DAM SAFETY REVIEW

Mount Polley Mine
Likely, British Columbia

DRAFT
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Submitted to:

Imperial Metals Corporation
200 – 580 Hornby Street
Vancouver, BC

Submitted by:

AMEC Earth & Environmental Limited
Burnaby, BC

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SUMMARY

A Dam Safety Review (DSR) has been carried out for the tailings storage facility (TSF) at the Mount Polley Mine in British Columbia. Though the mine has had a consistent dam safety inspection program and two independent reviews of the facility, this was an initial formal DSR for the mine which was recently restarted operations after a hiatus of several years during less favourable economic conditions.

The DSR was carried out in compliance with tailings dam specific dam safety classification guidelines Ontario Dam Safety Draft Guidelines though consistency with the Canadian Dam Safety Guidelines and British Columbia guidelines was an evaluation requirement. The evaluation is also considered compliant with the provisions for dam inspections from the Mining Association of Canada (MAC) Guide to the Management of Tailings Facilities (MAC, 1998).

In general, the Mount Polley TSF is a well-designed and well-constructed entity from a dam safety perspective with each of the three dams present showing similar good performance behaviour with little indication of potential concerns in the future. There are some operational concerns/issues that could be better addressed to optimize both the operating condition of the TSF as well as facilitate more successful closure consistent with stated closure objectives.

The DSR addressed all of the key elements required for a review of a tailings dam. From the DSR, it can be concluded that:

- The overall impoundment includes a consistent dam cross-section and no dam safety issues of concern have been noted in the comprehensive documentation available for the relatively new facility.
- The embankment cross-section is relatively complex but documented records and observations of the construction controls during this DSR indicate that this has not caused any concern to the to date development of sound dam sections.
- The reliance on constructed drainage measures post closure is unclear in the documentation reviewed and should be clearly stated in all future dam safety documentation (inspections and reviews).
- The South, Main and Perimeter embankment dams form a contiguous crest and toe footprint that is robust in terms of mass, material and, to date, monitored performance.
- Dam surveillance and operations protocols appear to have been followed appropriately in comparison to original design recommendations.
- Monitored results are evaluated on a “plane by plane” basis and overall trends in terms of seepage and/or drainage efficacy are not being tracked (or at least reported).

- The dam designer is being appropriately engaged in the ongoing construction and operational planning for the TSF.

- Operating criteria for pond and beach management are presently at odds with optimal dam seepage performance and closure expectations.

- The amount of wave induced freeboard being allowed for is likely excessive.

- The lack of determination of the nature of potential preshearing in the glaciolacustrine foundation leads to uncertainty in terms of present and post closure stability condition and commensurate the need, or lack thereof, of the closure toe berm presently in the mine's plans.

- The recommended ratings from this DSR were based upon their highest incremental consequence, which was deemed to be environmental impact in all cases. Potential threats to public safety or non-TSF infrastructure were both considered negligible.

- The dams require continued annual dam safety inspections and, given the excellent manner with which these have been completed to date, it is recommended that the original designer continue in this function. Assuming a continuance of operations, the next DSR should be carried out not later than 2011 or during detailed closure design, whichever is earlier.

The mine has a recent and thorough Operation, Maintenance and Surveillance (OMS) Manual for the TSF. This OMS Manual should be followed explicitly in terms of operational practices (including development and maintenance of tailings beaches) and reviewed during each annual DSI and updated as required.

In general, between the programs in place, the expertise of the site personnel tasked with dam safety and the inclusion of the original designer of the facility throughout the operating life of the TSF, the Mount Polley TSF is adhering to an excellent dam safety program.

Finally, the Mount Polley OMS clearly states the following is explicitly required on a DSR:

- *The consequences classification of the dam* – RATING HERE
- *The adequacy of past annual inspection practice, the annual inspection recommendations, and their implementation* – The annual inspections are thorough. There are minor upgrade suggestions present in terms of data presentation (piezometer information)
- *The Operation and Maintenance Manual* – The 2006 Mount Polley OMS for the TSF is……….
- *Timing for the next regular DSR* – approximately 2011 as described above.

1.0 INTRODUCTION

This report presents the findings of a dam safety review (DSR) carried out for the tailings storage facility at Imperial Metals Corporation's Mount Polley Mine near Likely, British Columbia.

AMEC Earth & Environmental Limited (AMEC) carried out the DSR at the request of Imperial Metals. The on-site period for the DSR was 5-6 October, 2006, inclusive. Mine site personnel, in particular Messrs. Ron Martel and Matt Silbernagel, assisted the DSR process and complete access to documentation and the Tailings Storage Facility (TSF) was provided. As the Environmental Superintendent, Mr. Martel also coordinated the overall DSR on behalf of Imperial Metals. The AMEC DSR engineer was Dr, Michael Davies from AMEC's Burnaby, British Columbia office. Dr. Davies is an experienced tailings dam safety engineer and is registered as both a Professional Engineer and Professional Geoscientist in the Province of British Columbia (No. 16408).

The overall objective of the DSR was to evaluate the safety of the Mount Polley TSF from the perspective of the current and the future (expected) dam conditions and, if required, make recommendations as to the necessary means to maintain the dams in adequately safe conditions consistent with the regulatory requirements and the current engineering standards.

The Mount Polley Operation, Maintenance and Surveillance (OMS) Manual, updated in 2006, is a thorough document that includes the mine's own perspective on the DSR process as follows:

> *The principle objective of a Dam Safety review (DSR) is to ascertain that a dam has an adequate margin of safety, based on the current engineering practice and updated design input data. A DSR may also be carried out to address a specific problem.*
>
> *A qualified engineer will be responsible for conducting each DSR at the Tailings Storage Facility. The engineer conducting the DSR must be qualified to conduct safety evaluations and be familiar with the designs and other site-specific conditions and requirements pertaining to operations of the impoundment and associated facilities; but ideally should not have been involved in the design, construction or operation of the TSF.*
>
> *Routine DSR's at the TSF will be carried out every 5 years but this scheduling requirement should be confirmed or revised at the time of each annual inspection. The next DSR for the TSF is scheduled for 2006.*
>
> *A detailed scope of work for each DSR will be defined by the engineer prior to conducting the review, and be consistent with current engineering practice at the time it is conducted. Each DSR will evaluate the safety of the TSF and incorporate a detailed review of the following:*
>
> - *The consequences classification of the dam;*

- *The adequacy of past annual inspection practice, the annual inspection recommendations, and their implementation;*
- *The Operation and Maintenance Manual;*
- *Timing for the next regular DSR.*

Each DSR report should include conclusions and, if necessary, recommendations pertaining to the safety of the TSF. Copies of the DSR will be sent to the Environmental Superintendent and the Ministry of Energy and Mines for review. Similar to the annual inspection report, an action plan should be prepared by the Mill Superintendent to address the DSR recommendations. A copy of each report will be sent to the Ministry of Energy and Mines and will also be available at the site and at the office of the Design Engineer.

According to the Canadian Dam Association (CDA) Guidelines (CDA, 1999) and the draft Ontario Dam Safety (ODS) Guidelines (1999), the objectives and scope of the DSR may be defined as follows:

> *The DSR includes a review of the design, operation, maintenance, surveillance and emergency plan, to determine if they are safe in all respect, and, if they are not, to determine required safety improvements. A DSR is a systematic evaluation of the safety of a dam, by means of comprehensive inspection of the structures, assessment of performance, and review of the original design and construction records to ensure that they meet the current criteria. Special attention should be given to those areas of design and performance having known or suspected weakness or which are crucial to dam safety. The level of detail required for a DSR should be commensurate with the importance, design conservatism and complexity of the structure, as well as with the consequences of failure*.

The ODS Guidelines are noted only insomuch as they remain the only Canadian regulatory published set of dam safety criteria that implicitly addresses the nature of actual concerns for tailings dams versus other types of dams. Specifically, the ODS Guidelines include environmental concerns in a manner consistent with the concerns that tailings impoundments bring to both owners of these facilities and their regulators.

The Dam Safety Review process can vary in terms of approach and reporting style as long as three fundamental components have been adequately addressed. These fundamentals are:

1. The dam(s) are appropriately evaluated in terms of a thorough visual inspection (DSI), a review of salient documentation and a review of any relevant monitoring information (e.g. piezometers or inclinometers) as they relate to the safety of the dam(s).

2. Potential failure modes for the dam(s) are recognized and tested against the available information to determine what, if any, of the candidate failure modes may be possible given the as-evaluated state of the dam(s).

3. The dam(s) is provided a classification in terms of its potential:

- Environmental Impact(s)
- Economic Losses
- Loss of Life

2.0 BACKGROUND

2.1 General

The Mount Polley mine commenced production on 13 June 1997. The mine operated until October 2001. The mine was on care and maintenance status from October 2001 to February 2005 when it was restarted.

Ore is crushed and processed by selective flotation to produce a copper-gold concentrate. The mill throughput rate is approximately 18,500 tonnes per day (approx. 6.8 million tonnes per year). Mill tailings are discharged as slurry into the TSF located on the south area of the Mine property.

2.2 Relevant Documentation to DSR

A comprehensive set of design, as-built and annual inspection documents relevant to the tailings storage facility were made available for review. A list of these reports is provided in Appendix A. Included in this appended listing are commentary notes made during the review of these documents.

2.3 Existing Dam Safety Program

2.3.1 Dam Safety Inspections

There have been annual inspection documents …….

2.3.2 Dam Safety Reviews

This current DSR is the initial one for this facility.

3.0 DAM SAFETY EVALUATION

3.1 General

The available records/information on the original design and construction of the Mount Polley tailings embankment dams is thorough and meets current practice expectations. This record of original design and construction has been augmented, as shown in Appendix A, with ongoing inspections and construction monitoring by the original dam design team. This has created a current, and comprehensive, database for a DSR. Coupled with the site inspection of the facility, which included viewing raise construction, an effective DSR was provided sufficient information to proceed.

The format of the DSR was chosen to, per Section 1, see if there were any deficiencies in overall dam safety from a design, construction or operating perspective that could impart undue risk to the mine and/or overall corporation. To meet this objective, the 2006 DSR included a step-by-step evaluation of various dam safety issues. For completeness, these issues are presented below in summary form:

- Static Load, Hydrologic, Seismic and Other External Loads – .
- Environmental Conditions – .
- Engineering Analyses and Design – .
- Dam Structures –.
- Discharge Facilities – .
- Dam Instrumentation – .
- Upstream of Dams – no indicated potential factors to influence dam safety such as failure of another facility impacting the tailings area. There was noted sufficient storage/dam raise potential should a problem with the backfill plant develop.
- Runoff Management System – no major issues. On many of the dams themselves, erosion gulleying from runoff (and high phreatic conditions) continues to move tailings downstream beyond the starter dams.
- Downstream of Dams – build up of fines from erosion creates tailings storage outside of formal North/South Basin impoundment. This is a potential regulatory, and not a dam safety, issue unless there is off-site environmental impact.
- Past Performance and Failures of Dam – no significant failures have occurred since 1998 (last “DSR”). There was a minor surficial slump on a starter dam and various “operational challenges”.

- Review of Tailings Dam Operations Manual – appears appropriate for nature of the dams and production rates. The plan needs to be appropriately updated for any changes in instrumentation or monitoring protocols that may arise following responses to the issues raised in Appendix C.

- Trigger for Additional Dam Inspections – use of the Modified Mercalli earthquake intensity classification system is recommended (Appendix D). Any event deemed VII or greater would indicate need for an immediate dam safety inspections above/beyond the annual requirement. Any 24-hour rainfall storm event deemed to have been of 1 in 100 year, or lower statistical probability, would also trigger an immediate inspection.

Table 3.1 - Most Significant Potential Failure Modes Applicable to Strathcona Dams

Mode	Description
Slope Instability of Containment Structure	
Shear failure of the slope, including failure through the foundation due to self-weight of structure and elevated water levels in the containment structure	Excessive loading of the crest or a weakness in the foundation or within the containment structure can lead to a failure of the slope or failure through the foundation. Excessive loading can develop during construction or when raising the structure. The passage of heavy trucks over the crest of the containment structures can generate excess pore water pressures in the foundation or structural fill and trigger a failure. Similarly, a raise in the reservoir water level may lead to an excessive load and/or increased pore pressures, and consequently a dam failure. Weakness of the foundation soil or dam material can develop through softening of the soil over time or an increase in water pressures. This can involve "static" liquefaction. Rapid draw down of a pond on the upstream side of the containment structure can result in slumping of the upstream slope, which, if large enough, might lead to a dam failure.
Sliding due to tailings and/or water load	Tailings and/or water on the upstream face of the containment structure can exert a lateral force causing it to slide in the downstream direction. This is particularly true if there is a near-horizontal plane of weakness within the structure or foundation. In addition, water against the upstream slope can lead to elevated pore pressures and excessive seepage forces.
Slumping due to earthquake	When an earthquake occurs, it applies cyclical horizontal and vertical forces on a containment structure. The increased horizontal forces can reduce the stability of the structure and result in deformations that could lead to overtopping and/or damage to the internal seepage control elements. In addition, the cyclic action can cause tailings to liquefy. If the tailings upstream of a containment structure liquefy, then the tailings can lose a significant portion of their strength and act as slurry exerting a significant lateral force on the structure.
Bearing capacity failure of a structure into tailings due to liquefaction of tailings	Liquefaction of the tailings can occur if the tailings are loaded too quickly during construction. As fill is placed over the tailings, excess pore water pressures are generated that dissipate over time. If the rate of loading is faster than the dissipation of pore pressures, then liquefaction can occur and the tailings would a significant portion of their strength. This loss of tailings strength would have a direct impact on the stability of structures built on

Mode	Description
	tailings, resulting in reduced factor of safety against a bearing capacity failure into the foundation and leading to an overall failure of the structure.
Slumping due to rapid draw down	If the level of the pond is drawn down rapidly, then the slope of the dam could slump. A rapid draw down event could occur if there is a sudden loss of pond contents.
Flooding	
Overtopping	Overtopping of the containment structures can occur, typically during an extreme flood event and/or when a spillway becomes blocked. Waves that are generated at high reservoir levels may also lead to erosion of dam crest. This could lead to progressive erosion and ultimately, a dam breach that could release of a significant amount of the contents stored by the containment structure.
Surface Erosion Leading to Uncontrolled Release of Tailings or Water	
Excessive gullies in downstream shell due to overland runoff	Runoff resulting from rainfall and/or snowmelt can flow down the slopes of the structures or abutment contacts and incise gullies in the shell of the structure. If the gullies are left unattended (i.e., not repaired), then the gullies can become large enough to trigger a slump by over-steepening portions of the slope locally. The local failures could trigger an overall failure of a dam (dam breach).
Erosion of upstream slope and crest	Wave action can cause significant erosion (e.g., benching and/or slope undercutting) on the upstream slope and crest of a containment structure even under normal operating pond levels. If left unattended, the erosion could progress in the downstream direction or lead to an over-steepened upstream slope that could fail locally. Either mechanism could result in a dam breach.
Internal Erosion	
Internal erosion (piping) through the containment structure	Seepage through a containment structure can mobilize material from within the structure and transport it downstream if there is no suitable filter zone to inhibit movement of solids. The removal of material will begin at the downstream face and continue in the upstream direction until a "pipe" or channel has formed through the containment structure, which may lead to dam failure.

Mode	Description
Internal erosion (piping) through the foundation	Seepage through the foundation of a containment structure can be complex with the seepage velocity varying in different soil and rock units and the contact between units that are variable and not filter graded. Piping in the foundation could lead to a loss of contents through the base of the facility, resulting in strength loss and pore pressure increase. If the piping occurs at the toe of a containment structure, then this could undermine the toe, lead to local slumping of the toe area that could, in turn, result in a failure of the structure through slumping/sliding of the downstream face.
Internal erosion around pipes through the structures	Seepage can occur along the outside of pipes installed through containment structures (e.g., culverts or decant pipes, active or abandoned). This can be a preferential seepage path because of poor bond or control of material placement along the pipe during construction and improper seepage control measures along the pipe (or the lack of such measures). Such seepage could result in internal erosion (piping) through the containment structure similar to that described above.
Collapse of Pipes Through Structures	
Collapse of pipe	Pipes through the containment structures can deteriorate over time and collapse. Old and damaged (i.e., rusted, broken) pipes that have not been properly plugged and backfilled can result in the following: loss of dam fill into the pipe; loss of pond contents through the pipe; and/or development of a preferred seepage path along and through the pipe that could result in uncontrolled seepage through the containment structure, and eventual failure of dam.

Slope Stability

Available Stability Assessments

Table 4.2 summarizes the available documents addressing stability issues for dams within the overall complex. Given the number of dams, there is a notable lack of detailed evaluation reports and certainly no overall document addressing the stability of the various dams.

Table 4.2 – Stability Evaluations and Summary Information

Dam Name	Reference and Summary of Stability Evaluation
Various	Golder (March 1991) Waste rock and other granular fill – ø = 40º Foundation Silts - ø = 28º

Dam Name	Reference and Summary of Stability Evaluation
	Low phreatic surfaces – FS = 1.6 High phreatic surfaces – FS = 1.3 "No seismic concerns at 0.2 g"
Cranberry Lake Dams (not part of this DSR but used for example on criteria and parameters)	Golder (February 1998) Waste rock and other granular fill – ø = 35º Foundation - ø = 35º Fully efficient core – FS = 1.5 Seismic coefficient of 0.1 g
Strathcona Tailings Dykes 1 and 2	Cell 1 = ± 3 m (above tailings) Cell 2 = ± 3.5 m (above tailings)
Dam 3A	Golder (December 1997) – "a rigorous stability analyses has not been carried out for the conceptual design since the stability of the dams will be largely dependent upon the foundation improvement technique utilized" Golder (January 2002) – "based upon the very loose state of the existing (foundation) tailings, liquefaction of the foundation tailings under the crests of Dams 3A and 3B, or under a 5 metre toe berm, is likely following a design earthquake event. Foundation improvement or densification of the tailings will be required to maintain stability of the dams and containment of impounded tailings upstream" Stability evaluation (Golder January 2002) showed post-earthquake FS = 0.3 (failure)
Dam 3B	Per dam 3A

One of the most concerning aspects of the review of available documents, a concern summarized in Table 4.2, is with respect to the foundations for Dams 3A and 3B. These dams were designed and constructed without seemingly a clear focus on the potential for the foundation issues related to potential undrained shearing and subsequent liquefaction. While Golder (2002) in their re-evaluation of the as-built dam identified the concern, a static liquefaction concern is also likely (and could be showing signs of manifestation as described in Section 4.4.2.2) let alone the clear concern for the design seismic load.

Summary Slope Stability Dam Safety Concerns

In terms of potential slope stability concerns relative to the modes of failure deemed possible for the dams at the site, the following concerns are present:

- Dam 3 A – active sand boils at the toe of the dam and excessive seepage are potential internal erosion concerns (noted in Section 4.3.5) and the embankment stability could be compromised due to a foundation condition that is far weaker than assumed in the design process (no upward gradients assumed in design documents). Also, as summarized in Golder (2002), there is liquefaction susceptibility in the foundation soils to both Dams 3A and 3B. While not addressed in project documentation to date, static liqueifactrion is also a concern beyond the post-earthquake concern noted in Golder (2002).

- Dam 3 B – similar concern to Dam 3 A.

- Fecunis Lake Tailings Dam – though it is beyond the scope of this DSR to have completed stability analyses, the downstream slope of the dam is judged to likely be steeper than would be consistent with the limit-equilibrium design criteria provided in Appendix B (e.g. Factor of Safety 1.5).

- Neutralization Pond Dam exposed upstream slope is steeper than is likely consistent with long-term stability expectations/requirements.

In an overall sense, there is a lack of clear design documentation, design criteria and current stability evaluations for each dam. While the construction records available show a fair degree of detail and engineering supervision, the inclusion of tailings in the foundation of Dams 3A and 3B, relatively recently constructed, that was later shown by the designers to not be capable of withstanding earthquake loading is a potential sign of an overall lack of a dam safety strategy in terms of physical stability issues. Furthermore, with both Dams 3A and 3B, the tailings foundation appears to be weakening due to excessive seepage. Sand boils in the dam toe areas suggest transmission of high pore pressures and foundation weakening in the dam foundation.

Flooding

Appendix D presents the potential result of a dam breach leading to an extreme downstream flood impact. One of the most critical failure modes that can lead to such extreme events is overtopping due to poor water management within the dam's impoundment either due to a lack of an effective and maintained spillway or general loss of containment due to inflows simply overwhelming storage potential.

For the dams evaluated as part of the DSR, there were some dam safety items noted relative to water management that are worthy of note for the following dams:

- West Morgan Lake Dam: The emergency spillway that would be required to avoid overtopping of this dam is located on the right abutment of Dam 3B which is quite a distant from West Morgan Lake Dam which itself has no spillway. Depending on the sequence and location of tailings discharge operations, there is potential isolation of the pond behind West Morgan Lake Dam from the water pond behind Dam 3B and the spillway.

- Dam 3B: While the majority of the emergency spillway is excavated in rock, some portions of the channel (upstream of the sloping discharge channel) appear to be located in overburden and lined with rockfill riprap over geotextile. There is also concern for potential beaver activity at the spillway channel and the culverts discharging out of the energy dissipation pond at the spillway toe.
- Strathcona Creek Outlet Dam: Head Pond is full of erosion debris, sediments and sludge, limiting the storage capacity of the pond and increasing the possibility of blocking the control structure.
- Fecunis Lake Tailings Dam: Intake to the concrete decant is not equipped with trash racks and there were no stop-logs present during the DSI site visit. The tailings surface adjacent the tower was at the same level as the intake invert creating the potential for tailings to flush through the system during high runoff conditions.
- Neutralization Pond Dam: It may not be possible to remove the stop-logs under high flow event as no lifting mechanism present.
- Causeway Culvert between the Neutralization Dam and the Polishing Pond Dam may fail unexpectedly due to corrosion of the metal culvert with the potential to block the flow from the Neutralization Dam which could result in overtopping of the Causeway and downstream impacts.

Surface Erosion

In terms of surface erosion, it is a rare operating mine or mill complex that has surface erosion as a viable failure mode. This lack of recognition as a viable failure mode for operating mines is due simply to the slow process that surface erosion is typically (almost never a single event but many repetitions of erosive events) and the number of visual observations the dam(s) will undergo from all the personnel present on an operating site. At the same time, some of the dams present at the Strathcona complex are relatively remote to the main site activity so there is some heightened issues in that regard. There is no question that surface erosion will be a key dam safety issue that should be addressed during the planned reclamation of each dam, prior to site closure.

Surface erosion issues of note from the 2005 DSR included:

- Strathcona Creek Outlet Dam: There is erosion in road embankment upstream of left abutment that could lead to a sudden slump of the road bed into the water reservoir that could conceivably inundate the dam. This is considered a relatively minor dam safety issue but is a staff/traffic safety concern.
- Fecunis Lake Tailings Dam: The downstream slope of the dam is heavily eroded with deep incisions. There is evidence of an old breach in the starter dam (or dam toe area) followed by some repairs with dumped waste rock fill.
- Neutralization Pond Dam: The exposed steep upstream slope exhibited some undercutting and bench formation at water level.

- Dam 3A and Dam 3B: Benching/beaching was occurring at the water on the upstream side of the dams but it was minor at the time of the DSR inspection and unlikely to ever develop into a dam safety issue.

- West Morgan Lake Dam: Upstream benching was visible just below water surface and some shallow erosion had occurred at slope surfaces not protected with riprap. Per Dams 3A and 3B, this is not expected to manifest into a dam safety issue of significance.

Internal Erosion

Internal erosion of earthfill dams is likely the most catastrophic failure mode as it can develop undetected for years and, yet, when it occurs it is often rapid and leads to complete dam breach. Some of the most dramatic earthfill dam failure case histories, many of them tailings dams, have had internal erosion as their primary failure mode. For the Strathcona dams, there are three dams that have internal erosion concerns that require focused attention. These dams are:

- Dam 3A: Extensive seepage emergence is occurring along the entire length of the dam toe and the ground beyond the toe. It is understood that this dam is founded on tailings deposit (with a limited core trench under the dam core according to the available documents), which in the presence of seepage pressure and absence of protective filter zone would be conducive to internal erosion. There are numerous active sand boils indicative of the degree of seepage gradient present (an essential ingredient for internal erosion) and the ability for material to be moved by the seepage forces present. The seepage outflow at dam toe at the right bedrock abutment contact was particularly large at the time of the DSR field inspection. Based on observations by Falconbridge representatives a few days prior to and during the May 2005 DSI in May 2005, the seepage flow rate was considered to be increasing with time.
- Dam 3B: The design and construction is essentially identical to that of Dam 3A and though sand boils were not noticed, significant seepage emergence and discolouration at dam toe area was evident.
- Fecunis Lake Tailings Dam: There was noticeable ground discolouration and seepage emergence was predominantly at dam contact with left abutment and the adjacent approximately 100 metre length of the dam toe. Small sand boils were also present along the left part of the dam toe suggesting that internal erosion processes were at least partially present in the toe area of the dam, which is always a “red flag” for internal dam erosion concerns.

Collapse of Pipes through the Structures

While there are a few pipes in several of the dams, there was only one noticeable dam safety concern with “pipes in dams” at the site. The dam noted below (also noted in the other potential failure modes) was clearly one of the largest dam safety concerns noted during the DSR simply given the number of potential failure modes present:

- Fecunis Lake Tailings Dam: A decant tower with questionable intake quality (e.g. trash-rack/tailings issues noted in Section 4.3.3) and an outlet with notable erosion only increases the concern for the state of this decant structure. As water during storm events and the spring freshet period will certainly be routed to this area where the decant structure exists, the potential ramifications of collapse of this decant are serious. This structure should be appropriately decommissioned (plugged) as part of facility closure works.

Consequence Classifications

The Province of Ontario provides specific draft Dam Safety Guidelines (ODS Guidelines). There are also the CDA guidelines, which may not be as appropriate for dams associated with mining activities, particularly tailings dams, as the current version explicitly exclude any environmental impacts in the consequence classification. The ODS Guidelines have been used in this DSR as the basis for classifying the consequence of dam failure. The selection of the ODS Guidelines was based upon both their completeness and better relevance to mine tailings facilities than, for example, the current CDA Guidelines. The Consequence Classification Categories according to the ODS guidelines are summarized in Table 4.2 and are consistent with those presented for the Inundation Study (Appendix D).

Table 3.2 - Consequence Classification Categories

Hazard Potential	Loss of Life	Economic and Social Losses	Environmental Losses
Very Low	Potential for loss of life: None	Damage to dam only. Little damage to other property. Estimated losses do not exceed $100,000	Environmental Consequences: Short-term: Minimal Long-term: None
Low	Potential for loss of life: None. The inundation area (the area that could be flooded if the dam fails) is typically undeveloped.	Minimal damage to agriculture, other dams or structures not for human habitation. No damage to residential, commercial, industrial or land to be developed within 20 years. Estimated losses do not exceed $1 million.	No significant loss or deterioration of fish and/or wildlife habitat. Loss of marginal habitat only. Feasibility and/ or practicality of restoration or compensating in kind is high, and/or good capability of channel to maintain or restore itself.
Significant	Potential for loss of life: None expected Development within inundation area is predominantly rural or agricultural, or is managed so that the land usage is for transient activities such as with day use facilities. There must be a reliable element of warning if larger development exists.	Appreciable damage to agricultural operations, other dams or residential, commercial, industrial development, or land to be developed within 20 years. Estimated losses do not exceed $10 million.	Loss or significant deterioration of important fish and/or wildlife habitat. Feasibility and/or practicality of restoration and/or compensating in kind is high, and/or good capability of channel to maintain or restore itself.
High	Potential for loss of life: One or more. Development within inundation area typically includes communities, extensive commercial and industrial areas, main highways, public utilities and other infrastructure.	Extensive damage to communities, agricultural operations, other dams and infrastructure. Typically includes destruction of or extensive damage to large residential areas, concentrated commercial and industrial land uses, highways, railways, power lines, pipelines and other utilities. Estimated losses exceed $10 million.	Loss or significant deterioration of critical fish and/or wildlife habitat. Feasibility and/or practicality of restoration and/or compensating in kind is low, and/or poor capability of channel to maintain or restore itself.

Notes for Table 4.2:

1. Consideration should be given to the cascade effect of dam failures in situations where several dams are situated along the same watercourse. If failure of an upstream dam could contribute to failure of a downstream dam(s), the minimum hazard potential classification of the upstream dam should be the same as or greater than the highest downstream hazard potential classification of the downstream dam(s).
2. Economic losses refer to all direct and indirect losses to third parties; they do not include losses to owner, such as loss of the dam, associated facilities and appurtenances, loss of revenue, etc.
3. Estimated losses refer to incremental losses resulting from failure of the dam or mis-operation of the dam and appurtenant facilities.
4. For Hazard Potential Classification and Safety Criteria for tailings dams, refer to “Guidelines for Proponents, Rehabilitation of Mines”, issued by Ontario Ministry of Northern Development and Mines, 1995.

It is important to note that in the ODS Guidelines (and similar guidelines), there is no consideration given to the owner’s losses, including public/market reaction.

There are no records that would indicate that the Strathcona Complex dams were ever previously classified as to the consequences of hypothetical dam failure. Examination of the dam and general site conditions including the area downstream of the dam, with consideration given to the probable modes of dam failure (Section 4.3), the consequences of a hypothetical dam failure were evaluated by assessing the impact of dam failure as shown on the inundation mapping in Appendix D.

Using Table 4.2 as the appropriate guidelines for this DSR, Table 4.3 presents the classifications for the 20 dams evaluated during the 2005 DSR of the Strathcona Complex. The overall classification was taken to be the highest ranking of the three discriminators of dam safety: life safety, socio-economics and environmental impact as described in Table 4.2.

Table 3.3 – Dam Consequence Classifications

Dam Structure	Loss of Life	Economic and Social Losses	Environmental Losses	Overall Classification
Strathcona Tailings Dykes	LOW	LOW	SIGNFICANT	SIGNIFICANT
West Morgan Lake Dam	SIGNIFICANT	LOW	HIGH	HIGH
Dam 3A	HIGH	SIGNIFICANT	SIGNIFICANT	HIGH
Dam 3B	HIGH	SIGNIFICANT	SIGNIFICANT	HIGH
Rockfill Berms S4, S5 and S6	VERY LOW	VERY LOW	VERY LOW	VERY LOW
Strathcona Creek Outlet Dam	LOW	VERY LOW	LOW	LOW
Bob's Lake Dam	LOW	LOW	SIGNIFICANT	SIGNIFICANT
Fecunis Lake Dam	SIGNFICANT	LOW	SIGNIFICANT	SIGNIFICANT
Fecunis Lake Tailings Dam	HIGH	SIGNIFICANT	HIGH	HIGH
Neutralization Pond Dam	HIGH	SIGNIFICANT	SIGNIFICANT	HIGH
Causeway in Lower Moose Lake	LOW	LOW	SIGNIFICANT	SIGNFICANT
Effluent Polishing Pond Dam	HIGH	SIGNIFICANT	SIGNIFICANT	HIGH
Moose Creek Gabion Weir	LOW	LOW	LOW	LOW
Gill's Pond Dam	LOW	LOW	LOW	LOW
Onaping Dam 1	LOW	LOW	LOW	LOW
Onaping Dam 2	LOW	LOW	LOW	LOW
Craig/Onaping Dam 3	LOW	LOW	LOW	LOW

B.C. Reg. 44/2000 O.C. 131/2000 Deposited February 10, 2000

Water Act

3.1.1 BRITISH COLUMBIA DAM SAFETY REGULATION

Schedule 1

(sections 2 (1) (d) and 3 (2))

Downstream Consequence Classification Guide

Rating	Loss of Life	Economic and Social Loss	Environmental and Cultural Losses
VERY HIGH	Large potential for multiple loss of life involving residents and working, travelling and/or recreating public. Development within inundation area (the area that could be flooded if the dam fails) typically includes communities, extensive commercial and work areas, main highways, railways, and locations of concentrated recreational activity. Estimated fatalities could exceed 100.	Very high economic losses affecting infrastructure, public and commercial facilities in and beyond inundation area. Typically includes destruction of or extensive damage to large residential areas, concentrated commercial land uses, highways, railways, power lines, pipelines and other utilities. Estimated direct and indirect (interruption of service) costs could exceed $100 million.	Loss or significant deterioration of nationally or provincially important fisheries habitat (including water quality), wildlife habitat, rare and/or endangered species, unique landscapes or sites of cultural significance. Feasibility and/or practicality of restoration and/or compensation is low.
HIGH	Some potential for multiple loss of life involving residents, and working, travelling and/or recreating public. Development within inundation area typically includes highways and railways, commercial and work areas, locations of concentrated recreational activity and scattered residences. Estimated fatalities less than 100.	Substantial economic losses affecting infrastructure, public and commercial facilities in and beyond inundation area. Typically includes destruction of or extensive damage to concentrated commercial land uses, highways, railways, power lines, pipelines and other utilities. Scattered residences may be destroyed or severely damaged. Estimated direct	Loss or significant deterioration of nationally or provincially important fisheries habitat (including water quality), wildlife habitat, rare and/or endangered species, unique landscapes or sites of cultural significance. Feasibility and practicality of restoration and/or compensation is high.

		and indirect (interruption of service) costs could exceed $1 million.	
LOW	Low potential for multiple loss of life. Inundation area is typically undeveloped except for minor roads, temporarily inhabited or non-residential farms and rural activities. There must be a reliable element of natural warning if larger development exists.	Low economic losses to limited infrastructure, public and commercial activities. Estimated direct and indirect (interruption of service) costs could exceed $100 000.	Loss or significant deterioration of regionally important fisheries habitat (including water quality), wildlife habitat, rare and endangered species, unique landscapes or sites of cultural significance. Feasibility and practicality of restoration and/or compensation is high. Includes situations where recovery would occur with time without restoration.
VERY LOW	Minimal potential for any loss of life. The inundation area is typically undeveloped.	Minimal economic losses typically limited to owner's property not to exceed $100 000. Virtually no potential exists for future development of other land uses within the foreseeable future.	No significant loss or deterioration of fisheries habitat, wildlife habitat, rare or endangered species, unique landscapes or sites of cultural significance.

Schedule 2

(sections 5 (a) and 7 (1))

Minimum Inspection Frequency and Dam Safety Review Requirements

Item	Very High Consequence	High Consequence	Low Consequence	Very Low Consequence
Site Surveillance (a)	WEEKLY	WEEKLY	MONTHLY	QUARTERLY
Formal Inspection (b)	SEMI-ANNUALLY	SEMI-ANNUALLY or ANNUALLY	ANNUALLY	ANNUALLY
Instrumentation	AS PER OMS * MANUAL	AS PER OMS * MANUAL	AS PER OMS * MANUAL	N/A

Test Operation of Outlet Facilities, Spillway Gates and other Mechanical Components	ANNUALLY	ANNUALLY	ANNUALLY	ANNUALLY
Emergency Preparedness Plan	UPDATE COMMUNICATIONS DIRECTORY SEMI-ANNUALLY	UPDATE COMMUNICATIONS DIRECTORY SEMI-ANNUALLY	UPDATE COMMUNICATIONS DIRECTORY ANNUALLY	N/A
Operation, Maintenance & Surveillance Plan	REVIEW EVERY 7 - 10 YEARS	REVIEW EVERY 10 YEARS	REVIEW EVERY 10 YEARS	REVIEW EVERY 10 YEARS
Dam Safety Review (c)	EVERY 7-10 YEARS (d)	EVERY 10 YEARS (d)	(d)	(d)

* Operation, Maintenance, and Surveillance Manual.

(a) Site surveillance may consist of visual inspections and/or monitoring of automated data acquisition systems. Reduced frequencies of visual inspections may be determined by seasonal conditions.

(b) Formal Inspections are intended as more thorough inspections performed by the appropriate representative of the owner responsible for safety surveillance.

(c) A Dam Safety Review involves collection of all available dam records, field inspections, detailed investigations and possibly laboratory testing. It then proceeds with a check of structural stability and operational safety of the dam, beginning with a reappraisal of basic features and assumptions. The level of detail required in a Dam Safety Review should be commensurate with the importance and complexity of the dam, as well as the consequences of failure.

(d) Dam owners must conduct an annual review of conditions downstream of their dam and notify a dam safety officer if the downstream consequence classification level increases. The downstream consequence classification guide is shown in Schedule 1.

Classification Summary

The crux of a DSR is the combination of the classification of the dam(s) in terms of potential hazard and the corresponding potential for a dam safety issue to arise allow that hazard to become a realized outcome. In very simplistic terms, the dual assessment is a form of risk assessment where:

Risk = (Likelihood of Event) x (Consequence of Event)

In the case of a DSR, the likelihood is not explicitly defined in terms of a probability or even a qualitative likelihood of failure. However, the level of dam safety issue relative to the "concern" it raises is a reasonable approximation of a qualitative likelihood. In other words, using a qualitative scale to rank dam safety issues for any given dam allows a form of assignment of dam failure likelihood.

For the DSR, a four point scale of dam safety issue concerns was judged appropriate and is as follows:

- None: No dam safety issue(s) noted that will require attention as of 2005 DSR and it would be unlikely to develop an issue prior to next DSR.
- Minor: Issue(s) that will require observation and perhaps modest non-urgent works on an as-need basis.
- Moderate: Issue(s) that may require attention within a year or so and heightened observation is essential through to next DSR if issue not completely addressed.
- Major: Issue(s) that could seriously impact dam safety. Reasonable likelihood of providing a trigger(s) mechanism for dam failure if not addressed.

In terms of ranking whether a dam represents a dam safety concern of an appreciable degree to the Strathcona Complex, any dam that had a consequence classification of SIGNIFICANT or HIGH combined with a Moderate dam safety issue is considered to have a dam safety risk that should be evaluated in more detail prior to the next annual DSI. In addition, it is possible that some form of remedial works will need to be completed within a time period of not more than 24 months. Two dams fall under this combined ranking and should be evaluated and addressed as noted above:

- West Morgan Lake Dam
- Neutralization Pond Dam

There is one higher level of dam safety concern. That is for dams that have a SIGNIFICANT or HIGH consequence classification combined with a Major dam safety issue. These dams are considered to have an immediate concern in terms of further evaluation and a probable situation of remedial measures within a 12 month period. The key if any such dams exist on a given site is to get the dam safety issues down to at least the Moderate level so that the inherent risk is far more acceptable. The Strathcona Complex has three dams that fall under this combined classification which is considered to be a significant risk in terms of dam safety and not a level considered acceptable for a sound long-term dam safety stewardship program. These dams are:

- Dam 3A
- Dam 3B
- Fecunis Lake Tailings Dam

Each of the above three dams as viewed during May 2005 and evaluated in the format of a formal DSR fail to meet acceptable dam safety levels. AMEC issued a specific letter, contained in Appendix E, to Falconbridge on May 20, 2006 addressing the major concerns with two dams, 3A and 3B given their operating status and full-pool reservoir condition. Falconbridge took actions shortly thereafter to address the concerns raised in the letter. At the time of writing this DSR report, it is uncertain as to the net benefit of the actions taken will be to enhancing static and seismic stability of Dams 3A and 3B. Until the recommended stability evaluation is completed, using the altered geometry per the recent actions, this uncertainty in degree of benefit will remain.

Table 3.4 - Classification and Dam Safety Summary

Dam Structure	Previous DSR(s)	Most Recent DSI	2006 Consequence Classification	Dam Safety Issues			
				None	Minor	Moderate	Major
South Embankment	None. 2006 = initial DSR	2005	SIGNIFICANT		✓		
Main Embankment	None. 2006 = initial DSR	2005	HIGH		✓		
Perimeter Embankment	None. 2006 = initial DSR	2005	HIGH		✓		

Dam Safety Issue Ranking:
None – No dam safety issue(s) noted that will require attention as of 2005 DSR and unlikely to through to next DSR (2010)
Minor – Issue(s) that will require observation and perhaps modest non-urgent works on an as-need basis
Moderate – Issue(s) that may require attention within a year or so and heightened observation is essential through to next DSR if issue not completely addressed
Major – Issue(s) that could seriously impact dam safety. Reasonable likelihood of providing a trigger(s) mechanism for dam failure if not addressed.

3.2 Operational and Closure Challenges

The objectives of the long-term tailings deposition strategy is to:

- *Maximize the storage capacity of the facility.*
- *Maintain the supernatant pond in the area of the reclaim barge so as to maximize the amount of clean process water available for reclaim.*
- *Establish free draining tailings beaches adjacent to the embankments during the winter season to facilitate future embankment raises and to enhance embankment stability.*

The above strategy is implemented by sequentially rotating the tailings discharge point along the entire length of the Perimeter, Main and South embankments on the upstream face, which allows inactive areas of the tailings beach to partially dry and consolidate. Eventually, beaches will be formed around the entire upstream perimeter of the Facility and all supernatant water will be centralized around the reclaim barge.

The TSF is required to have sufficient live storage capacity for containment of 679,000 cubic meters of runoff from the entire contributing catchment area during a 24-hour PMP event. This volume of stormwater would result in an incremental rise in the tailings pond level of approximately 0.39 meters. The TSF design also incorporates an allowance of 1 metre of freeboard for wave run-up. Therefore, the normal and maximum operating pond levels are as follows:

Normal Operating Level – Water level at least 1.39 meters below the embankment crest;
Maximum Operating Level – Water level is 1 meter below the embankment crest, which also means the loss of storage capacity for a 24-hour PMP event.

4.0 DAM SAFETY PROGRAM

Overview

In addition to the hazard classification discussed in Section 4, the following components need to be evaluated during a DSR:

- Design, construction, and performance;
- Operation;
- Maintenance;
- Surveillance and Monitoring of Dam Performance; and
- Emergency Preparedness.

Operations, Surveillance and Maintenance

In general, Strathcona operations personnel conduct the routine surveillance in conjunction with the ongoing operational activities. On an annual basis, an independent engineer conducts an inspection of the each of the dams.

The operation of these 20 dams should be described in an Operations Manual. Such a manual (OMS) is a thorough document that is used regularly by Operations Staff and should be updated on an annual to bi-annual basis. The manual should be prepared in accordance with the Mining Association of Canada's Guide for Developing an Operation, Surveillance, and Maintenance Manual. Falconbridge has been advised to improve their OMS Manual by their environmental auditors.

Emergency Preparedness

Falconbridge has an emergency response plan but it is directed at chemical and product spills and not the impacts of dealing with a tailings dam or water retention dam failure.

Program Summary

Taking into consideration:

- The present site status (in operation) and the location and accessibility to the dams,
- The existing and expected (future) conditions of the dams,
- The hazard classifications of the dams, and
- Falconbridge's dam safety program and generally acceptable dam safety standards

The following dam safety program is considered adequate and should be followed for dam safety stewardship of the tailings and water management facilities at the Strathcona Mines and Mills Business Unit's:

1. The conditions at the dam in general should be viewed at least once per week by Falconbridge personnel using the same format (forms) in Appendix C (DSI). A few photographs should accompany the inspection note.

2. An annual dam safety inspection (DSI) by a qualified engineer should be continued and a formal DSI report issued. Annual inspections are only required annually for those dams classified as having a high hazard potential. However, by continuing the existing inspection schedule that includes all of the dams Falconbridge is demonstrating “due diligence” with respect to monitoring the condition of its dams. A formal inspection should also be carried out whenever observations made under any of the routine inspections referred to under above indicate potential problem with, or a change in dam condition and/or performance.

3. An evaluation of the stability of each dam relative to a static and post-earthquake design criteria (Appendix B) should be completed by the end of 2007 and the results reviewed during the next DSR (approximately 2010). For Dams 3A, 3B and the Fecunis Tailings Dam, this review should be completed in 2006.

4. Given the active nature of the site, the significant concerns with at least three or four of the dams and the fact that new dams are being commissioned on the site, the next DSR should be carried out in 2010.

5.0 REPORT CLOSURE

This report has been prepared in draft for comment. The report will be issued in final following receipt and discussion of review comments from Noranda.

Recommendations presented herein are based on an evaluation of the findings of the dam safety review. If conditions other than those reported are noted during subsequent stages of mine operation, AMEC should be notified and be given the opportunity to review and revise the current recommendations, if necessary. Recommendations presented herein may not be valid if an adequate level of review or inspection is not provided during ongoing mine operations and into the mine closure period by the mine and/or its design engineer(s).

This report has been prepared for the exclusive use of Imperial Metals Corporation for specific application to the dam safety aspects of the Mount Polley Mine Tailings Storage Facility. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. AMEC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report. It has been prepared in accordance with generally accepted tailings dam safety engineering practices. No other warranty, expressed or implied, is made.

Sincerely,

AMEC Earth & Environmental Limited

Michael Davies, Ph.D, P.Eng., P.Geo.
Principal Geotechnical Engineer

Reviewed by:

Todd Martin, P.Eng., PGeo.
Principal Geotechnical Engineer

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APPENDIX A

Reference Documents and Review Commentary

APPENDIX B

Selected Photographs