Expert advice in relation to the Environmental Impact Statement on matters relevant to aquatic ecotoxicology

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9 March 2020

I have read the Australian Federal Court Rules and Expert Evidence Practice Note and agree to be bound by it.

Here I provide expert advice on aquatic ecotoxicology (see CV) in relation to the Environmental Impact Statement (EIS) for the Sepik Development Project by PanAust. Ecotoxicology is the study of organism response to contaminants and is used in a multiple line of evidence approach to assessing risk of pollution (adverse effects) to the environment. It requires an understanding of the pathways of uptake, exposure concentrations, bioavailability and speciation, and the behaviour of contaminates in the environment over time. Ecotoxicology is also used to inform the setting of guideline values for contaminants in the environment (e.g. Australian and New Zealand Guidelines for Fresh and Marine Water Quality (WQGs) through the development of species sensitivity distribution curves and the development of levels of protection. Organisms respond to contaminants in many different ways, depending on the way they interact with their environment (e.g. how they feed, the food they consume, their reproductive stages, their biology and related ecology). For this reason, ecotoxicology assessment should consider the site-specific nature of the environment and the species in that environment that are potentially at risk.

Summary of the key issues raised by the Project EIS

In my understanding the Project consists of four components, namely the Frieda River Copper-Gold Project (FRCGP), the Frieda River Hydroelectric Project (FRHEP), the Sepik Infrastructure Project (SIP) and the Sepik Power Grid Project (SPGP). The total Project will cover approximately 16,000ha with the largest component being the integrated storage facility (or tailings dams) (~75% of the total footprint), followed by the open-pit void and haul roads, spoil dumps and the infrastructure corridor.

I understand the Project will occur in four geographically distinct areas:

1. Mine area – drilling and blasting, steep topography, high rainfall, intact biodiversity, sparse population.
2. FRHEP area - steep topography, high rainfall, intact biodiversity, sparse population.
3. Infrastructure corridor -includes the concentrate pipeline, influences from forestry with increased distance from the mine site to the norther coast
4. Vanimo Port -dewatering of concentrates

In my view, the mine area activities, the tailings storage at the FRHEP, the concentrates pipeline through the infrastructure corridor and the dewatering and loading of concentrations at Vanimo Port, (being all four geographically distinct areas) all pose potential risk to aquatic ecosystems through contaminant exposure, changing physico-chemical conditions in waterways and reduced water flow rates (noting 3,800 cubic meters of water per hour will be used for ore processing and-non-potable consumption). For this reason, my expert advice will be relevant to all four geographic areas. Impacts are likely to be variable between the construction (including road upgrades, bridge building, upgrading of the airstrip and berth construction at Vanimo Ocean Port) and operation phases (including ore extraction, processing, transport and dewatering, and tailing placement along with related activities).

Common elements of the four components relevant to my expertise include, hazardous material management and waste management (Chapter 5).

I understand the life of the mine will be 33 years (+7 years implementation period), with two large open pits where approximately 45 Mt/year of mill feed and 42 Mt/year of waste rock will be generated. Total material movement 135 Mt/year, mill throughput will be up to 65 Mt/year (8,000 t/h) and processed using crushing, grinding and floatation circuit (it is my understanding that the ore processing is an assisted physical process and does not include chemical extraction). In this case sedimentation, smothering, water clarity, changes in channel morphology, changing redox chemistry of waste rock (e.g. acid generating sulphides), and the high copper and other elements from freshly exposed ore and concentrates are factors that risk aquatic ecosystems).

The key issues raised by the Project EIS include:

1. Magnitude of the project being the four major locations mentioned above along with the many additional small activities that are not really considered in terms of environmental impact (e.g. 5 major and 16 small bridges, Ok Binai catchment waste dump).
2. Quality of ISF discharge water, sediment water interactions, and potential impacts on the downstream catchment.
3. Challenges associated with working in a region with 8,000 mm rainfall annually in terms of sediment and water management.
4. Risk of the impacts of landslides and earthquakes to the integrity of 325 km pipeline carrying Cu concentrate to the Vanimo Port. The potential for leaks and breakages resulting in concentrate (25% Cu) spill in catchments where the pipeline traverses and the environmental significance of these catchments.
5. The risk to the high biodiversity value of the area with the discovery of new species during the assessment (terrestrial (Executive summary) and aquatic (Chapter 7a)).
6. The importance of the pristine nature of the upland river sites which had an apparent absence/low abundance of non-native species.
7. Treatment and disposal of the overflow water from the thickening and dewatering of concentrate at the Vanimo Ocean Port.
8. Port expansion impacts.

Consideration of if the assessment of environmental impacts was appropriate and sufficient

After reviewing Chapter 5, 7, 8, 10, 12 to the best of my ability with my other time commitments and referring to Appendices (1, 2b, 5, 6a, 7a, 7b, 12a, 12b) I have identified some areas where the assessment of environmental impacts was limited or couple be improved.

1. <u>Waste rock management</u> – the rather extensive geochemical characterisation of the potential future waste rock concluded that acid generating capacity is mainly a function of sulphur content and alteration. Acid mine drainage (AMD), as recognised in the EIS, is a key risk factor requiring management. There is proposed to be a different management practice for the non-acid forming waste rock compared to the acid forming waste rock.

    a. Non-acid forming waste rock (around 22%) will be hauled and dumped from an elevated ridgeline in conjunction with the organic waste (pre-strip of the open pit) at a waste dump in the Ok Binai catchment. The dump is expected to gradually erode over a period of 22 years.

Elements other than Cu that are shown to be elevated in the range of drill cores (Appendix 1; Fig 28) above soil background Bi, Co, Mo. Other suggested leachates include Mn, Zn, Ni, Co, Cr, Cd it seems that this is an assessment that is an average of 7 potentially acid forming samples and 3 non-acid forming samples (Appendix 1; 7.3). It would be helpful to understand the risk of contamination of these elements in the Ok Binai catchment.

I do not understand the statement: "*Sediment eroded from the Ok Binai waste dump will report to the ISF located downstream of the dump*.' (Chapter 5, 5.21). Is this suggesting that some monitoring will occur? If so is there an action plan related to the monitoring results?

It is important to remember the commonly understood knowledge that enhanced sediment loads impact water clarity and smother benthic aquatic communities and high organic loads in waterways are likely to impact life supporting dissolved oxygen levels. I am not clear that this risk has been addressed in the Ok Binai catchment waste dump.

b. Waste rock with acid forming potential management is considered according to the International Network for Acid Prevention (INAP). It is proposed that such waste rock will be stored in a means that provides permanent water cover of the waste rock to avoid oxidation and acid generation (i.e. 'subaqueous deposition').

There will be an initial 10 months of waste rock with acid forming capacity having exposure to the air prior to the lake for the FRHEP reaching appropriate levels. The potential acid forming waste rock production that requires safe long-term storage is large, some 86% of 1,450 Mt. I note that Attachment 2a stated that '*solute release from the waste rock was estimated conservatively based on an average exposure time of 12 weeks*', which suggests that the initial exposure period of 10 months may result in solute release that would require management. Once the FRHEP reaches appropriate levels there is a fleet of barges that will apparently transport the waste rock to the subaqueous dumpsite.

In principal the planned management of the potential forming acid waste rock seems sound, however, I have raised some concerns in regards to the water quality of the ISF in later text.

2. <u>Ore Processing</u> -The crushing and grinding process plant will operate 24 hours a day 365 days a year, with a process rate up to 65 Mt/year, with two major preventative maintenance shutdowns per year. With these tasks being performed infrequently it is important to have regular training to ensure no errors are made that could be potentially be catastrophic (e.g. Recent Ramu NiCo spill was related to a mistake in a maintenance process).

a. Will the floatation reagent and frothing agent use; hydrated lime (45,300 t/y), frother (2,500 t/year methyl isobuytyle carbinal), flocculant (unknown chemical) 50 t/y, primary collector (2,500 t/y potassium amyl xanthate), secondary collector (1,600 t/y dithophosphate) be part of the tailings and managed with the tailings in the ISF or will

they predominantly be in the concentrate? Do these chemicals have any potential to impact water quality? Little seems to be known about their aquatic toxicity.

b. The concentrates (particles 80% at 15-20 µm, 26% Cu) will be transported 325 km to the Vanimo Ocean Port. This pipeline is a point of risk due to potential leakage and breakage. Is the pipe earthquake resilient, will it be monitored, what type of terrain, is there potential for tampering? The high rainfall in the area would suggest risk of landslide particularly on recently disturbed areas.

3. Tailings characterisation and placement -Appendix 2a describes the tailings character. I did not receive a copy of this but I assume that it contains some of the processing agents along with being very fine grained with a similar element signature as the raw ore, excluding most Cu and Au.

   The tailings will be transported via pipeline 10-16 km to the ISF. This pipeline is proposed to have safety features in place to detect leaks or blockages. Is it earthquake resilient? The high rainfall in the area would suggest risk of landslide, particularly at recently disturbed areas.

   Once placed in the ISF with the acid forming waste rock the tailings are expected to be covered with water 100% of the time. The ISF will essentially be a retention pond for upstream catchment activities and these activities along with the high rainfall may influence the sediment/tailings water mixing and as such consideration should be given to the multitude of risks of discharge water from the ISF for hydroelectricity generation contaminating the catchment.

4. Water management and water use -The site receives about 8,000 mm of rainfall annually. Water removed from open pits will be treated at a treatment plant prior to discharge. The level of treatment is not described. Water in the ISF facility will be at risk of contamination but will be discharged to the downstream catchment through the hydroelectric power system or via a spillway, with pulses between low flow and high flow being dependant on the operation of the facility.

   There was mention of risks to water quality in the ISF in Chapter 5 which included:
   a. low dissolved oxygen,
   b. generation of anoxic sediments which could in fact create porewater conditions that favour the mobility and solubility of metal contaminants,
   c. Nutrient enrichment from decay of flooded vegetation,
   d. Release of tailing or fine waste rock into the water column during the deposition process
   e. Scouring of fine tailings from the bottom storage during natural water inflows
   f. Release of metals from waste rock and tailings

   The assumption of suitable water quality for discharge to the catchment is of concern to me. It is a risk area that could be evaluated in more detail to gain a better understanding of contaminant composition and organism response (ecotoxicology). Furthermore, a safeguard system employing a mesocosm (small pond/stream with representative species of the downstream catchment) to test discharge water for 48-96 hr for toxicity prior to discharge would provide security to the broader catchment area by mitigating risks of aquatic ecosystem

impacts. This mesocosm systems would allow the whole of the discharge water to be assessed in a changing environment that will be influence by rainfall, turbidity etc.

5. Concentrate thickening and filtering- Treatment and disposal of the overflow water from the thickening and dewatering of concentrate at the Vanimo Ocean Port is somewhat unclear. Toxicity of the material to be disposed of has not been assessed in terms of ecotoxicological studies /organism responses. Given this will be a whole effluence and made up of a mixture of chemicals and be in freshwater going to a marine ecosystem, toxicity studies could investigate the dilution required to ensure no deleterious effects on species in the receiving environment, or at least ones to represent these species. It is stated in Appendix 12b that mechanical or chemical treatment will be employed to ensure dissolved Cu concentrations meet various guidelines values but these guidelines are based on a single contaminant. The treatment should be fully explained so an appropriate assessment can be made. The effluent will be freshwater at 30°C and will flow at a rate of 55L/s at a depth of 13m. Being freshwater water it will be less dense than seawater due to the lack of dissolved salts etc., hence it will be less likely to mix poorly and be a significant plume of freshwater/low salinity. If this very low salinity lens covers marine corals and/or benthic communities that are used to marine water which is 35 part per thousand salinity (or 3.5%) they will likely be negatively impacted.

6. Chapter 12 provides details information on monitoring and reporting, it would be good to see adaptive management strategies which engages in conversation with the community, understands their environmental values and other important aspect of space, place and aesthetic, and the way in which communities members use and interact with their environment.

Concerns related to the environmental impacts of the Project, with consideration of mitigation measures proposed

Major concerns:

1. Lack of explanation on the management of the waste dump in the Ok Binai catchment.

2. The assumption of suitable water quality from the ISF for discharge to the catchment is of concern to me. Even the estimation that 99% of sediment inflow to the ISF would remain in the ISF doesn't account for the fact that fine particles remain in suspension for long periods of time. These fine particles have a greater surface area to volume ratio and hence are able to bind contaminants more effectively than coarse sediments, thus potentially carry contaminants in suspension. Further to this, dissolved contaminants also need to be considered. It is a risk area that could be evaluated in more detail to gain a better understanding of contaminant composition and organism response (ecotoxicology). This was actually highlighted in the executive summary as a potential action (page 47) along with biological monitoring of aquatic biota in the Frieda and Sepik Rivers.

3. Transport of concentrate along a 325 km pipeline and difficult terrain highlights a risk point of pipe failure and leakage of the concentrate into the catchments and associated waters along the path of the pipe.

4. General localised elevation in contaminant concentrations and availability due to the scale of the project, i.e. potential increase in local background concentrations during construction and operation.

5. High biodiversity value and endemism (unique species) in the local flora and fauna and unknown sensitivity of these to contaminants.

6. Small activity impacts including in areas of the 5 major and 16 smaller bridges, airport construction, etc. do not seem to have been addressed and the multitude of these should be noted.

7. Landslide risk from disturbance of lands for roads and pipelines and uncertainty about the adequate management of the spoil dump (Chapter 5; 5.6.5). With 8,000mm of rainfall the spoil dumps would need to be carefully managed to avoid sediment loading in to aquatic environments. I did not find much information on how this was going to be done.

8. Minimising marine environmental impacts during the bay reclamation process at Vanimo Ocean Port does not seem to have been addressed, nor has the risk of introduced and invasive species from enhanced shipping activity.

9. The mixing of the freshwater discharge effluent and its potential toxicity at the Vanimo Ocean Port has not been clearly addressed.

EIS compliance with the Information Guidelines

Environment Act 2000 Operation Procedures section 53(2) which regulates EISs and provide that "Operational Procedures shall provide for the form, content, timing and procedures for the preparation and submission of an environmental impact statement."

To make my assessment on this matter I have applied the Fourth National Goal National Constitution PNG (in essence promote sustainable development in PNG, by encouraging socio-economic development while protecting and maintaining environmental quality by safeguarding the life supporting capacity of air, water, soil, and the ecosystems for the present and future generations) and more specifically point 3:

> *"all necessary steps to be taken to give adequate protections to our valued birds, animals, fish, insects, plants and trees"*

The Information Guidelines notes that the developer "*must submit and Environmental Impact Statement that provides a full documentation of all environmental and social issues and committing to the employment of relevant mitigation measures in relation to the development activity.*" Noting in the guidelines the Content of the Environmental Impact Statement points of responses required of the applicant and where I feel I have some knowledge to respond;

In general, I think the EIS has covered a lot of detail related to the receiving environment (guideline 6). I have highlighted above where I think this is lacking in regards to my expertise. However, some things I have noted while doing this review that may be further considered. I am not certain that noise levels associated with blasting at the mine site or traffic have been considered.

Guideline 7 focuses of waste management, cleaner production and energy balance. I know of several tailings management technologies that could have been explored including paste production where the tailings are hardened and can backfill a mine. I appreciate that this venture is multifaceted and the hydroelectricity plant is designed to complement the tailings and waste rock storage. I am just noting that I didn't see a solid review on options and alternatives.

Guideline 8 addresses environmental monitoring and reporting. It would be good to understand how the funding for the long decommissioning process can be guaranteed to ensure that the developers don't 'walk away' if things don't go to financial plans.

I also think that given the magnitude of the EIS, the four locations, the related infrastructure upgrades and transport networks it is not easy to ensure everything is covered in this EIS. For example, as noted above I am conscious of the many smaller activities and potential impacts that have seemingly been brushed over for example, bridge construction, road construction, road kills of native fauna, transfer of tailings onto barge facilities, the risk to catchments and the environmental quality of the catchments that the 325km pipeline to Vanimo Ocean Port.

Cumulative impacts of sedimentation, road development and river use (Chapter 10) are important in regards to river health as well as cumulative impacts of shipping to the ocean port area. These are highlighted in Chapter 10, however, there are no management, monitoring or reporting processes suggested to address this.

There are very many people who have worked on various sections of the EIS who are mentioned in Chapter 15 -The Study Team. Given Guideline 13, their expertise, and their contribution to the project could be explained further using template CVs and statements that demonstrate their expertise and how it was applied in the project. It would be useful to have this for future reference.

Further observations and opinions

In my opinion if the ISF were to fail there would be wide ranging and long-term environmental impacts in the downstream catchments, potentially causing irreversible damage.

I have covered my other observations and opinions in the above.