June 30, 2015 Reference No. 1522835-2015-083-L-Rev0-1000

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RESPONSE TO MINISTRY OF ENERGY AND MINES MEMORANDUM DATED FEBRUARY 3, 2015 REGARDING THE FORDING RIVER OPERATIONS TAILINGS STORAGE FACILITIES

Dear Mr. Geoghegan,

1.0 INTRODUCTION

The findings of expert review panel (IEEIRP 2015) of the August 4, 2014, Mount Polley tailings dam failure has prompted the British Columbia Ministry of Energy and Mines (BC MEM) to request review of the design and operations of all tailings dams in BC. In a memorandum dated February 3, 2015, the BC MEM directed all mines in BC, including Fording River Operations (FRO) to undertake an assessment to determine if the dams associated with the tailings facilities on site may be at risk due to:

1) undrained shear failure of silt and clay foundations;

2) water balance adequacy; and

3) filter adequacy.

Each identified risk included a list of specific items to be addressed (BC MEM 2015).

As Engineer of Record for the North Tailings Pond (NTP) and South Tailings Pond (STP) at Teck Coal Limited's (Teck Coal) FRO, Golder Associates Ltd. (Golder) has prepared this letter response to address the three identified risks and their associated lists of specific items. As requested by the BC MEM, the numbering system for each item in this response is consistent with that presented in the BC MEM memorandum. Background information about the tailings facilities is included for reference.

This letter should be read in conjunction with the attached ***Study Limitations***.

2.0 BACKGROUND INFORMATION

There are currently two tailings pond facilities at FRO: the NTP and the STP. The NTP facility has been filled to its design capacity and is currently inactive. The NTP facility is located on the west side of the Fording River across from the Maintenance Complex. The STP facility is currently used for tailings discharge from the coal preparation plant. The STP facility is located south of the coal preparation plant, on the east side of the Fording River.

2.1 North Tailings Pond

The NTP facility was constructed on the west side of the flood plain of the Fording River. Construction of the starter dam (Phase 1) of the NTP dam was completed in 1971 based on the original design by Golder (then Golder, Brawner & Associates) (Golder 1969). Design and construction of Phases 2, 3, and 4 were completed between 1970 and 1975 (Golder 1973, 1974a,b, 1975). The NTP facility was in service until 1979 when it reached its full capacity.

The NTP dam is a downstream-raised zoned earth fill dam. It has a crest length of 1,295 metres (m) and has been built to a minimum crest elevation 1,653.3 m, which is approximately 24 m high at its highest point near the south abutment. The elevation of the foundation at the downstream toe along the Fording River ranges from about 1,630 m at the south end to about 1,640 m at the north end.

The land area and storage capacity of the NTP are approximately 32 hectares and 3.8 million cubic metres (m^3), respectively. At times between 1979 to 1993, the NTP was dewatered and excavated to create additional tailings storage capacity, which was filled with tailings dredged from the STP. Since 2007, no tailings have been sent to the NTP facility.

2.2 South Tailings Pond

The STP facility was constructed on the east side of the flood plain of the Fording River. The Fording River was diverted from the STP area to a new alignment by the excavation of a channel through a topographic bench on the west side of the Fording River flood plain. Confinement at the STP facility is provided by the West Dam, which extends parallel to the east side of the Fording River diversion channel, and the Main Dam, which extends across the width of the Fording River flood plain from the diversion channel to the south abutment.

Initial construction of the STP dams was performed between 1977 and 1979 based on the original design by Golder (Golder 1976a,c). The STP dams have been raised in six stages:

- 1983 to 1984 (FCL 1984);
- 1985 to 1990 (FCL 1988,1989,1990);
- 1993;
- 2008 (Golder 2009b);
- 2010 (Teck Coal 2010); and
- 2012 to 2013 (Golder 2013a, 2014a).

The STP dam is a downstream-raised zoned earth fill dam. It has a crest length of 2,079 m and has been built to a minimum crest elevation 1,638.3 m, which is approximately 35 m high at its highest point near where the West and Main dams meet. The elevation of the foundation at the downstream toe ranges from about 1,603 m at the south end to about 1,625 m at the north end.

The land area and storage capacity of the STP are approximately 67 hectares and 12.1 million m^3, respectively. The design crest elevation of 1,638.3 m was specified in the original design report (Golder 1976a), and this elevation was reached with construction carried out in 2013.

3.0 RESPONSE TO BC MEM MEMORANDUM

3.1 North Tailings Pond Facility

1. Risk Due to Undrained Shear Failure of Silt and Clay Foundations

Based on review of the original design report and published regional geomorphology data, glacio-lacustrine deposits are not expected to be present beneath the NTP dam. However, investigation records such as drill hole or test pit logs have not been located to confirm the subsurface conditions presented in Section 1a. Buried lenses of alluvial deposited silt are a possibility, however were not mentioned in any of the existing reports.

a) Including a determination with respect to whether or not similar foundation conditions [to those found at the Mount Polley site] exist below the dams on your site.

The original design report for the starter dam (Golder 1969) describes the subsurface conditions as follows:

- Surface soils 0.2 to 0.9 m (0.7 to 3 feet) thick, described as fine sand, silty, organic, pervious [high hydraulic conductivity]. Deposited during flood stages when river rises above banks of low-water channel and spreads over flood plain.
- Sand, gravel, cobbles 2.4 to 3.6 m (8 to 12 feet) thick, described as coarse, dense, very pervious [very high hydraulic conductivity]. May be thicker at isolated locations. Represent bed deposits of the Fording River.
- Glacial Till unknown thickness, described as clay-silt-sand-gravel mixture with scattered cobbles and small boulders. Dense, incompressible, and impervious [low hydraulic conductivity].

The report on the 1974 Phase 2 Tailings Dam Construction (Golder 1974a) indicates that prior to placement of fill material, the foundation of the Phase 2 embankment was stripped of organic matter and the exposed naturally occurring sands and gravels were levelled and compacted to provide a dense foundation for the coarse rejects (CR) shell.

George et al. (1986) report that deposits of glacio-lacustrine sediments can be found throughout the Elk Valley, and that more significant distribution of the glacio-lacustrine deposits would be expected below elevation 1,384 m, with only local deposits at higher elevations. The NTP tailings dam foundation elevation ranges from approximately 1,630 m to 1,640 m and, based on George et al. (1986), significant glacio-lacustrine deposits are not expected.

b) Whether or not sufficient site investigation (drill holes, etc.) has been completed to have confidence in this determination.

Detailed site investigation results for the NTP have not been located. The 1969 NTP design report describes the foundation conditions with a range of depths, but information on the scope and methods of foundation investigation are not provided (Golder 1969). The Phase 2 construction report is consistent with the described subsurface conditions (Golder 1974a).

Based on review of the original design report and published regional geomorphology data, glacio-lacustrine deposits are not expected to be present beneath the NTP dam. However, investigation records such has drill hole or test pit logs have not been located to confirm the subsurface conditions presented in Section 1a. Buried lenses of alluvial deposited silt are a possibility, however were not mentioned in any of the existing reports. The missing site investigation results are considered a gap.

The 2014 Dam Safety Review for the North and South Tailings Ponds (KCB 2014) identified that a site investigation to collect additional foundation information should be completed. Teck Coal is undertaking a site investigation during 2015 to address this recommendation. As part of this site investigation, Teck Coal will be collecting data which can be used to corroborate the foundation conditions listed in Section 1a.

c) If present, whether or not the dam design properly accounts for these materials.

The design of the NTP accounts for the subsurface conditions as described in Section 1a.

d) If any gaps have been identified, a plan and schedule for additional subsurface investigation.

Teck Coal is planning a site investigation for the NTP dam during 2015. As part of this site investigation, Teck Coal will be collecting data which can be used to corroborate the foundation conditions and address the gap identified in Section 2b.

2. Risk Due to Water Balance Adequacy

The water balance for the NTP facility is relatively simple as most of the flow into the tailings facility is from precipitation. Flows of surface water into the tailings facility are limited to the immediate catchment of the tailings facility. Surplus flows from other facilities are generally not redirected to the NTP facility, except as noted in Section 2b.

The pond level in the NTP facility is monitored regularly, and an emergency preparedness plan is in place in the event of a high water level. As such, the NTP facility is not considered to be at risk due to the adequacy of the water balance.

a) Including the total volume of surplus mine site water (if any) stored in the tailings storage facility.

For the purpose of this assessment, surplus mine water is defined as mine water redirected to a tailings facility for storage.

Currently there is no surplus mine water redirected to or stored in the NTP facility. The free water in the tailings facility is due to precipitation and a small immediate catchment area.

b) The volume of surplus mine water that has been added to the facility over each of the past five years.

No surplus mine water was redirected to the NTP facility during the years of 2010, 2011, 2013, and 2014. Between April 6 to 10, 2012 an estimated 60,000 m^3 of site drainage water was pumped from the North Loop Settling Pond to the NTP facility. FRO reports that this increased the NTP facility pond elevation by 0.93 m which remained below the recommended maximum operating pond elevation.

c) Any plans that are in place or that are under development to release surplus mine water to the environment.

FRO is currently developing a plan that considers routing mine water through a separately constructed sediment pond located within the NTP facility from which the mine water would be subsequently be released to the environment through a dedicated discharge point (subject to permit conditions). This plan is currently in feasibility level design stage and would be subject to regulatory review and approval prior to being advanced.

d) Recommended beach width(s), and the ability of the mine to maintain these widths.

There is no minimum or recommended beach width for the NTP facility. The NTP dam is designed to accommodate the conditions of having water or a tailings beach against the dam.

e) The ability of the TSF [tailings storage facility] embankments to undergo deformation without the release of water (i.e., the adequacy of the recommended beach width).

The NTP dam construction was completed in 1975 and no future raises are envisioned. As noted above, the NTP tailings facility does not have a minimum or recommended beach width.

The containment of water is a function of the freeboard and the integrity of the upstream till blanket. The maximum operating pond level allows for 1.2 m of freeboard (measured vertically from the lowest point of the dam crest to the pond elevation).

Deformations in an earth dam can results from a new or increased load to the facility such as a crest raise or an externally imposed load by an earthquake. In the event of the design seismic event, settlement is predicted to be less than 0.011 m (Swaisgood 2003). Therefore, the freeboard is sufficient to accommodate potential deformations.

f) Provisions and contingencies that are in place to account for wet years.

The emergency preparedness plan for the tailings facilities outlines the following response to the water reaching or exceeding the freeboard in the NTP facility (Teck Coal 2014):

- As water level approaches the freeboard (1.2 m) all flows entering the pond will be shut off or diverted, if applicable.
- If the water level exceeds the freeboard, water will be pumped from the NTP facility to the STP facility. The pump will be set up in the southwest corner of the NTP and connected to the nearby T fixture on the Shandley pipeline.
- If water levels continue to rise, the downstream slope of the dam will be armoured with pit run to minimise embankment erosion in the event of overtopping.

g) If any gaps have been identified, a plan and schedule for addressing these issues.

There are no data gaps related to water balance of the NTP facility.

3. Risk Due to Filter Adequacy

The compatibility between the till (base soil) and the CR shell or flood plain sand and gravel (filter) met the filter compatibility criteria for two of the three methods checked. The internal stability of the CR shell material was confirmed. Based on the seepage performance observed at the NTP dam over the last 45 years along with the current low hydraulic gradients, piping due to filter incompatible materials is considered to be a low risk.

a) Including the beach width and filter specifications necessary to prevent potential piping.

The NTP facility does not have a minimum or recommended beach width.

The NTP dam was constructed with an upstream till blanket and a CR shell. The CR shell also acts as the filter to prevent internal erosion and piping of the upstream till blanket through the CR shell. A till cut-off was constructed through the flood plain sand and gravel foundation of the NTP.

The following filter relationships were checked:

- Compatibility between the upstream till blanket (base soil) and CR shell (filter).
- Compatibility between the till cut-off (base soil) and flood plain sand and gravel foundation (filter)
- Internal stability of the CR shell (filter).

Various methods are available to check filter compatibility. The compatibility between the till (base soil) and the CR shell or flood plain sand and gravel (filter) met the filter compatibility criteria for two of the three methods checked. The internal stability of the CR shell was confirmed.

The CR and the glacial till were noted as filter compatible when the CR were first used as part of the Phase 2 design (Golder 1973). A specified grain size envelope was provided for the CR material (Golder 1974b) that met filter compatibility requirements based on the Terzaghi method (Terzaghi 1922). Gradations of the flood plain sands and gravels were provided in Golder (1970). The specified CR envelope is provided in Chart 1 with the gradation curves of a sample of till used on the NTP upstream blanket and the flood plain sand and gravel deposit.

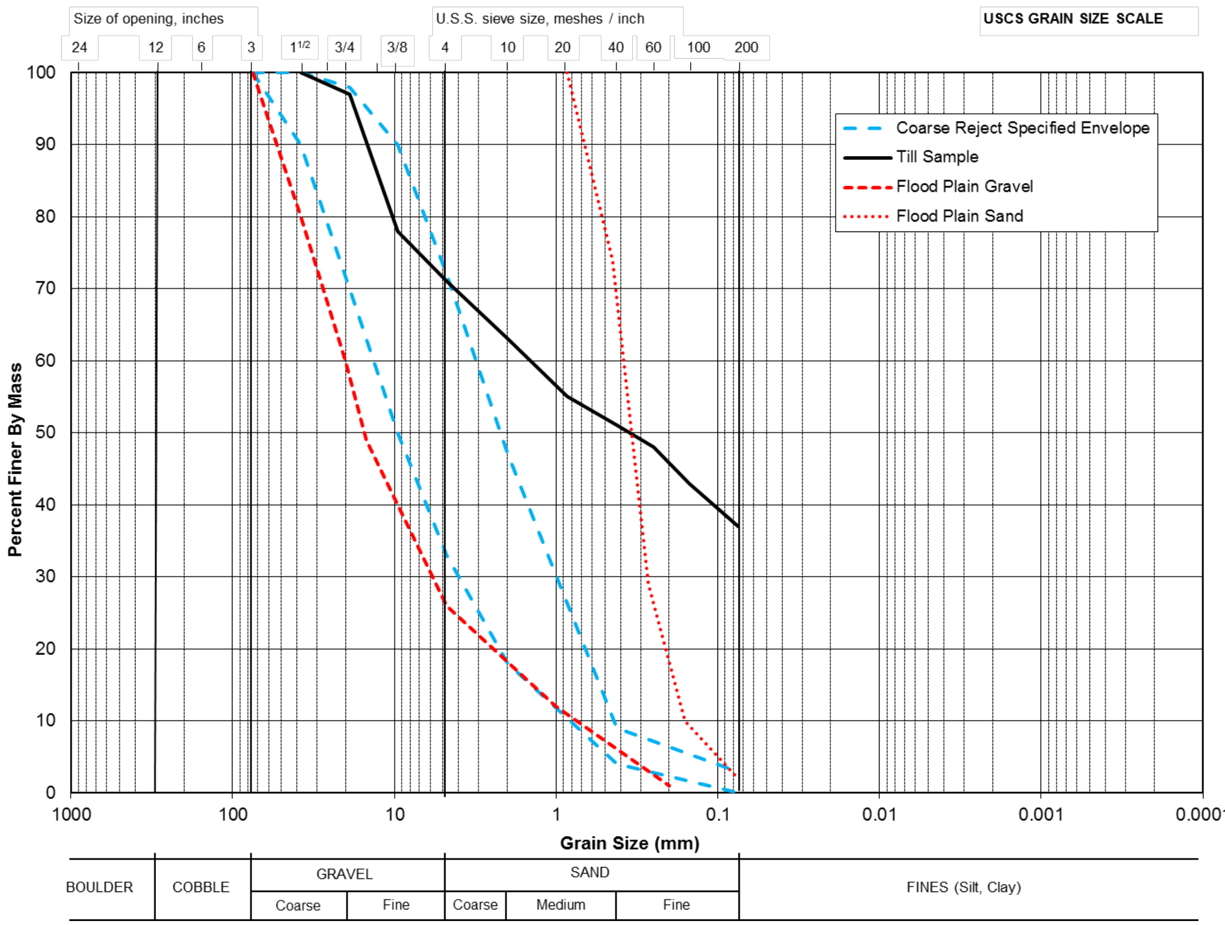

Chart 1: Specified Gradation Envelopes and Specific Samples for Filter Compatibility Assessment

Details of the filter compatibility methods and the required specifications of each are provided in Table 1.

Table 1: Summary Filter Compatibility Methods and Specifications for the NTP dam

Method/Criteria	Filter specification for till base soil	Result
Terzaghi method (Terzaghi 1922)	$D_{15(filter)}\,/\,d_{85(base)} \leq 4$	Passes
Sherard criteria (Sherard et al. 1984, Sherard and Dunningan 1989)	$D_{15(filter)} = 0.7$ mm	Passes for fine fraction of CR and flood plain sand Not met for the coarse fraction of CR and flood plain gravel
US Army Corps of Engineers (USACE 2004)	$D_{15(filter)} \leq \frac{40-A}{40-15}$, A=percent fines	Passes
Internal Stability (Kenney and Lau 1985; Li et al. 2009)	n/a	Passes

Gradation of the CR material is presented in Chart 1, and it can be noted that the CR material does not always meet the Sherard criteria, as the coarse limit of the envelope has a $D_{15(filter)}$ equal to about 1.5 mm, which exceeds the specification of 0.7 mm. However, Golder (1973) included an assessment that demonstrated the breakdown of the CR material during compaction, which reduced the $D_{15(filter)}$ of the material from 0.95 mm to 0.68 to 0.57 mm (within specification).

Gradation of the expected range of foundation sand and gravel materials is presented in Chart 1, and it can be noted that the coarse limit of the flood plain gravel does not meet the Sherard criteria, as the $D_{15(filter)}$ of the gravel is about 1.5 mm, which exceeds the specification of 0.7 mm. However, the flood plain gravel is generally mixed with the flood plain sand, which would reduce the effective $D_{15(filter)}$ size.

The compatibility between the till (base soil) and the CR shell or flood plain sand and gravel (filter) met the filter compatibility criteria for two of the three methods checked. The internal stability of the CR shell was confirmed. Based on the performance of the dam over the last 45 years, piping due to filter incompatible material is not expected to be an issue.

b) Whether or not the filter has been constructed in accordance with the design.

The CR shell, which acts as a filter for the upstream till blanket, was constructed in accordance with the design. The Terzaghi method is the likely method that was used to confirm compatibility during design and construction; however, this was not explicitly stated in the reports.

Phase 1 of the NTP construction included gradations of the glacial till used (Golder 1970). Phase 1 did not include any placement of the CR filter/shell. The construction report for Phase 2 of the NTP dam noted that the gradation of the coarse reject material was such that it could be placed in direct contact with the glacial till core and would also provide the relatively high permeability required to ensure stability of the section. Four gradation tests of the CR were included (Golder 1973). Ten particle size distribution tests on the CR were carried out as part of the 1974 Phase 3 Construction, and all tests were found to lie within the boundaries of the specified grain size envelope (Golder 1974b).

It is noted that there are some gaps in construction quality assurance records. Where data were available, they indicated that filter compatibility was achieved. The gaps in the quality control records are considered to be low risk to confirming filter compatibility.

c) If any gaps have been identified, a plan and schedule for addressing these issues.

The gradation of the underlying flood plain sand and gravel should be confirmed via sampling from the planned 2015 drilling program.

3.2 South Tailings Pond Facility

1. Risk due to Undrained Shear Failure of Silt and Clay Foundations

Based on review of the design reports, site investigation records, construction reports, and published regional geomorphology data, silt and clay deposits, including glacio-lacustrine deposits, are not present beneath the STP dams.

a) Including a determination with respect to whether or not similar foundation conditions [to those found at the Mount Polley site] exist below the dams on your site.

Drilling results from early investigations in the location of the STP facility footprint, the STP starter dam, and the adjacent diversion channel show that glacio-lacustrine deposits are not found beneath either the West Dam or Main Dam of the FRO STP facility. Construction specifications and drill records through the starter dam indicate that surficial alluvial silt deposits were stripped prior to construction of the STP dam.

George et al. (1986) report that deposits of glacio-lacustrine sediments can be found throughout the Elk Valley, and that more significant distribution of the glacio-lacustrine deposits would be expected below elevation 1,384 m, with only local deposits at higher elevations. The STP dam foundation elevation ranges from approximately 1,603 m to 1,625 m and based on George et al. (1986) significant glacio-lacustrine deposits are not expected.

Geotechnical investigations were carried out by Golder in 1975 and 1976 to determine the subsurface conditions underlying the STP West and Main dams. The foundation conditions for the Main and West dams are summarized below.

Main Dam Foundation

The majority of the Main Dam is constructed over the sand and gravel deposit of the Fording River flood plain. In general, subsurface conditions prior to construction comprised:

- Topsoil described as loose, sandy, organic silt, varying from 0.6 to 2.5 m thick.
- Flood plain deposits comprised of interlayered silty sands and sandy gravels which are clean and sub-rounded with occasional cobbles, generally varying from 3.0 to 6.5 m thick, with one localized area 10 m thick (buried channel).
- Dense to very dense or very stiff to hard silt-sand-gravel glacial till underlies the flood plain deposits. The till deposit varies from 0 m thick to greater than 5.8 m thick (borehole terminated in unit).
- Shale and siltstone bedrock was encountered in boreholes BH-11, BH-12, BH-25, BH-27, and BH-28 at depths of 4.4 m, 4.1 m, 11.9 m, 12.8 m, and 15.2 m, respectively.

West Dam Foundation

The West Dam of the STP is founded on the till bench that borders the western edge of the natural Fording River floodplain. The Fording River diversion channel was constructed below the downstream toe of the West Dam. In general, subsurface conditions prior to construction of the West Dam comprised:

- Topsoil described as loose, sandy, organic silt, varying from 1.8 to 3.0 m thick.
- Discontinuous flood plain deposits described as interlayered silty sands and clean, sub-rounded, sandy gravels with occasional cobbles, varying from 0.9 to 4.0 m thick. The flood plain deposits are not located throughout the foundation of the West Dam; they are found within the area of the footprint that was located on the original floodplain, between stations 0+000 and 0+600.

- Dense to very dense or very stiff to hard silt-sand-gravel glacial till. The till deposit underlying the West Dam (Stations 0+000 to 1+200) varying from 1.5 to 13.7 m thick. The till deposit was located directly under the topsoil along the western side (Stations 0+600 to 1+200) or located under the flood plain deposit for the remainder (Stations 0+000 to 0+600).
- Shale and siltstone bedrock was encountered in boreholes BH-1 to BH-5 at depths of 7.0 to 13.7 m, respectively. Shale bedrock was encountered underneath the till fill (starter dam) from approximately Stations 0+000 to 0+250.

The specification for earthworks associated with the construction of the STP included clearing and grubbing of the tailings pond basin, dike foundations, and Fording River diversion channel, as well as disposal of all organic material (KWL 1976). Construction records and results of drill holes through the starter dam and through the completed dam confirm that organic material and alluvial silt was stripped prior to construction of the West and Main dams.

b) Whether or not sufficient site investigation (drill holes, etc.) has been completed to have confidence in this determination.

Sufficient site investigation has been completed to have confidence in the determination foundation conditions as discussed in Section 1a.

The investigation for the STP included the following:

- Sixteen boreholes were drilled on the floodplain along the proposed upstream (inside) toe of the dike at an approximate spacing of 60 m and 5 boreholes were drilled along the proposed adjacent Fording River division channel, completed by Golder (1976a).
- Ten boreholes were drilled in the Main Dam footprint to determine the extents of the gravel fill channel as part of 1976 investigation by Golder (1976c).
- Thirty boreholes at an approximate spacing of 40 m were completed along the Main and West dams. These boreholes were assumed to have been drilled along the centreline of the starter dam. Nineteen of the 30 boreholes were drilled into the underlying till, and the other 11 were drilled into shale bedrock (Golder 1978).
- Ten boreholes were drilled using an air rotary rig downstream of the Main Dam in 1978, with piezometers installed in 27-79, 28-79, 29-79, and 32-79 (Golder 1980).
- Five boreholes were drilled as part of vibrating wire piezometer installation in 2014 (Golder 2014a).

The available records of drill holes were examined for evidence of a glacio-lacustrine unit within the glacial till. Recorded observations did not indicate a glacio-lacustrine unit or layers of clay or silt within the glacial till.

c) If present, whether or not the dam design properly accounts for these materials.

As previously identified, silt and clay deposits, including glacio-lacustrine deposits, are not present beneath Main or West dams of the STP facility.

The dams have been designed in accordance with the foundation materials present.

d) If any gaps have been identified, a plan and schedule for additional subsurface investigation.

There are no data gaps related to undrained shear failure in the foundation and no further work is recommended.

2. Risk due to Water Balance Adequacy

The STP facility is not considered to be at risk due to the adequacy of the water balance.

The water balance for the STP facility is relatively simple as most of the flow into the facility is from the tailings slurry and process make-up water. Flows of surface water into the STP facility are catchment of the tailings facility and site drainage around the maintenance complex.

Pond level in the tailings facility is monitored regularly.

a) Including the total volume of surplus mine site water (if any) stored in the tailings storage facility.

For the purpose of this assessment, surplus mine water is defined as mine water redirected to a tailings facility pond for storage, and does not include water redirected to the tailings facility to be reclaimed for use in the process plant.

No surplus mine water is stored in the STP facility, water redirected to the STP is sent there to be reclaimed for use in the process plant.

b) The volume of surplus mine water that has been added to the facility over each of the past five years.

No surplus mine water was directed to the STP between 2010 and 2014. Based on the water balance, the STP operates with a water deficit.

c) Any plans that are in place or that are under development to release surplus mine water to the environment.

As no surplus water is currently stored in the STP, there are no plans in place or under development to release surplus mine water to the environment from the STP facility.

d) Recommended beach width(s), and the ability of the mine to maintain these widths.

There is no minimum or recommended beach width. The STP dams are designed to accommodate the conditions of having water against the dams or having a tailings beach against the dams.

e) The ability of the TSF embankments to undergo deformation without the release of water (i.e., the adequacy of the recommended beach width).

As noted above, this tailings facility does not have a minimum or recommended beach width.

The containment of water is a function of the freeboard and the integrity of the upstream till blanket. The maximum pond operating level allows for 1.2 m of freeboard.

Deformations in an earth dam can result from a new or increased load to the facility such as a crest raise or an externally imposed load such as an earthquake. As the STP dam was progressively raised most deformations associated with the construction have been incorporated into subsequent raises and any ongoing deformations would be expected to be a minor portion of the existing freeboard. In the event of the design seismic event, settlement is predicted to be less than 0.025 m (Swaisgood 2003). Therefore, the freeboard is sufficient to accommodate potential deformations.

f) Provisions and contingencies that are in place to account for wet years.

Based on the water balance, the STP operates with a water deficit. However, the emergency preparedness plan for the tailings facilities outlines the following response to the water reaching or exceeding the freeboard in the STP facility (Teck Coal 2014):

- As water level approaches the freeboard (1.2 m) all flows entering the pond will be shut off or diverted.
- If the water level exceeds the freeboard, water will be pumped from the STP facility to the Kilmarnock settling ponds located to the south of the STP facility.
- If water levels continue to rise, the downstream slope of the dam will be armoured with pit run to minimise embankment erosion in the event of overtopping.

g) If any gaps have been identified, a plan and schedule for addressing these issues.

There are no data gaps related to water balance of the STP facility.

3. Risk Due to Filter Adequacy

The compatibility between the till (base soil) and the CR/CCFR shell or flood plain sand and gravel (filter) met the filter compatibility criteria for two of the three methods checked. The internal stability of the CR/CCFR shell was confirmed.

a) Including the beach width and filter specifications necessary to prevent potential piping.

The STP facility does not have a minimum or recommended beach width.

The STP is constructed with an upstream till blanket and a CR (lower portion) or combined coarse and fines rejects (CCFR) (upper portion) shell, which also acts as the filter. A till cut-off was constructed through the flood plain sand and gravel foundation of the STP.

The following filter relationships were checked:

- Compatibility between the upstream till blanket (base soil) and CR/CCFR shell (filter).
- Compatibility between the till cut-off (base soil) and flood plain sand and gravel foundation (filter).
- Internal stability of the CR/CCFR shell (filter).

Various methods are available to check filter compatibility. The compatibility between the till (base soil) and the CR/CCFR shell or flood plain sand and gravel (filter) met the filter compatibility criteria for two of the three methods checked. The internal stability of the CR/CCFR shell was confirmed.

The specified grain size distribution envelopes for placed till (cut-off and upstream blanket), CR (shell), and CCFR (shell), as well as a sample of the flood plain sand and gravel (foundation), are shown in Chart 2.

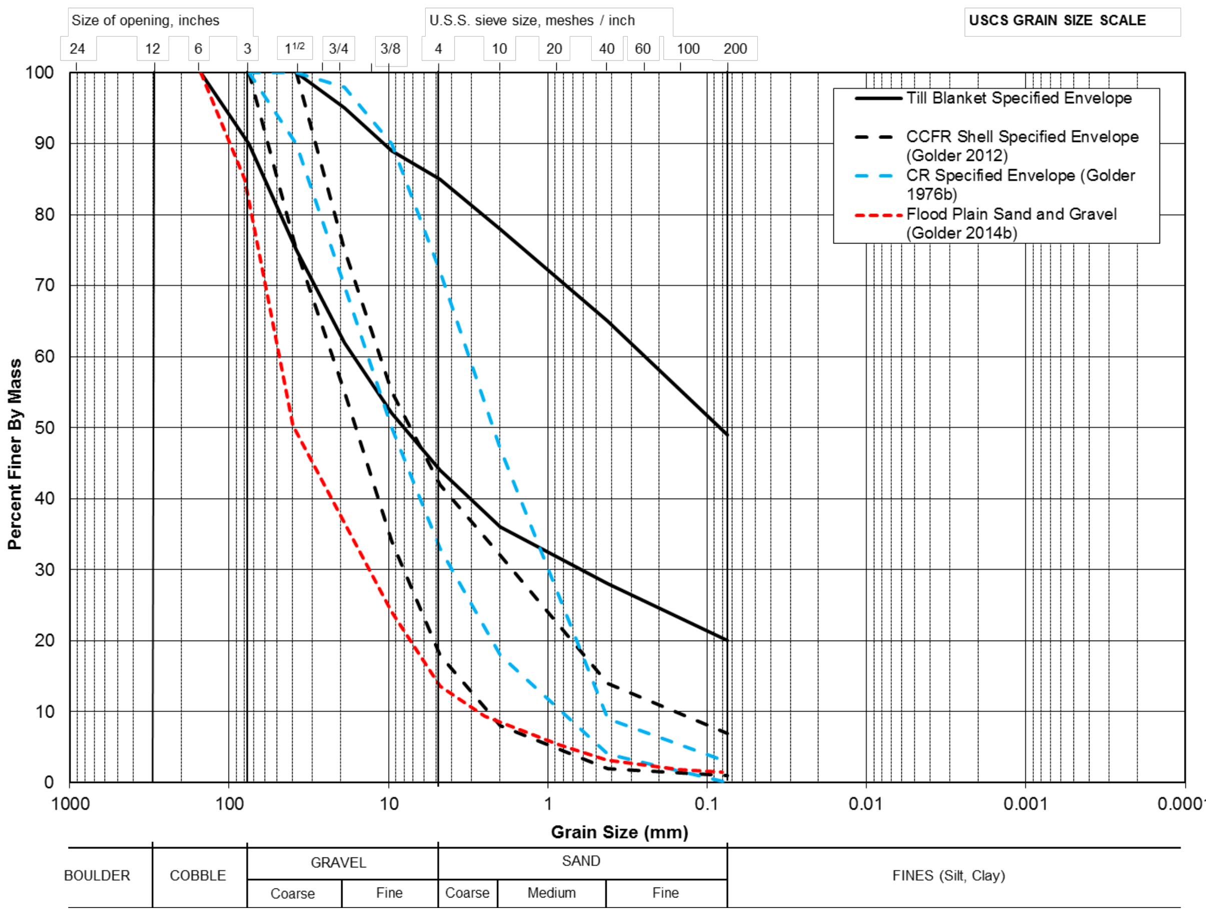

Chart 2: Specified Gradation Envelopes and Samples for Filter Compatibility Assessment

Details of the filter compatibility methods and the required specifications of each are provided in Table 2.

Table 2: Summary Filter Compatibility Methods and Specifications for the STP dam

Method/Criteria	Filter specification for till base soil	Result
Terzaghi method (Terzaghi 1922)	$D_{15(filter)} / d_{85(base)} \leq 4$	Passes
Sherard criteria (Sherard et al. 1984, Sherard and Dunningan 1989)	$D_{15(filter)} = 0.7$ mm	Passes for fine fraction of CCFR/CR Not met for coarse fraction of CCFR/CR and flood plain gravels
US Army Corps of Engineers (USACE 2004)	$D_{15(filter)} \leq \frac{40-A}{40-15}$, A=percent fines	Passes
Internal Stability (Kenney and Lau 1985; Li et al. 2009)	n/a	Passes

Gradation of the CR and CCFR materials are presented in Chart 2, and it can be noted that the materials do not always meet the Sherard criteria, as the coarse limit of the envelopes has a $D_{15(filter)}$ which exceeds the specification of 0.7 mm. Breakdown of the CR and CCFR materials occurs during compaction, which is expected to reduce the $D_{15(filter)}$ of the material somewhat, but some materials may still not meet the Sherard criteria.

Gradation of a sample of flood plain sand and gravel is also presented in Chart 2, and it can be noted that the materials do not always meet the Sherard criteria, as the $D_{15(filter)}$ of the sand and gravel is about 5 mm, which exceeds the specification of 0.7 mm. The $D_{15(filter)}$ of the flood plain sand and gravel was identified as being between 0.1 mm and 1.0 mm in KWL (1976), which is closer to meeting the criteria.

Based on the performance of the dam over the last 37 years, piping due to filter incompatible materials is not expected to be an issue. Continual seepage is evident at the toe of the STP dam, particularly along the West Dam, and has been reported for many years. Cloudy seepage water can indicate internal erosion, but records of the seepage from the STP indicate clear water. Regular inspections for evidence of increased seepage and piping should continue. Seepage from the STP dams should be collected as per the recommendation in the 2014 annual dam safety inspection (Golder 2014c) and monitored for particulate prior to the 2016 freshette.

b) Whether or not the filter has been constructed in accordance with the design.

Compatibility of local till with the CR material was established during construction of the NTP and the gradation specification of the CR was provided in Golder (1976b). Specifications from the initial construction of the STP between 1977 and 1979 remain consistent with recent construction specification and records.

Till for initial construction of the dam was taken from the excavation of the Fording River diversion channel (KWL [date unknown]) and from an existing borrow pit. One gradation of the borrow pit till and eleven gradations of till to be excavated from the diversion channel were confirmed to be filter compatible with the CR envelope (Golder 1976b).

The borrow pit till used during the initial construction is presumed to have been used for construction of the upstream blanket for raises between initial construction (completed in 1979) and the development of the Kilmarnock Pit in 2002. The CR material from the plant is known to have been used for the filter/shell for raises after the initial construction until 1993.

For the 2008, 2010, 2012, and 2013 embankment raises, till for the upstream blanket was sourced from the Kilmarnock pit based on an evaluation carried out by Golder (2002). The filter and shell material used was CCFR produced by the plant. For the 2008, 2010, 2012, and 2013 raises, gradations of the till and CCFR were taken for every 5,000 m^3 of material placed, as per the specifications. Gradation quality control data from the 2008, 2012, and 2013 as-built reports, as well as the 2002 till evaluation, were used to confirm filter compatibility of all materials placed (Golder 2002, 2009b, 2013a, 2014a).

It is noted that there are some gaps in construction quality assurance records, particularly for the 1983 to 1984, 1985 to 1990, and 1993 raises; however, the gradation of the CR and CCFR filter/shell material created by the plant appears to have remained relatively consistent from the 1970s to present day, as shown in Chart 2. Where data was available, it indicated that filter compatibility between the local till and the CR/CCFR was achieved. Gaps in the construction quality assurance records are considered to be very low risk.

c) If any gaps have been identified, a plan and schedule for addressing these issues.

The seepage from the STP dams should be collected as per the recommendation in the 2014 annual dam safety inspection (Golder 2014c) and monitored for particulate prior to the 2016 freshette.

Gaps in the quality control records are considered to be low risk, and no action is required to address this.

4.0 CLOSURE

We trust this letter satisfies your current requirements. If you have any questions or require further assistance, please do not hesitate to contact the undersigned.

Yours very truly,

GOLDER ASSOCIATES LTD.

PROFESSIONAL
PROVINCE OF
J. C. CUNNING
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Attachments: Study Limitations

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