Formal response to the report entitled *Evaluation of a Buffer Zone at an Ilmenite Mine operated by Rio Tinto on the Shores of Lakes Besaroy and Ambavarano, Madagascar*

Introduction

This is a formal response to the report entitled "Evaluation of a Buffer Zone at an Ilmenite Mine operated by Rio Tinto on the Shores of Lakes Besaroy and Ambavarano, Madagascar" prepared by Steven H. Emerman for the Andrew Lees Trust UK (ALT UK) and dated August 2018. Since receiving the report there have been several correspondences between Rio Tinto and ALT UK regarding specific elements in the report as well as other related questions. This response is intended to cover all of those areas in sufficient detail to ensure there is clear and shared understanding of operations at QIT Minerals Madagascar (QMM).

Overview of the area in which QMM mines

QMM's current mining area in Mandena is situated approximately one kilometre inland from the Indian Ocean on the south eastern coast of Madagascar. The area is a littoral zone, and an estuary area is present between the mining site and the coast. The estuary area technically ceased to be an estuary after a weir was built at the system's primary inlet/outlet to the Indian Ocean in 2008. The weir was built to provide a source of fresh water by preventing the daily ebb and flow of brackish seawater inland from the tides. As a result, the estuary area is now a freshwater wetland with a relatively stable shoreline.

QMM mining method

QMM mines the sands in the area due to the concentration of the mineral Ilmenite which is processed to produce Titanium Oxide. The mineral is used as an input into a range of industrial and consumer products.

The mining process involves a dredge floating on a pond. The dredge excavates sand from the forward facing area of the mining pond, and the sand is then put through a series of mechanical processes involving gravity and magnetism to separate the heavier ilmenite ore from ordinary sand in a wet plant floating behind the dredge. The ordinary sand is then sent to the back of the pond from the wet plant to fill voids created from areas of previous excavation work. Approximately 95 percent of the sand that is excavated is returned to the pond.

Within the mining industry, rock or materials not retained for their economic value during the refining process are referred to as "tailings". This term can refer broadly to a number of different types of discarded rock or materials, and in the case of QMM it is sometimes used to refer to the ordinary sand that is returned to the pond after separating the Ilmenite. The practical difference between the sand at the start and end of the process is the absence of Ilmenite.

Dredge mining is a continuous process, the dredge pond advances as the forward face is excavated and the void at the back is filled with ordinary sand. This process does not involve stacking the sand in benches that rise above the surrounding area. The pond acts as a natural basin or bowl below the surrounding area, and as the mined areas of the pond are backfilled and closed, they are rehabilitated to return to functioning forest and wetland areas.

Water management

The mining separation process in the dredge is mechanical and does not involve chemical agents. Water and sand released from the dredge is the same water and sand entering the dredge (except the absence of the Ilmenite ore). Water in the dredge pond has a low pH and a high total suspended solids as the result of the churning action of the mining process. Any unintended release of toxic material such as operating fuels or oils are reported and resolved through standard operating procedures.

The ilmenite ore is further refined in a processing plant away from the ponds. Water used in the mining and refining process is released into a series of flow-through holding ponds where its elevated suspended solids levels are naturally reduced through retention time and particle settling. Once the suspended solids have settled, the treated water is then directed through a natural wetland cell prior to discharge back into the surrounding environment.

As noted in previous correspondence with ALT UK, water levels and quality are regularly monitored as part of standard operating procedures.

Ordinary High-Water Mark (OHWM)

The OHWM's purpose is in defining the outer edge of a body of water's (or a river's) ordinary area (or course). This characterization is independent of irregular or temporary fluctuations to area (or volume) due to floods, droughts, or tides. This provides a consistent definition of the expanse of a water body and "zero mark" for measuring distance from the shoreline to other points.

The water bodies known as Lakes Besaroy and Ambavarano were previously part of an estuary system before the construction of the weir at the inlet/outlet to the Indian Ocean. As an estuary, its shoreline was influenced by the tides. High tide in the area is approximately 0.6 metres above sea level (masl), so the OHWM of the shoreline of the estuary under normal conditions would be expected to cut a contour through the landscape up to 0.6masl.

The construction of the weir has effectively eliminated the influence of tides on the water level (note that the weir's low flow spillway is 0masl and main spillway only 1.1masl.), but 0.6m is still the practical "zero point" for mapping the shoreline of the water bodies and was (and continues to be) used as the basis of mapping the 80m 'buffer zone' between QMM's mining operations and the lakes. As provided in previous correspondence (16 August 2018) to ALT UK, monitoring data gives empirical evidence consistent with this determination. Lake Ambavarano's surface level in 2017, for example, was under 0.5masl for more than half the year, above 1masl only six times (on average for less than one week in each instance), and never above 2masl.

Hydrology overview

The mining pond surface level is maintained in a range of 0.5 metres below sea level (mbsl) to 1.5mbsl; in other words, the elevation of the surface of the mining ponds is maintained below the surface of the nearby bodies of water. This results in negative hydraulic pressure due to water's natural movement towards lower areas. As a result, under normal conditions the water is disinclined to transfer from the mining ponds to surrounding areas. More than 80 percent of the time the surface of Lakes Besaroy and Ambavarano has been more than a meter higher than the surface of the mining pond, and as shown in the 2017 monitoring data referred to above, the mining pond surface was never greater than Lake Ambavarano's surface (note that Lake Besaroy is connected to Lake Ambavarano, so their surface levels can logically be inferred as equal).

Although the target level of the mining pond is 1mbsl (in the middle of the target range referred to above), there are exceptions such as when a +2masl rise, for approximately three weeks, was required in order to float the dredge and wet plant over a rocky ridge in the mining pond.

Berm design and construction

The function of the berms between the mine pond and Lakes Besaroy and Ambavarano is to act as temporary barrier (or levee) against transmission of the mining pond water to the surrounding areas in the event of severe flooding. They are constructed from material (mainly sand or "sand tailings" as noted above) available in the area, and beyond their function as a barrier, the use of the sand is intended to facilitate post-mining rehabilitation into forest and wetland as the mining dredge moves inland away from the areas the berms are protecting.

Designating them as "dams" as a semantic alternative to "berms" does not fundamentally alter the expected function and associated risks with the structures. Semi-permanent or permanent structures such as a concrete dam would be excessive and run counter to the environmental rehabilitation goals that have been agreed with local authorities and the surrounding communities.

The berms facing the lake front of the mining zone are designed to meet Rio Tinto's Management Standard, which includes a Hazard Risk Management set of standards applied and regularly audited at all Rio Tinto managed sites globally. The Hazard Risk Management is built upon internationally recognised frameworks and codes of practice, which include among others the Risk Analysis Framework of the US Bureau of Reclamation (USBR) and US Army Corps of Engineers (USACE) and the South African National Standards SANS 10286.

Although the berms are constructed by layering sand into 4m high by 30m wide embankments, the design of the berms is an applied iterative process that includes aspects of engineering, geotechnical, structural and hydraulics, economics, hydrology, environmental and social principles and criteria, experience and monitoring, amongst others to ensure hazard risks are safely managed and controlled.

For the lakefront berm, attention has been paid to hydraulic and stability issues, in particular. The excavations and construction of the berms is short-term, temporary and transient and typically work is operational for no longer than three to four months in an area as the dredge and pond progress through the mining area.

The design contains an analysis component that is used to assess the conditions numerically using the Factor of Safety (FoS) approach. The FoS is an assessment of the state of the slopes (in this case) through a model based on the limiting conditions of shear strength of the materials and the hydraulic conditions. The parameters chosen for the shear strength are assessed from the vast database of information available from site materials and experience over some 10 years of operation. The parameters used are the minimum (conservative) values for the sand strata present and the most adverse water table levels applicable to the section being constructed. The sands on site are consistent in terms of their shear strength (friction angle - as would be expected from material of this type), meaning there is a low margin of error around average values.

As an operating site there is the added advantage of routine inspection of actual conditions to assess and update performance expectations making the iterative design process robust. The limit equilibrium program SLIDE (RocScience, Canada), an industry standard software code, is used for this numerical work, which is used by site staff for routine (daily) calculations. SLIDE also has the ability to calculate the Probability of Failure (PoF) from statistic data sets defined by a range of probability density functions. This method is used when considered necessary.

The conditions along the lake front area are consistent and controllable throughout. As noted in previous correspondence, even if slope stability issues were to develop in the berms (which they have not), the consequence could not physically (or logically) result in a breaching into the lake because the slope crest could not physically recede backward through the full width of the berm and would be confined to a narrow failure in close proximity to the mining face. It would only occur in this area because of the underlying slope grade and presence of water as a result of the excavation of sand near the mining pond shoreline. Any issues of this kind would be reported and remedial incident responses would be initiated according to standard safety and risk procedures. The lakefront side, on the other hand, has no such risk given the absence of excavation activity and standing or flowing water.

Berm risk analysis and design

The primary risk of failure for the berms is overtopping as the result of flooding from heavy rains from tropical storms or cyclones. These are events that can be predicted through weather forecasting and evacuation procedures would be initiated in circumstance in which a significant failure of the berms became possible. Under normal operating conditions the risk of significant failure is unlikely given the mining pond surface is below the surrounding topography and the berms are not under routine hydraulic pressure. Moreover, the design height of the berms of 4masl is greater than the estimated flood levels on either side of the berm, making overtopping an unlikely risk. The Regional Maximum Flood level estimate for the lakes is 3.45masl.

The berms have been constructed to meet Rio Tinto’s D3 standard (Management of slope geotechnical hazards) and complies with Malagasy regulatory standards. Probabilistic analysis of the berms assuming the largest flood levels that could conceivably occur in the lakes or by varying the dredge pond levels produce negligible probabilities of failure.

As part of Rio Tinto’s regular internal review process, the technical services division has recommended the berm designs be reassessed against Rio Tinto’s D5 standard (Management of tailings and water storage), which applies more stringent flood and seismic criteria. An action plan is in place to verify the berm design conforms to D5 and to remedy any gaps in the design before the end of 2019. The berms will be rehabilitated as forest and wetland area, so the design should mitigate post-closure risks in addition to current operating risks.

Rio Tinto’s standards require hazard planning even for exceedingly rare events, and this is managed through a Trigger Action Response Plan (TARP), as noted in previous correspondence to

ALT UK. The trigger criterion set in QMM's TARP for when to evacuate personnel from the mining pond area during a flooding event is 1:50 year flood levels. Even under this criterion the flood levels peak 2m below the top of the 4m high berms. Cyclone Enawo, for example, in March 2017 triggered a pond evacuation based on wind speed, but the lake level only reached 1.73masl.

Berm and Buffer zone definitions – Malagasy Regulations

The Republic of Madagascar's inter-ministerial Decree N° 4355/97 provides for a generic 80m zone around sensitive water bodies such as lakes and lagoons for the protection of surface water. Although the Decree does not refer to a "buffer zone" the term has been generically applied in the development of the QMM mitigation and management measures adjacent to the lakes.

The OHWM is important in determining the starting edge of the buffer zones around the water bodies, and this is determined as part of the environmental impact assessment and mine planning. This includes an assessment of areas of greater or lesser sensitivity within the buffer zones. As noted above, the OHWM of Lakes Besaroy and Ambavarano are naturally inferred from their histories as estuary bodies and the ordinary high tide in the area, which is 0.6masl. The 0.6masl contour has been used as the starting edge of determining the 80m buffer zone around those bodies of water, and the 0.6masl contour has been mapped using ground calibrated aerial LIDAR survey data.

QMM has been authorised and permitted by the Madagascar regulatory authority, the National Office for the Environment Ministry (ONE), to implement the general buffer zone at Mandena with a 30m berm (crest width) which, in addition to acting as a barrier against transmission of water during flooding events, is used to flank the mining pond/dredge operation area and to allow for the placement of anchor points for the dredge and wet plant, pipelines and power supply services, and other required infrastructure, including access roads for servicing and monitoring purposes.

Decree N° 4355/97 does not prevent work within a sensitive zone to take place, but it instead requires an Environmental Impact Assessment (EIA) is undertaken and agreed and authorised by ONE prior to any work occurring. Whilst work in sensitive zones is avoided whenever possible, it is recognized and accepted that under localized and limited circumstances where the risk to the aquatic system is sufficiently mitigated that necessary work may be permitted.

As noted in previous correspondence with ALT UK and outlined in the 2014-2018 SEMP, most of the lakefront berm is constructed outside the full 80m buffer zone. However, as also previously documented, consistent with the application of Decree N° 4355/97, QMM received permits from ONE to place portions of the lakefront berm up to 50m away from the lakes at five "pinch points".

Encroachment into buffer zones

As previously noted in the analysis conducted by Ozius Spatial and provided to ALT UK in 2018, there were two sites along the lakefront buffer zone in which QMM conducted work activities. The work in these areas did not involve mining as the term might be commonly understood of extracting ore, but it produced disturbances as the result of mine infrastructure construction and support activities. Nevertheless, in keeping with global industry terminology, it is correct to describe it as mining activities.

Site 1 was an access area to a licensed pumping station that is no longer used. QMM retains the permit for activity in the area for potential future use of the pumping station if required. This area has been left to regenerate with wild vegetation.

The work in Site 2 involved disturbances from piled (or layered) sand related to berm construction from December 2014 to January 2015. As documented previously, there was an attempt to construct the section of the lakefront berm in this area using the sand ordinarily pumped from the wet plant back into the dredge pond (as noted above this sand is also broadly referred to as “tailings” or “tails”). This proved an ineffective method of berm construction given the reduced viscosity of the wet sand and the narrow area between the dredge pond and the permitted 50m buffer zone boundary. It ultimately resulted in the disturbances beyond the permitted 50m boundary in the area.

As confirmed in the Ozius Spatial analysis, the encroachment of sand extended past the 0.6m OHWM contour line of Lake Besaroy in this area. The piled sand ran approximately 300m wide at an average distance past the contour line of approximately 22m. This resulted in encroachments past the permitted 50m buffer zone up to 90m in some places (in other words, 40m past the 0.6m OHWM contour). To put into perspective, the encroachment due to the berms covered an area of approximately 0.67ha (the Ozius Spatial analysis identified another 0.36ha of disturbances as the result of a community access road in the same area). The dredge typically mines 40ha to 60ha in a year.

The sand was subsequently re-shaped towards the mine to the required berm design and planted with fast growing species to rehabilitate the vegetation in the area, and trucking of dry sand, which offered greater control over the sand placement, was implemented for berm construction. As noted in previous correspondence with ALT UK, QMM raised the disturbances at Site 2 with ONE subsequent to the Ozius Spatial analysis, and ONE inspected Site 2 in September 2018. ONE assessed the impact of the encroachment in the area as negligible and did not issue any regulatory actions.

The encroachment at Site 2 was an unintended occurrence that has produced several important learnings. To ensure encroachments do not reoccur as the dredge pond progresses, survey controls are in place for determining berm position and dimensions, and field survey marker flags placed to indicate the buffer zone boundary. There are daily inspections of compliance with the boundaries, and controls in place to limit access ahead of the dredge pond for brush clearing and berm construction to trained, authorised personnel only.