Assessment**

This memorandum report has been prepared for Reward Minerals to provide an assessment of the ecotoxicological hazard posed to environmental receptors as a result of implementing the proposed Lake Disappointment Potash Project. This memorandum presents an independent expert opinion on the potential ecotoxicological hazards that could arise as a result of project activities.

Scope

In particular, this report aims to address the following issues raised by the Commonwealth Department of the Environment (DoE) outlined in a letter to Reward Minerals dated 15th July 2016 (EPBC Ref: 2016/7727):

What is the potential for the proposed action to directly or indirectly impact matters of national environmental significance including listed migratory birds through:

- hydrogeochemical changes to lake sediments and waters during wet and dry episodes
- generation of acid sulphate soils
- mobilisation, bioavailability and toxicity of heavy metals (including uranium and thorium).

Additionally, the memorandum provides summary information on major and trace chemical constitutes of sediment, brine and groundwater in the Lake Disappointment project area, drawing on information presented in Pendragon (2016) and other laboratory test results supplied by Reward.

Method

The analysis presented below was conducted through the review of previous studies conducted for the Lake Disappointment Project and consideration of other relevant sources of technical information, including published, peer-reviewed scientific works and Hydrobiology's own specialist knowledge of avian biology, salt lake ecology and environmental geochemistry. No independent testing was conducted by Hydrobiology to confirm the laboratory results presented in other consultants' reports. This technical review and assessment was conducted as a desk study and did not include a site visit to the project area.

The following project-specific reports were reviewed as part of the ecotoxicity hazard assessment:

- Bennelongia (2016) – Ecological Character of Lake Disappointment. Report for Reward Minerals, June 2016;
- Harewood (2016)) – Fauna Survey (Level 2) - Phase 1 (May 2013) and Phase 2 (October 2013) - Lake Disappointment Potash Project;
- Pendragon (2016) – Acid Sulfate Soil Investigation - Lake Disappointment; and
- Pendragon (2016) - Hydrological (Surface Water) Investigation and Assessment - Lake Disappointment

A risk-based approach, consistent with the requirements of AS/NZS ISO31008:2009, was adopted for the assessment of ecotoxicological hazards. In the first instance, the risk-based assessment framework involved the identification of:

- toxicological hazards associated with environmental media (sediment, groundwater, brine);
- vectors (mechanisms or pathways that could give rise to the toxicity hazards); and
- receptors, especially those directly or indirectly important to the protection of species protected under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).
- pressures (the ways in which toxic constituents in the environment could directly or indirectly affect the health or behaviour of protected species)

Hazard Vector-Receptor-Pressure Identification

This section aims to fulfil the requirements of AS/NZS ISO 31000:2009 and HB203:2012 (Risk Management) for Problem Formulation/Risk Identification respectively. This assessment has been conducted within the bounds of the scope outlined above. It is primarily concerned with the potential geochemical and environmental ecotoxicological hazard associated with the project. In addition, the assessment aims to provide a synthesis of information gathered for the project by previous studies (Bennelongia 2016, Harewood, 2013, JRHC 2016, Pendragon 2016a, Pendragon 2016b) and a supporting literature review. It does not aim to comment on potential project impacts outside of this scope and any reference to these impacts is incidental and secondary to information provided by the other studies as listed.

Hazard Vector Identification

The key characteristic of the Lake Disappointment Potash project relevant to the current assessment is the construction and operation of a network of shallow (~2m bgl) trenches across the western portion of the lake. These trenches have the purpose of draining and transporting shallow highly saline groundwater to a processing facility for recovery of potash salts. The construction of these trenches will potentially provide an opportunity for the dewatered sediments and associated groundwater/porewaters to be exposed to atmospheric conditions with consequent geochemical changes occurring. The primary vectors or pathways of potential environmental hazard for consideration have been identified as:

- Acidic drainage caused by oxidation of naturally occurring sulfides (monosulfidic black ooze – MBO) within the shallow (surficial) sediments;
- Mobilisation of metals from the sediment porewaters into the trench water (surface waters);
- Evapo-concentration of metals within the trench (surface) waters;
- Ecotoxic/bioaccumulation effects on aquatic macroinvertebrates within the trench water (e.g. brine shrimp);
- Ecotoxic effects on birds which may predate on macroinvertebrates within the trenches; and
- Food availability effects on birds which may predate on macroinvertebrates within the trenches.

Hazard Receptor Identification

The primary receptors for any potential hazard associated with chemical constituent concentrations and geochemical conditions within trench surface waters at the Lake Disappointment project have been identified as:

- Aquatic macroinvertebrates extant (living) within the trench waters;
- Birds which may predate on those macroinvertebrates.

It is unlikely that the salinity range observed in test trenches for this project (136-290 g/L TDS) would support ingestion by other terrestrial fauna for drinking purposes (ANZECC/ARMCANZ 2000).

Hazard Pressure Identification

The primary pressures for consideration by the current assessment have been identified as:

- Reduction in the availability of food for birds; and
- Reduction in the quality of the food.

Vector Characterisation

This section aims to fulfil the requirements of AS/NZS ISO 31000:2009 and HB203:2012 for Risk Analysis as well as provide the information requirements of the DotE letter dated 15th July 2016 (EPBC Ref: 2016/7727) within the identified scope.

Hydrogeochemical (including ASS) Hazard Assessment

Acid Drainage Hazard

The primary reference for characterisation of acid sulfate soil (ASS) hazard was the information provided in Pendragon (2016a). In addition, discussions with Reward Minerals (pers. conv. Dan Tenardi) regarding the extent and character of MBOs within the project area have provided more insight.

The ASS investigations to date have identified a discrete, sporadic and discontinuous MBO type sediment layer to contain the highest potential ASS risk. While the Western Australian state guidance on ASS investigations states that any samples exceeding action criteria should trigger the development of an ASS management plan (DER 2015), review of the data presented in Pendragon (2016a) clearly indicates that the risk is limited in nature and extent. Of the more than 120 samples collected for ASS analysis, across 5 sediment depth ranges, only the MBO material routinely recorded Net Acidity above the action criteria (Net Acidity above 0.03% sulfur; DER 2015; Net acidity = potential acidity + existing acidity; excluding acid neutralising capacity). Figure 1 presents the Net Acidity results (both including and excluding acid neutralising capacity) for sediment samples across the project area with outliers (i.e. results not representative of the wider distribution shown as "o" symbols). It can be seen from this figure that, within the general sediment profile to 1 m depth, there is a large difference in exceedance of the Net Acidity action criteria (DER 2015) between results including and excluding the acid neutralising capacity (ANC) of the soils (Pendragon 2016a). When ANC is taken into account the Net Acidity for the Project soils has a median value of below detection limit (<0.02 %S).

It is important to note that the MBO layer is only a thin subset of the 0.0-1.0 m profile and represents less than 1% of the 0-0.25 m depth interval, described in Pendragon (2016a) as "[30%] *of samples had a thin dark brown to black layer with organic matter at between 2 cm and 5 cm below ground level… Their thickness ranges between 1mm to 40mm with an average of 6 mm*". In addition, of the ~30% of sediment profile samples containing the MBO layer, only 47% of these (i.e. 14% of the total sampling sites) contained Net Acidity within the MBO layer greater than the 0.03% (as sulfur) after ANC. Calculations without allowance for ANC indicate that the median Net Acidity value for each soil profile depth range (i.e. 0-0.25 m, 0.25-0.5 m etc.) is below detection (Figure 1) in all except the thin and sporadic MBO material.

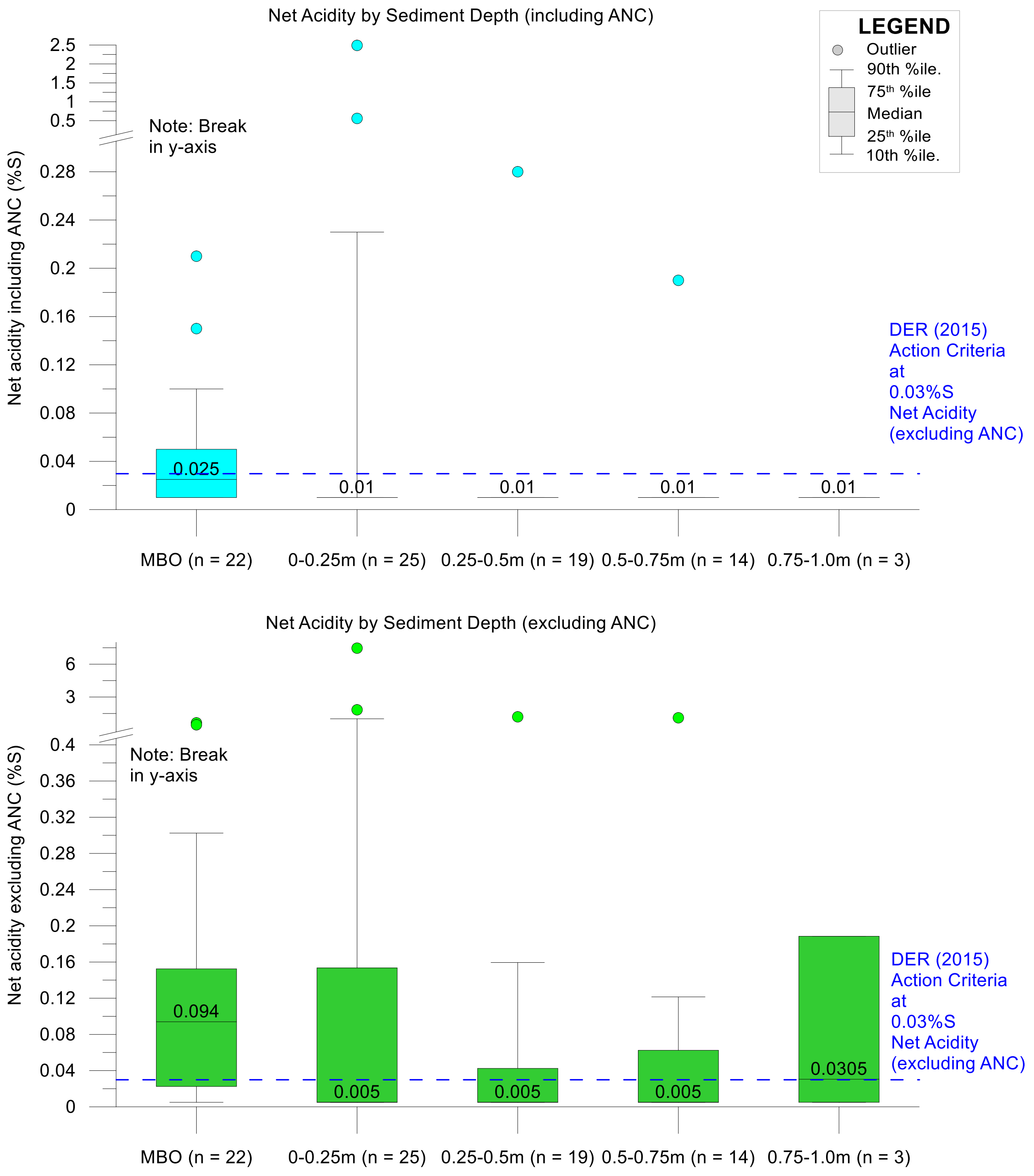

Figure 1 Net Acidity as % sulfur with increasing sediment depth, showing the guideline action criteria (DER 2015); o symbol indicates outliers (factor 1.5) – including (top) and excluding (bottom) acid neutralising capacity (ANC) respectively

Further to the analysis of the Net Acidity of sediment samples, the MBO layer has been investigated using kinetic testing. Three MBO samples were tested for 9 weeks through incubation to replicate disturbance and exposure to atmospheric conditions. Figure 2 provides a plot of the field pH (pH_f; actually a 1:5 soil:water mixture pH in the incubating laboratory) and chemical oxidation pH (pH_{fox}) range for these MBO samples over the 9 week test period. It would be expected that the pH_f and pH_{fox} values would converge over time if acid generation through oxidation of reduced sulfides within the sediments was occurring. There is little to no indication of any acid generation within these samples over the test period and therefore risk of acid drainage export.

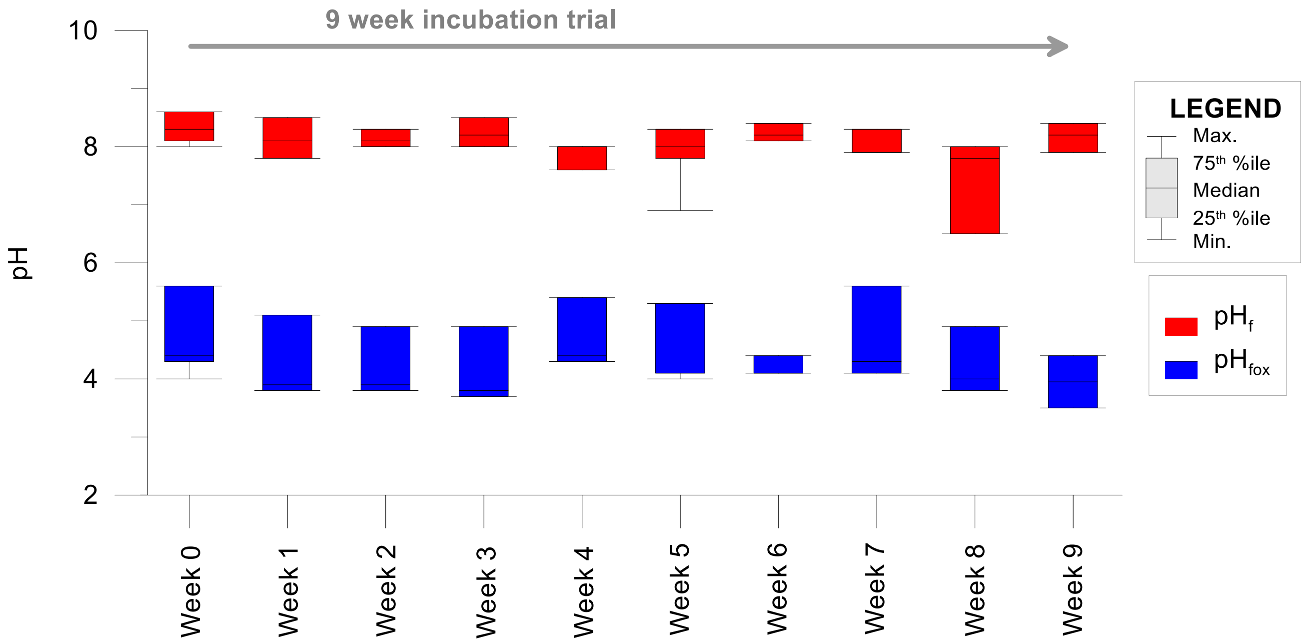

Figure 2 pH results for leachates from incubation of MBO samples for 9 weeks (data from Pendragon 2016a)

Further to the evidence provided on the amount of net acidity in the system (Figure 1) and the likely formation of acid conditions over time within the highest risk sediment strata (Figure 2), there is also indication that pH of water observed within test trenches excavated for the Project is reasonably represented by the pH_f and pH_{fox} values within the lake sediment profile. Figure 3 provides the pH_f ranges with sediment depth and, Figure 4 the pH_{fox} ranges, with test trench water pH (sediment porewater/superficial groundwater inflows) for reference. The water within test trenches had a neutral median pH (6.8) indicating that while there was localised variability, on average the potential Net Acidity within the system was not being expressed as acid drainage within the proxy operational conditions for the Project. Another consideration for the operational risk of acid drainage occurring is that the trenches being excavated for the collection and delivery of the brine (i.e. product) to the processing area are in static locations. Upon first operation, a cone of groundwater depression is likely to occur adjacent to the trenches, any oxidation of sulfides and flushing of pre-existing acidity would therefore occur as a first flush. Acids salts forming within the dewatered soil profile would not have a significant transport mechanism to the aquatic environment due to the very infrequent wetting and surface water infiltration events at Lake

Disappointment (Pendragon 2016b). Ongoing risk is likely to be mitigated unless frequent wetting and drying of the "cone of depression" occurs in conjunction with supply of sufficient organic matter to drive sulfate reduction. During operations any acidity formed within the dewatered zone, and which was transported to the trenches, would be further diluted by the product brine.

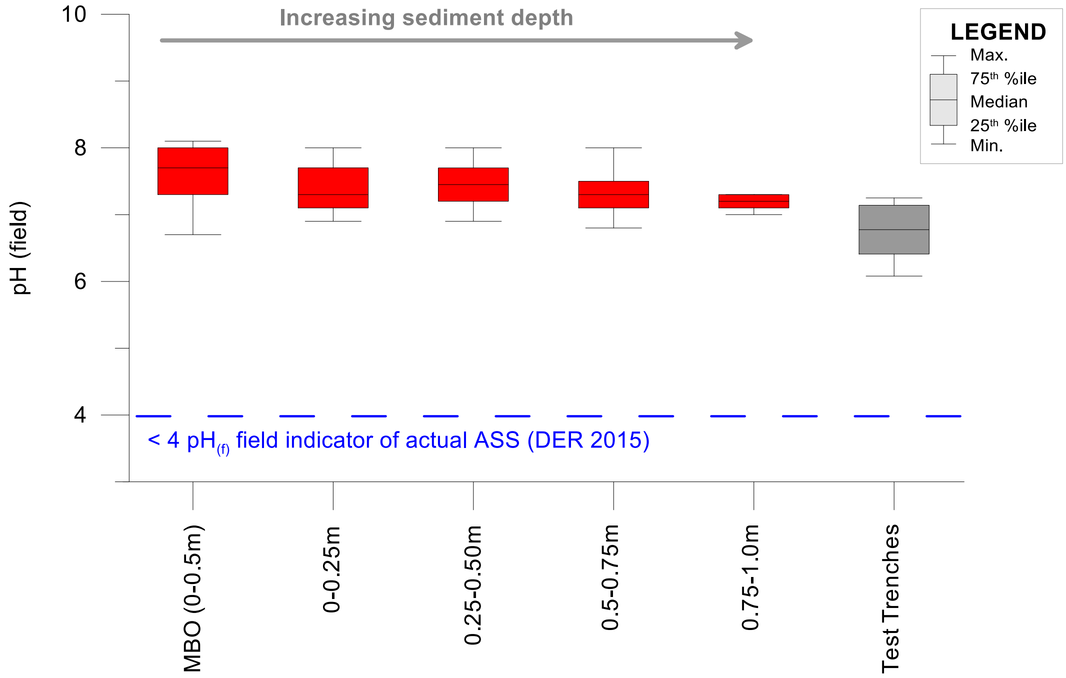

Figure 3 Field pH (pH_f) with increasing sediment depth across all sites, including test trench water pH for reference

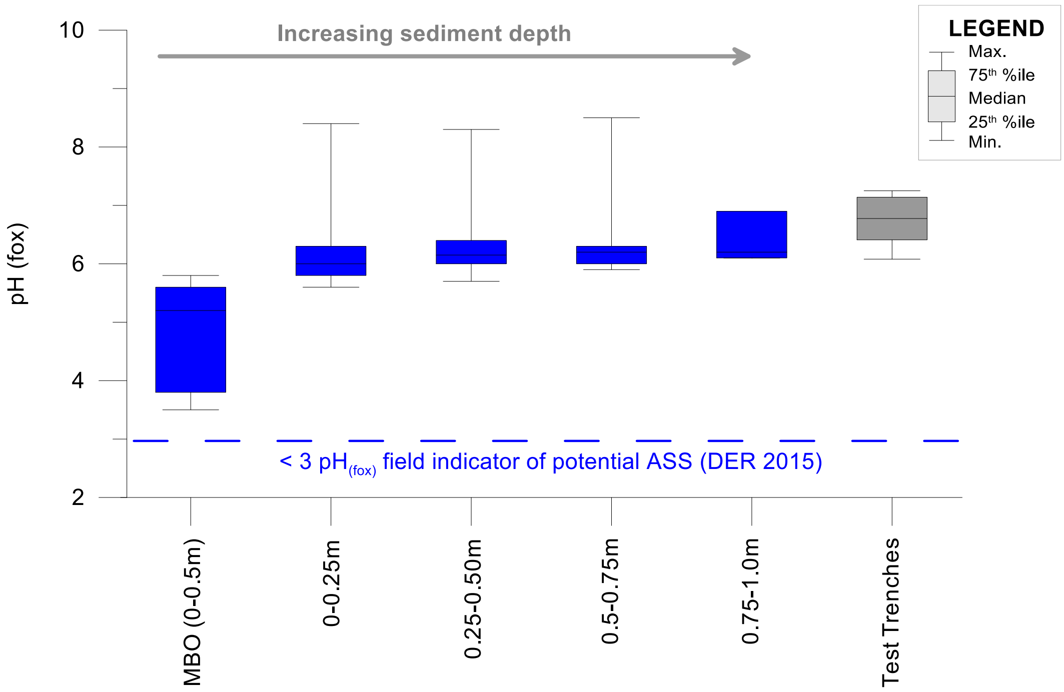

Figure 4 Chemically oxidised pH (pH_{fox}) with increasing sediment depth across all sites, including test trench water pH for reference

Metalliferous Drainage Hazard

There are likely to be two potential primary drivers of drainage containing elevated metals, including uranium or thorium, to enter the Project trenches, (1) acid drainage and (2) metalliferous drainage. As discussed in the section above, the risk of acid drainage and pH conditions reaching levels which would mobilise otherwise solid phase or adsorbed metals is considered low (Pendragon 2016a). Metals, may however be mobilised within the porewaters through non-acidity related mechanisms such as dissolution (if the porewaters become less saline) or oxidative reduction of solid phases and associated adsorbed metals. The primary solid phases of concern with respect to the release of adsorbed metals are likely to be iron and manganese oxy-hydroxides of various amorphous and crystalline structure. In lake bed systems where there is sufficient supply of organic carbon, bacterial reduction of this organic material will follow a chain of consumption of oxidants starting with dissolved oxygen. Once the dissolved oxygen is consumed, nitrates and manganese/iron oxy-hydroxides become a preferred oxidant (e.g. Emmerich et al., 2012; Libes 2009).

The concentration of solutes within salt lake basins through evapo-concentration, sedimentation and salt/solid phase precipitation is a key and defining geochemical feature of these systems. The surface waters of salt lakes of Western Australia have been found to naturally contain multiple metals above ANZECC/ARMCANZ (2000) marine guideline levels including cadmium, cobalt, chromium, copper, lead, nickel and zinc (Gregory 2007). While data on the natural level of these and other metals and radionuclides within the Lake Disappointment surface waters are limited, inference from the high salinities in the lake and test trench infiltrate water metal concentrations would suggest that the project area follows a similar pattern. The ANCECC/ARMCANZ (2000) freshwater trigger values for metals are not considered likely to be relevant to salt lake conditions, including those at Lake Disappointment, due to the extremely high salinity and suite of aquatic biota that are adapted to elevated solute concentrations. Even application of the marine trigger levels would be considered indicative at best or misleading at worst. The ANZECC/ARMCANZ (2000) guidelines states in reference to applicability to salt lakes "[There is not] *sufficient information to characterise the water quality requirements of ephemeral rivers or **saltwater lakes***" (Chapter 3, Section 3.1.2.2).

Given the very high salinity range found within the project test trenches (136-290 g/L TDS) they are likely to be a poor habitat for aquatic invertebrates with the exception of the most salt tolerant (see the section on Receptor Characterisation below). Although these levels of salinity are close to or exceeding the upper tolerance levels of brine shrimp (*Artemia* sp/*Paratemia* sp.), as a key potential food for birdlife on the lake (e.g. the Banded Stilt), an assessment has been made of the potential ecotoxicity of the trench waters to these organisms. A direct assessment of toxicity to birds has not been made as this would rely on knowing the existing concentration of metals in the lake resident prey macroinvertebrates, the relative number of prey obtained per bird from the lake and trenches respectively and, the ability of the birds to metabolise or excrete metals obtained from the prey macroinvertebrates. All of these factors are unknown. As the trenches are only a minor spatial component of the potential aquatic macroinvertebrate habitat of the lake (i.e. in comparison to the lake during inundation/bird breeding events), and they are likely to present a relatively saline and poor habitat, it is this relative loss of habitat and food abundance (were ecotoxic conditions to macroinvertebrates to occur within the trenches) which has been considered.

The most comprehensive study of the toxicology of Brine Shrimp (*Artemia* sp.) under hypersaline conditions found within salt lakes (150-320 g/L TDS) found that "*Results of this study indicate that cadmium, copper, and mercury toxicities to the brine shrimp may not be comparable at varying salinities. Findings of acute toxicity experiments were compared to other heavy metal studies on marine organisms. The brine shrimp was found to be very resistant to cadmium and copper poisoning*" (Gebhardt 1976). Lethal effects to the tested species of brine shrimp were all several orders of magnitude above levels found within the Project test trenches or well-field waters (Gebhardt 1976). It is important to characterise the hazard from metalliferous drainage in terms of the sensitivity of the local biota and existing (natural) conditions.

For the current Project, copper, lead, nickel and zinc were all found to have at least one water sample (well-field[1] or test trench) above the ANZECC/ARMCANZ (2000) marine trigger level for the 95% ecosystem protection level (EPL). However, the maximum concentration of each of these metals was at least 2 times (up to 260 times) lower than the natural range found in Western Australian salt lakes by Gregory (2007).

Copper was below the 90%EPL (0.003 mg/L) at all of the well-field sites and three of the five tested trench samples (median 0.02 mg/L, max. 0.05 mg/L). The pattern of distribution suggests that elevated copper in groundwater or lake sediment porewaters (test trenches) is localised (i.e. occurs at a wide range of different concentrations between individual sample locations) and occurs in a minority of cases. Given the referenced elevated copper levels in many salt lakes, it is likely that this is a naturally and pre-occurring condition. Artemia have been shown to be insensitive to copper below 0.04 mg/L with a lowest observed effect concentration of >0.08 mg/L (Eriksen et al 2001) whereas the ANZECC/ARMCANZ (2000) marine trigger value is 0.013 mg/L (95%EPL).

Lead was elevated (median 0.016 mg/L) above the 90%EPL (0.0066 mg/L) at all test trench sites though not within the well-field samples. While the lethal concentration for brine shrimp after 48 hours has been tested to be 1.4 mg/L at marine water salinities (Gajbhiye and Hirota 1990), the relative tolerance of macroinvertebrates within hypersaline systems as found at Lake Disappointment is unknown. Brooks et al (1995) found an 8 day LC50 of 2.2 mg/L for salt lake ostracods (*Diacypris compacta*), a genus which is also recorded in Lake Disappointment. Gregory (2007) found up to 1.9 mg/L of lead naturally occurring in Western Australian salt lakes though no data is available on the impact this level of concentration had on the aquatic fauna diversity. It is likely that the best proxy for lead tolerance within this system would be a local trigger value developed from lake surface water samples under natural conditions.

[1] The well-field refers to a series of groundwater testing/observation bores drilled adjacent to the Project area to assess local groundwater quality and suitability for Project process water supply.

Nickel was below the 95%EPL at all well-field sites and all but one (of 5) test trench sites. The 90%EPL for nickel (marine water) jumps markedly to 0.2 mg/L which is an order of magnitude above the highest nicked value recorded. Nickel is considered likely to present a low risk for the Project site.

Zinc was only elevated in the well-field (i.e. not within the lake sediment porewaters/test trenches) and only above the 95% marine EPL at 3 of 10 sites. As the well-field water would be reporting to the processing plant and the elevated salinities of the evaporation ponds, it is unlikely to be of ecotoxicological concern under operational conditions. Further, if concentrations were elevated within the groundwater feed, there are alternate wells with lower zinc concentrations from which to source water supply.

While there is insufficient data to provide a high-reliability trigger value for uranium under ANZECC/ARMCANZ (2000) for either freshwater or marine water, a discussion and low-reliability guideline is provided. Uranium toxicity is mitigated by water hardness and alkalinity, particularly in the presence of carbonates (ANZECC/ARMCANZ 2000, Section 8.3.7). Goulet et al (2015) found that while water hardness mitigated uranium toxicity for some aquatic organisms, the effect was not uniform. The waters within the Project test trenches were very hard (~17,000 mg/L as $CaCO_3$), well above those levels for which uranium toxicity has been tested in the literature. Test trench values for uranium were all below detection limit (0.005 mg/L; n = 11) as were levels recorded within brine from drilling operations (<0.001 mg/L; JRHC Enterprises 2016). The No Observable Effect Limit (NOEL) for uranium ranges widely from 0.01 mg/L in crustaceans to 2 mg/L in algae (ANZECC/ARMCANZ 2000; Section 8.3.7). There is unlikely to be a hazard associated with uranium concentrations within the Project surface waters. Additional sampling of lake waters for uranium would provide better information on natural levels within the lake.

Thorium values within the test trenches were all below detection limit (0.005 mg/L; n = 11) as were well-field samples (<0.001 mg/L; n = 7). Hinck et al (2010) conducted a literature review and found a single study on thorium toxicity to a freshwater algae species (*Chlorella vulgaris*) with a NOEC of 0.8 mg/L. ANZECC/ARMCANZ (2000) do not provide any guidance on thorium. Borgmann et al. (2005) exposed the North American freshwater amphipod, *Hyalella azteca*, to thorium and recorded an LC50 of 0.005 mg/L for a 7-day exposure in a soft water (hardness of approximately 66 mg/L) with survival improving in harder waters. Given that the study area sediments display below crustal abundance concentrations of thorium and that it is below detection in waters, it is unlikely to present an ecotoxicological hazard.

Receptor Characterisation

Macroinvertebrates

Banded Stilt (*Cladorhynchus leucocephalus*) feed primarily on brine shrimp (Johnstone and Storr, 1998) – *Artemia salina*, found more commonly in coastal wetlands, and *Parartemia* species, which provide the large pulse of food required during breeding events in inland salt lake systems. *Parartemia laticaudata* were found at several sites in and around Lake Disappointment during macroinvertebrate sampling (Bennelongia, 2016). While all lake macroinvertebrate species could constitute some prey to Banded Stilt (they may feed more diversely on other prey away from breeding sites) the larger species, such as ostracods, copepods, and nematodes (compared to the ubiquitous protozoans, or the rotifer *Proales sp*., found in most samples from the lake) are more likely to be actively hunted, through sight, probing, and scything (sweeping the bill from side-to-side in the water column).

Overall, macroinvertebrates listed from Lake Disappointment itself in the Bennelongia survey (2016) comprise a relatively small list compared with that from several other salt lakes sampled. However, in their report Bennelongia (2016) noted that "Lake Disappointment was sampled less intensively during a 'small' flood event when the extent of flooding was sufficiently small that water was being driven across the lake by wind and inundation of the lakebed was intermittent". It would be expected that in a large flood, Lake Disappointment would be likely to have a larger species list than currently documented. Therefore, the macroinvertebrate data from Lake Disappointment is insufficient to determine which prey species Banded Stilt would primarily be feeding on and in what required densities during breeding events, however, high densities of brine shrimp *Parartemia* sp. (or potentially other species) are likely to be a critical component of breeding success for Banded Stilt at Lake Disappointment.

Brine shrimp were reported to be present in one of the trial trenches, however the TDS of the trench brine had been diluted to approximately 26 g/L at the time representing around 10% of the expected operational salinity of the trenches (pers. comm. Dan Tenardi, Reward Minerals). It is possible that salinity levels may exceed the tolerance limits for brine shrimp species for much of the time, especially as the trenches become hypersaline with further contribution of saline groundwater, and due to evaporation. Salinity limits vary widely among species though tend to be in the order of 140-240 g/L for the more tolerant species (Timms 2012). The test trench waters ranged from 136-290 g/L with a median of 232 g/L. It is likely that salinity will restrict growth of brine shrimp within the trenches during operations.

The suitability of permanent water in the proposed trenches to individual species of *Parartemia* (and other species of macroinvertebrates) is uncertain. The eggs of some brine shrimp require a dry stage in between rain events, lying dormant in wetland sediment, and appearing in huge numbers within days of inundation. Trenches may therefore not provide suitable habitat beyond the first flush of water, if they are to permanently contain water, however the trenches may indeed provide suitable habitat for other macroinvertebrate prey species.

Birds

Twenty-nine species of water bird have been recorded in and around Lake Disappointment between 2012 and 2016 (Bennelongia, 2014), though many of these species were found only outside of the lake area. Arguably Banded Stilt (*Chadorhynchus leucocephalus*) is of greatest conservation significance, due to the use of the lake for significant albeit intermittent breeding events (Bennelongia, 2016; Harewood 2016; Reece Pedler, 2016). Other bird species of conservation significance are four migratory shorebirds listed under the Commonwealth legislation - Sharp-tailed Sandpiper, Red-necked Stint, Common Greenshank and Marsh Sandpiper.

Banded Stilt are a nomadic, endemic shorebird with a unique and specialist breeding strategy among shorebirds, responding opportunistically to inland rainfall and inundation of large salt lakes often thousands of kilometres away, and forming dense breeding colonies on the lake islands (Geering, et al, 2007). They are intensely gregarious and feed together in large groups. Further detail about sightings of Banded Stilt and breeding events at Lake Disappointment (both successful and failed attempts) can be found in Bennelongia (2016) and Harewood (2013), along with details of other bird species occasionally frequenting the lake.

The specific requirements contributing to the success of Banded Stilt breeding events is still poorly quantified, however it is known to be dependent on access to lake islands which protect the species from predation by foxes, cats and wild dogs, and to sufficient water and associated prey in the lake to sustain both adults and chicks. In addition to the lake, surrounding salt lakes/claypans may provide foraging opportunities whilst adults are nesting. Banded Stilts are known to spend days away from the nest foraging (Pedler et al 2016b) though the distance they may roam at Lake Disappointment is unknown. The surrounding salt lakes/claypans may also provide additional suitable foraging habitat when chicks leave the nesting areas, as the chicks are born precocial and able to walk large distances from a very young age (Geering et al. 2007). Both adults and fledged chicks then disperse to coastal and other wetlands throughout southern Australia, until sufficient desert rains refill suitable inland salt lakes, often years later. The actual mechanism by which the birds know of such rains, often thousands of kilometres away, is still unknown. The other bird species of conservation significance recorded at Lake Disappointment are Sharp-tailed Sandpiper, Red-necked Stint, Common Greenshank and Marsh Sandpiper.

Sharp-tailed Sandpiper forages in a variety of habitats and are also likely to be able to utilise surrounding wetlands for feeding. They are not likely to feed within the trenches whilst these contain water above wading depth. Red-necked Stint feed more on the exposed flats throughout the lake, and shorelines, hunting opportunistically for small, winged and other invertebrates.

Similarly to Banded Stilt, Marsh Sandpiper and Common Greenshank would also feed on invertebrates within the lake itself, through both wading and swimming. Depending on prey availability, these species could possibly just as readily feed in the surrounding smaller salt lakes and claypans, whilst water persists, but Banded Stilt may be restricted to feeding around the breeding islands in the lake, depending on the island location.

Pressure Characterisation

Although the high salinity of Lake Disappointment is the characteristic which leads to its use by Banded Stilt, this is also the factor limiting biological diversity. Trenches could attract Banded Stilt (as well as other waders of conservation significance, migratory Common Greenshank and Marsh Sandpiper) to feed, if they were of suitable water quality to sustain numbers of brine shrimp and other prey; certainly trenches, ponds and channels do not deter Banded Stilt in non-breeding feeding areas, such as sewage works and saltworks, and these areas can provide important foraging areas to shorebirds. However, salinity in the trenches discussed above would likely prevent the sustained growth of *Parartemia* and other prey, and therefore reduce the likelihood of Banded Stilt utilising these areas for feeding. Given the overall small area of impact (i.e. the trenches themselves) the absence of brine shrimp in these areas, were they not suitable for *Parartemia* species that could be present at the lake, may not be of concern. This assumes the area immediately surrounding the trenches, and the remainder of the lake, remains unmodified in terms of water quality and quantity (Pendragon 2016b).

In the context of the proposed potash project, it is assumed that a relatively continuous supply of water to the trenches, particularly after rain when the lake surface water increases the hydraulic head to promote groundwater flow into such trenches, should not be sufficient to lure Banded Stilt to the lake with expectations of breeding. Insights into the required amount of rainfall to trigger such an event, and its associated conditions, is soon to be published (Reece Pedler, pers comm). The study aims to review known breeding events in conjunction with satellite imagery of water presence and other hydrological factors, to determine the specifics of both successful and failed breeding events.

Conclusions

The hazard associated with acid drainage is likely to be low due to the limited extent and volume of acid sulphate soils and the mitigating factors inherent in the Project design.

Metalliferous drainage including the hazard associated with metals reaching ecotoxic levels in surface waters is likely to be similar in extent to that naturally occurring in the lake. The overall processes of metal accumulation in evapo-concentration dominated lake surface waters is unlikely to be substantially altered by the project. The restricted suitability of the trench waters for macroinvertebrate growth (i.e. very high salinity) is likely to further mitigate risk associated with metals. Additional lake water sampling for a range of metals would confirm this assumption.

Within the limitations of the available dataset, there is not considered to be a significant hazard presented by uranium or thorium concentrations within sediments or surface waters.

The primary receptor of ecotoxicological hazard, were deleterious water quality to occur in the Project surface waters (trenches and/or process ponds), would be aquatic macroinvertebrates in the first instance (e.g. brine shrimp) and their avian predators (e.g. Banded Stilts) as a secondary receptor. It is likely that salinity within these Project surface waters will be frequently too high to support significant quantities of brine shrimp, a primary food source for the lake ecosystem. In addition, if the lake hydrological conditions are not significantly altered (as is predicted; Pendragon 2016b), the lake surface waters will continue to provide the brine shrimp habitat which currently exists.

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