Teck Coal Ltd.

Teck

2022 Dam Safety Review

Main and West Tailings Dams and Greenhills Settling Pond Dam

Teck Greenhills Operations near Elkford, British Columbia

Prepared By:

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March 24, 2023

680.220015.003

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Teck Coal Limited
Greenhills Operations
PO Box 100
Elkford, British Columbia

March 24, 2023

ATTN: Patrick Green

RE: 2022 Dam Safety Review
Tailings Storage Facility and Greenhills Settling Pond
Teck Greenhills Operations
Elkford , British Columbia

Mr. Green,

This report presents the results of NewFields Canada Mining & Environment ULC Dam Safety Review for the Tailings Storage Facility and the Settling Pond at Teck's Greenhills Operation near Elkford, British Columbia.

If you have any questions or require additional information, please contact the undersigned.

Best Regards,

NewFields Canada

Leon Botham, MSCE, P.Eng.
President, Principal Engineer

JJD/LCB/EMT/emt/kb

https://newfields365-my.sharepoint.com/personal/lbotham_newfields_com/Documents/Projects/2022/680.220015 - Teck Dam Safety Reviews - Elk Valley/003 - Greenhills Operations/x.x Reporting/Final/680.220015.003-002-Teck-Greenhills Operations DSR-Rev0-24 Mar 2023.docx

EXECUTIVE SUMMARY

The 2022 Dam Safety Review (DSR) was completed for the Tailings Storage Facility (TSF) and Settling Pond (GSP) at Teck Coal Ltd. (Teck) Greenhills Operations (GHO), located near Elkford British Columbia. The DSR completed was commensurate to an audit-type review as requested by Teck, and was based on review of relevant documentation provided by Teck, inspection of the facilities, and interviews with operating staff, engineering staff, and the Engineer of Record (EoR). The DSR includes review of the credible failure modes, provides commentary on the risk management controls in place, and provides comment on continual improvement opportunities for the TSF and GSP. The DSR found that the facilities reviewed meet or exceed current regulatory guidance and are safe relative to current best practice. No dam safety issues were identified.

The TSF is confined by natural topography and two engineered embankments. The Main Tailings Dam (MTD) and West Tailings Dam (WTD) are constructed of Coarse Coal Refuse (CCR) with a clay blanket on the upstream face. Both structures were raised to 1,736 m during the summer of 2022, and are currently permitted to a crest elevation of 1,740 m. The GSP is confined on the west, south and east sides by a ring dam, which was constructed of granular materials excavated from the pond footprint. The GSP ring dam was originally constructed in 1981 to an elevation of 1,512.8 m and has not been modified since.

Key hazards as they relate to credible modes of failure for the TSF and GSP include instability leading to structural failure and loss of containment, exceedance of water storage capacity leading to overtopping, and internal erosion leading to a loss of structural integrity of the containment structures.

Teck has established operating, maintenance, surveillance and emergency procedures for the TSF and GSP. Annual Facility Performance Reviews (AFPR) are completed for each facility by the EoR. Observed performance of the TSF and GSP indicate that both facilities are performing as designed.

Throughout the DSR process, it was evident that Teck corporate and operational teams, and the EoR are engaged, well-coordinated, understand their roles and responsibilities, and are well-integrated into management and operation of the site. NewFields' observations during the site inspection, the surveillance records and monitoring data available, and the understanding that the site is well managed generally corroborate that the likelihood of a dam safety issue at the TSF and GSP remains low. The risks that the facilities are exposed to are well understood by Teck and the EoR, and Teck strives to continually improve the safety of the site.

The DSR found no new recommendations that pose an immediate threat to human health, the environment, or regulatory compliance (Teck priority ranking 1). Additionally, the DSR did not identify any issues that, if left unaddressed, could lead to dam safety issues, injury, environmental harm, or significant regulatory action (Teck priority ranking 2). There were also no repetitive deficiencies indicating a systematic breakdown in procedures (Teck priority ranking 2).

Several recommendations and opportunities for improvement were identified throughout the DSR. These recommendations are presented in Table 6 in Section 7 of this report. Opportunities for improvement are also included in Section 7. A Dam Safety Review Assurance Statement, site inspection report and interview summaries can be found appended to this report.

LIST OF ABBREVIATIONS

AEP	Annual Exceedance Probability
AFPR	Annual Facility Performance Review Report
ALARP	As Low As Reasonably Practicable
BC	British Columbia
CCR	Coarse Coal Refuse
CDA	Canadian Dam Association
CFMA	Credible Catastrophic Failure Modes Assessment
CQA	Construction Quality Assurance
DSR	Dam Safety Review
EDGM	Earthquake Design Ground Motion
EGBC	Engineers and Geoscientists BC
EMLI	Ministry of Energy, Mines and Low Carbon Innovation
EoR	Engineer of Record
EPP	Emergency Preparedness Plan
EPRP	Emergency Preparedness and Response Plans
FS	Factor of Safety
GHO	Greenhills Operations
GISTM	Global Industry Standard on Tailings Management
Golder	Golder Associates Ltd.
GSP	Greenhills Settling Pond
Hardy	Hardy Associates Ltd.
HEC-HMS	Hydrologic Engineering Centre Hydrologic Modeling System
HSRC	Health, Safety and Reclamation Code for Mines in British Columbia
H:V	Horizontal:Vertical
IDF	Inflow Design Flood
KCB	Klohn Crippen Berger
km	Kilometres
km^2	Square Kilometres
m	Metres

m^3	Cubic Metres
Mm^3	Million Cubic Metres
mm	Millimetre
MAC	Mining Association of Canada
MERP	Mine Emergency Response Plan
MTD	Main Tailings Dam
NewFields	NewFields Canada Mining & Environment ULC
OMS	Operations, Maintenance, and Surveillance Manual
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
QP	Qualified Professional
QPO	Quantifiable Performance Objectives
SCS	Soil Conservation Services
SWWB	Site Wide Water Balance
t/m^3	Tonnes per cubic metre
TARP	Trigger Action Response Plans
Teck	Teck Coal Ltd.
TSF	Tailings Storage Facility
TWRS	Tailings and Water Retaining Structures
VWP	Vibrating Wire Piezometer
WTD	West Tailings Dam

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1. INTRODUCTION

This report has been prepared by NewFields Canada Mining & Environment ULC (NewFields) for Teck Coal Ltd. (Teck) to document the results of an audit-type Dam Safety Review (DSR) completed for the Tailings Storage Facility (TSF) and Settling Pond (GSP) at Teck's Greenhills Operations (GHO) site, located near Elkford, British Columbia (BC).

The DSR has been completed in accordance with the scope of work presented in NewFields' proposal 680.22P019.003, dated August 26, 2022.

1.1. Dam Safety Review Purpose, Scope, and Methodology

The purpose of the DSR is to evaluate the safety of the TSF and GSP relative to current standards and practice. The DSR is based on review of all aspects of design, construction, maintenance, operation, process, and systems affecting the safety of the structure, including the dam safety management system. The assessment includes review of the credible failure modes, provides commentary on the risk management controls in place, and provides comment on continual improvement opportunities for the structures under review. The DSR also includes review of the application of the "As Low As Reasonably Practicable" (ALARP) principles employed by Teck.

The DSR completed for the TSF and GSP was an audit-type. An audit-type DSR is intended to review safety of the facility based on review of relevant documentation, inspection of the facility, interviews with operating staff, and preliminary engineering analysis (EGBC 2016). A previous DSR was completed in 2017 for the TSF and GSP, so this DSR primarily focuses on conditions at these facilities since that time.

The methodology and scope of work associated with this DSR is listed below:

- Collection and review of relevant data provided by Teck.
- Kick-off meeting between Teck and NewFields to discuss project scope, schedule and arrange a site visit.
- Site inspection and key personnel interviews completed in November 2022.
- Audit-style DSR of the TSF and GSP to determine the adequacy of the design, construction and operations of the facilities to address potential failure modes, taking into consideration:
    - Review of historical investigations, design, and record of construction reports and drawings to confirm that the facilities conform with the intended design.
    - Review of climate data, design storm analysis, and water balance used for design of the facilities.
    - Capacity and structural integrity of all discharge structures.
    - Operating procedures for the impoundments.
    - Review of instrumentation and surveillance programs and available data to assess the performance of the structures.
    - Review of hazards and credible failure modes with considerations for Teck's internal risk assessment and Credible Catastrophic Failure Modes Assessment (CFMA).

- The effectiveness of the dam safety management systems, including, operations maintenance, and surveillance (OMS) manuals and records, and Emergency Preparedness and Response Plans (EPRP).

1.2. Regulatory Requirements and Industry Guidelines

The safety of mining dams in BC is governed by the Mines Act and the accompanying Health, Safety and Reclamation Code (HSRC) for Mines in British Columbia (EMLI 2021), administered by the Ministry of Energy, Mines and Low Carbon Innovation (EMLI). Supplemental to the HSRC, the EMLI Part 10 Guidance Document (EMLI 2016) provides specific guidance to consider for application of the HSRC to mining dams and tailings operations.

Additional guidance considered includes the Engineers and Geoscientists BC (EGBC) Professional Practice Guidelines – Legislated Dam Safety Reviews (EGBC 2016), as well as industry best practice guidance from the Canadian Dam Association (CDA), the Global Industry Standard on Tailings Management (GISTM) (ICMM et al. 2020), and the Mining Association of Canada (MAC) (MAC 2021a).

The last DSR for the GHO TSF and GSP was completed in 2017 by Klohn Crippen Berger (KCB) and was submitted to Teck in March 2018 (KCB 2018). The HSRC requires DSRs be completed every 5 years and this DSR has been completed in accordance with those requirements. It is understood that this report will be submitted by Teck to EMLI to fulfill the requirements of Part 10.5.4 of the HSRC.

1.3. Reviewers

Mr. Leon Botham, MSCE, P.Eng., was the lead Qualified Professional Engineer for the DSR. Mr. Botham is a professional engineer and has more than 30 years of experience in civil and geotechnical engineering related to dam safety, tailings storage and mine waste management, engineering design, environmental impact assessment, permitting, construction oversight, operations, and closure. He has performed DSRs for a number of tailings dams, and has been involved in technical due diligence reviews, and served as an independent review board member for a number of major mining projects in Canada and internationally. He is familiar with the regulatory requirements for tailings impoundments in BC, CDA guidelines, GISTM, and the MAC tailings guidelines. Mr. Botham is a licensed Professional Engineer in British Columbia and is considered the Qualified Professional Engineer for the DSR report. A DSR letter of compliance, as required by EGBC, is included in Appendix A.

Mr. Botham was supported by a team of qualified professionals that included Mr. Justin Desjardins, P.Eng., Mrs. Erin Moss Tressel, M.Eng., P.Eng., Mr. Ty Lloyd, M.Eng., P.Eng., and other supporting staff.

1.4. Organization of the Report

The organization of the report following the introduction section is listed below:

- ***Section 2 – Facility Description:*** This section includes a description of site conditions, description of the facilities, past construction, any previous issues, design basis, and description of hazards.
- ***Section 3 – Background Review:*** This section includes a summary of documents reviewed as part of the DSR.

- ***Section 4 – Facility Inspection and Interviews:*** This section details observations from the site visit, interviews, and inspection completed by Mr. Leon Botham and Ms. Erin Moss Tressel.
- ***Section 5 – Dam Safety Assessment:*** This section offers an overview of the facilities' construction and operation, taking into account the design basis, HSRC, and relevant guidelines. Additionally, it includes a review of the current instrumentation and surveillance programs, which focuses on identifying patterns and/or changes in behavior over time while considering the established alarm levels, and hazards and failure modes.
- ***Section 6 – Dam Safety Management System:*** This section provides a summary of the review of the available dam safety management documents, including OMS manuals, EPRPs, public safety and security of the site, regulatory compliance and conformance to CDA principles.
- ***Section 7 – Conclusions and Recommendations:*** This section provides a summary of the DSR recommendations made in this report.

The documents referred to in this report can be found in the references section following the report. Site photos, the site inspection summary memorandum, and the DSR assurance statement are included in the appendices.

1.5. Site Elevation Datum

It is noted that all elevations described in this report are referenced to the Elk Valley Elevation Datum.

2. FACILITY DESCRIPTION

2.1. General Description

Teck's GHO is one of four metallurgical coal operations located in the Elk Valley region of BC, approximately 8 kilometres (km) northeast of Elkford. Westar Mining Ltd. commenced mining operations at the site in 1982, which continued until 1992 when the mine was temporarily closed. The site has been in continuous production under several owners since 1993. Teck assumed ownership and control of the mine in 2008.

The GHO is an active open pit mining facility. The coal extracted from the pit undergoes processing at the wash plant, resulting in the production of two by-product streams: coarse coal refuse (CCR), and fine refuse tailings. The CCR is stored in stockpiles near the TSF. The fine refuse tailings consist of a slurry of silt sized coal and rock particles and are transported to the TSF via gravity where they are discharged at an approximate solids content of 20%. The dry density of the fine refuse tailings is approximately 1.13 tonnes per cubic metre (t/m^3) (Golder 2022a).

The GSP is used to manage surface water runoff from the Greenhills Creek catchment area. The site location and general arrangement of the GHO TSF and GSP are shown in Figure 1.

Mr. Andy Haynes, P.Eng. of WSP serves as the Engineer of Record (EoR) for the TSF and the GSP.

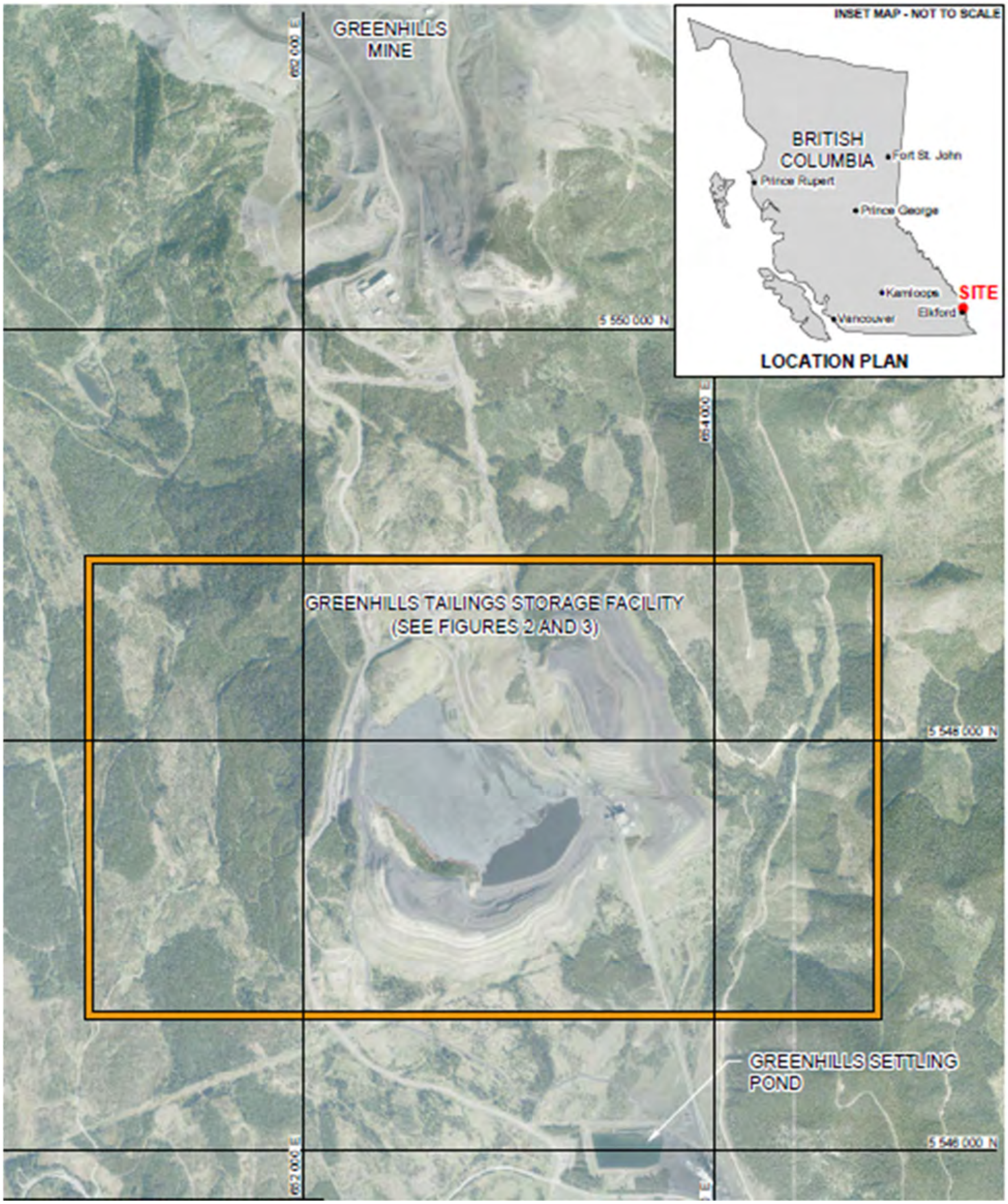

Figure 1: Greenhills Operations General Arrangement Plan (from Golder 2022a)

2.2. Tailings Storage Facility Description

Located on the western side of the coal wash plant, the GHO TSF is impounded by two structures: the Main Tailings Dam (MTD) and the West Tailings Dam (WTD). Both dams have been designed and permitted to be raised to an elevation of 1,740 m, the anticipated ultimate configuration of the facility (Golder 2021a). Embankment raises were completed in 2021, and 2022, and the current embankment elevation is 1,736 m (based on correspondence with Teck). Construction reporting for the 2022 raise was in progress during the preparation of this DSR and not available for review. The configuration of the TSF is shown in Figure 2.

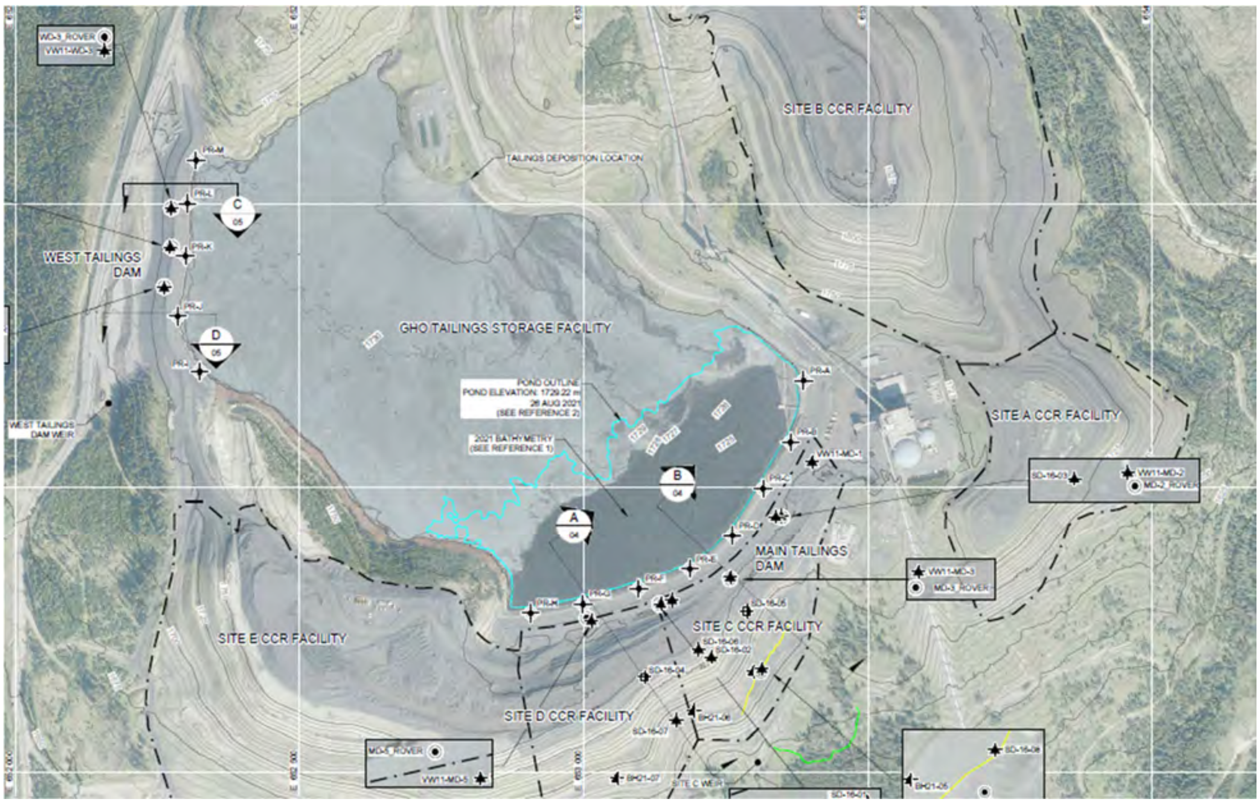

Figure 2: Greenhills Tailings Storage Facility (from Golder 2022a)

At the time of the DSR site visit, slurry tailings were being deposited into the TSF through a single discharge point located near the midpoint of the MTD, to develop a beach against the upstream face of the MTD. Pond water is returned from the TSF to the process plant by a reclaim barge located near the eastern abutment of the MTD. Currently tailings are deposited into the TSF at a rate of approximately 500,000 cubic metres (m^3) to 600,000 m^3 annually (Golder 2021d).

A bathymetric survey completed in 2021 indicated that the deepest point of the impoundment was located approximately 65 m south of the barge. It had an elevation of approximately 1,723 m, which corresponded to a pond depth of 6.3 m at the time of the survey.

2.2.1. Main Tailings Dam

The MTD has been progressively developed with periodic downstream raises occurring since the original construction of the MTD starter dam. Tailings do not constitute any structural component of the dam. The MTD is a zoned earth fill dam consisting of a CCR shell with an upstream clay blanket. The upstream clay blanket is composed of clay till and is approximately 6 m to 7 m wide. The filter compatibility of the CCR, clay blanket and tailings have been evaluated by the EoR, who determined that materials met filter compatibility requirements.

The crest of the dam is approximately 12 m wide and the length of the dam is approximately 760 m. The downstream slope is approximately 2.5 horizontal to 1 vertical (H:V) and the upstream slope is approximately 2H:1V. The maximum current height of the MTD is approximately 50 m above original ground surface. CCR stockpiles have been placed on the downstream toe of the MTD with variable height and geometry. A typical cross section of the MTD is presented in Figure 3.

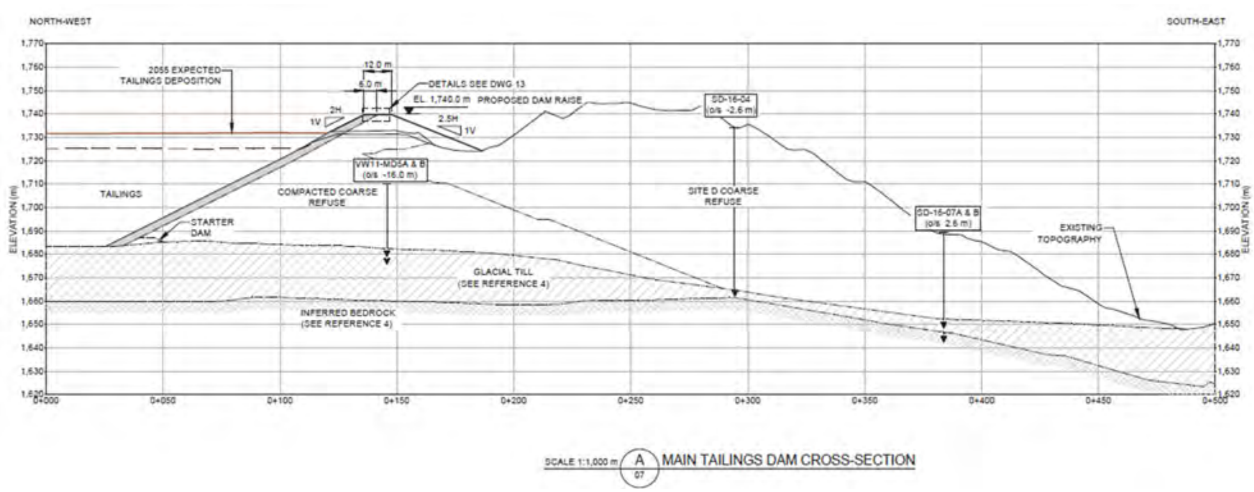

Figure 3: Main Tailings Dam Typical Cross Section (Golder 2021a)

2.2.2. West Tailings Dam

The WTD is a zoned earth fill dam consisting of a CCR shell with an upstream clay blanket, designed in a similar manner as the MTD. The upstream clay blanket is composed of clay till and is approximately 6 m wide. All materials have been evaluated by the EoR and meet filter compatibility guidelines. The crest of the dam is approximately 12 m wide and the length of the dam is approximately 480 m. The downstream slope is approximately 2.5H:1V and the upstream slope is approximately 2H:1V. The current maximum height of the WTD is approximately 25 m above original ground surface. The GH1 access road is located downstream of the WTD. A typical cross section of the WTD is presented in Figure 4.

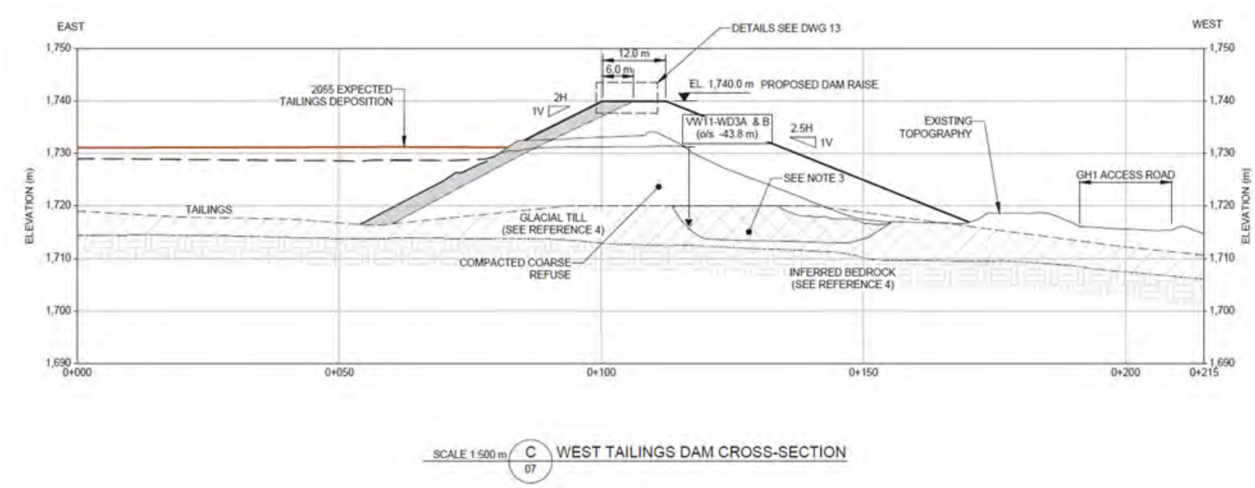

Figure 4: Main Tailings Dam Typical Cross Section (Golder 2021a)

Similar to the MTD, the WTD has been progressively developed with periodic downstream raises occurring since the original construction of the dam in 1993. It is noted that tailings do not constitute any structural component of the dam.

2.2.3. Subsurface Conditions

The foundation conditions at the MTD and WTD sites have been characterized as the dams have been raised over the operational life of the facility, including two geotechnical investigations at the MTD, two geotechnical investigations at the WTD, a preliminary geohazard study for the TSF, and a geotechnical investigation at the Site C CCR stockpile at the downstream toe of the MTD. The geotechnical reports are summarized and referenced in the WSP design report for the most recent dam raise (Golder 2021a) and the last DSR completed for the facility (KCB 2018). The following descriptions of the subsurface conditions at the MTD and WTD are based on review of these reports.

The general soil stratigraphy at the MTD and WTD foundations consisted of localized surficial layers of colluvium and/or organics/muskeg overlying glacial till, followed by shale bedrock. The colluvium was composed of a mixture of clay, sand, and gravel and had a thickness up to 2 m. During construction of both the MTD and WTD, organic materials and soft colluvium materials were reportedly excavated to expose the underlaying glacial till and backfilled with selected waste rock material (Golder 2021a). Glacial till was encountered at surface or underlying the colluvium ranging in thickness from 3 m to 57 m and consisted of medium plasticity clayey silt matrix with gravel and cobbles. The glacial till is very dense in nature with Standard Penetration Test N values above 50.

Upon review the most recent geotechnical investigation at the MTD (Golder 2017a), it was found that there were 27 boreholes within and near the dam footprint, providing sufficient coverage of the MTD foundation in NewFields' opinion. Upon review the most recent geotechnical investigation at the WTD (Golder 2013), it was found that there were 17 boreholes and 6 test pits within and near the dam footprint, providing sufficient coverage of the WTD foundation in NewFields' opinion.

2.3. Greenhills Settling Pond Description

The GSP is located approximately 1.5 km south of the GHO TSF and west of the dryer plant. The GSP is a rectangular pond approximately 170 m wide by 330 m long covering an area of approximately 6 ha, with a storage volume capacity of 300,000 m^3. The pond is a side-valley impoundment contained by a perimeter dyke along the south and west and natural topography to the north and east. The dyke has a maximum height of up to 10 m, a 6 m crest width, 2H:1V downstream slopes, and is approximately 600 m in length. The current crest elevation of the GSP dyke is 1,512.8 m (Golder 2022b). The GSP consists of two ponds that were constructed in stages. The primary pond is approximately 15 m wide and is separated from the larger secondary pond by a finger dyke approximately 1 m in height at the northern extent of the GSP.

The pond receives surface water runoff from the Greenhills Creek catchment area, including the wash plant, the MTD of the TSF, several CCR stockpiles, and the coal conveyor. Water enters the GSP from Greenhills Creek through a 1 m diameter corrugated metal culvert located at the northeast corner of the facility. Flow from the primary pond then passes over a rock weir at the western edge of the finger dyke, where it enters the secondary pond. Water is discharged over a concrete spillway located on the downstream slope of the southern embankment with an invert elevation of 1,511.5 m, which is 1.3 m below the crest. Discharge water passes through a concrete stilling pond and discharges into Greenhills Creek through a 1.5 m diameter culvert. The primary pond is periodically dredged to remove sediment collected in the pond. The layout of the GSP is shown in Figure 5. Typical cross sections of the perimeter dyke are shown in Figure 6.

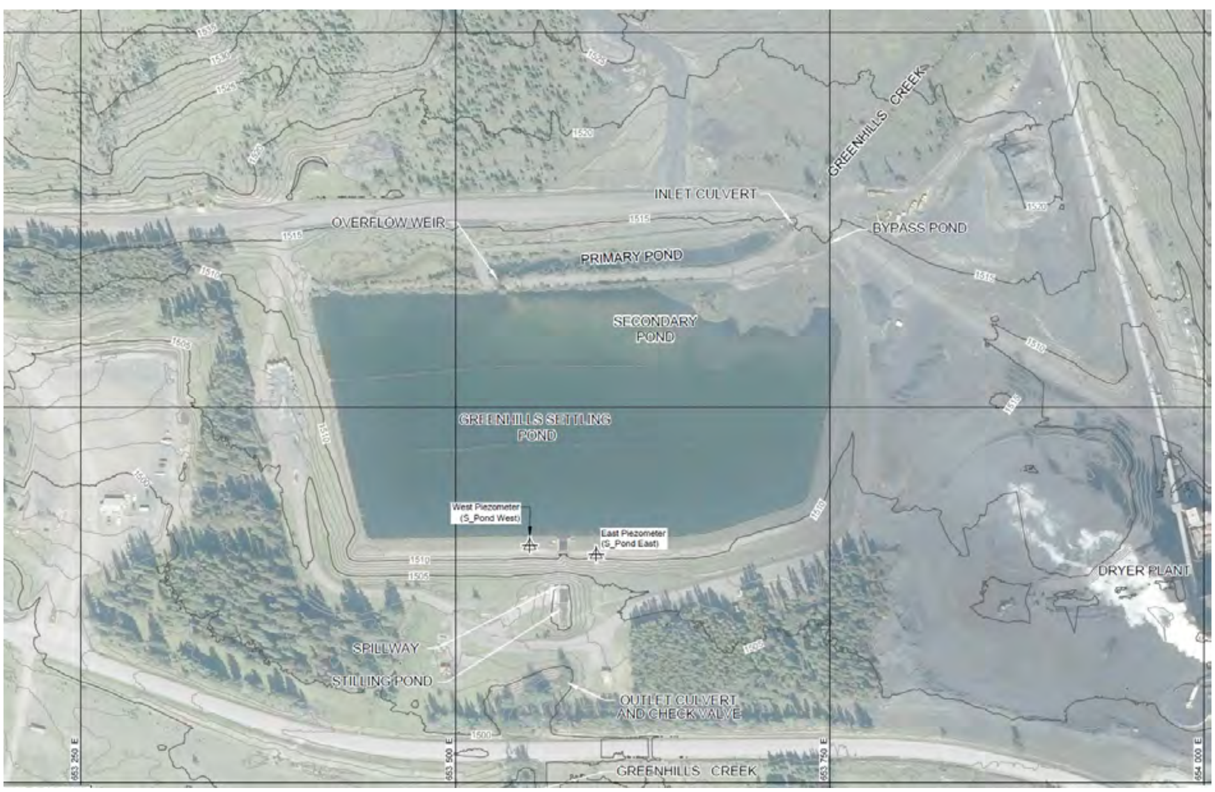

Figure 5: Greenhills Settling Pond (from Teck 2022c)

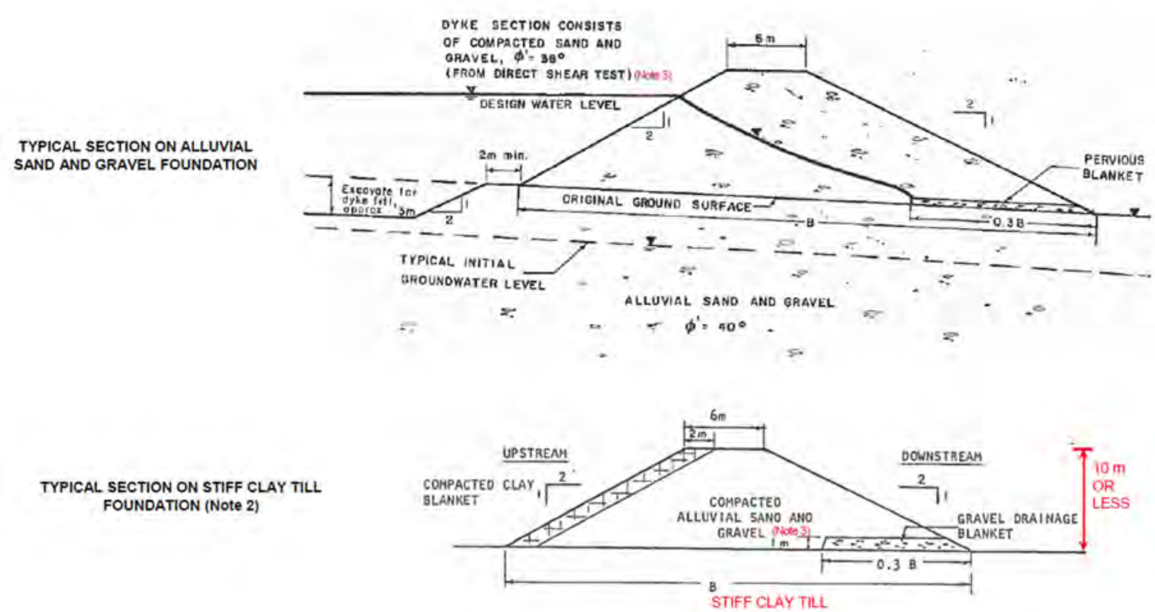

Figure 6: Greenhills Settling Pond Dyke Typical Cross Section (Golder 2022b)

Silt curtains were added to the pond in 1982 to increase retention time. Additional silt curtains were added to the pond in 2009 and replacement/reconfiguration of the silt curtains has occurred as a part of regular maintenance since. Maintenance and repairs to the concrete spillway have occurred periodically since 1997 on an as required basis.

The pond dykes were designed as homogenous earth fill structures consisting of alluvial sand and gravel with a compacted clay blanket on the northern end of the west dyke where the dyke is founded on glacial till. Construction records are not available for the GSP; however the design indicates that coarser gravels would be placed in the downstream portion of the embankment and finer-grained sands would be placed within the upstream portion of the embankment.

2.3.1. Foundation Conditions

The foundation conditions at the GSP were characterized during the initial design of the facility by Hardy Associates Ltd. (Hardy) in 1981 and were reviewed in the 2017 DSR completed by KCB. The general soil stratigraphy at the GSP consists of dense alluvial gravels containing variable amounts of sand and occasional silty and clayey zones. Glacial till comprising of stiff silty clay was encountered at the northern half of the west portion of the embankment.

2.4. Consequence of Failure

Teck is aligned with the most conservative interpretation of the GISTM and consequence classification is not part of their tailings and water management governance. An extreme consequence of failure rating has been applied to facilities with a credible failure mode that would lead to a loss of containment. For facilities without a credible failure mode in terms of a life safety issue, Teck has mandated that credible risks will be reduced to ALARP. This approach meets or exceeds regulatory requirements, is consistent with the new GISTM, and is consistent with industry-leading best practices.

The consequence classification for MTD and WTD is High (Golder 2022a). However, the recent raise design to 1,740 m was assessed based on extreme loading cases for earthquake and flood events (Golder 2021a) which is consistent with guidance from the GISTM and leading industry practice. The consequence classification for the GSP dyke is Significant (Golder 2022b). As reported in the most recent Annual Facility Performance Review (AFPR), the GSP dyke was assessed based on an extreme loading case for earthquakes and a significant loading case for flood events (Golder 2022b). NewFields considers this approach suitable to manage the risks associated with the GSP.

2.5. Hazards and Credible Failure Modes

Hazards and credible failure modes are reviewed annually by the EoR and documented in the AFPR reports. Key hazards that could impact the structural safety of a dam and potentially lead to loss of containment from the TSF or the GSP include:

- **Slope Instability** – characterized by slope failure when the forces acting on the containment structure exceed the shear strength of the foundation and embankment soils under the certain loading conditions, causing the dam to collapse and potential loss of containment.
- **Internal Erosion** – weakening of the embankment caused by soil particles becoming dislodged and transported away by the seepage flow, thereby creating empty spaces or voids that can further propagate the erosion process, potentially leading to piping failure and loss of containment. This is often seen in materials that are not filter-compatible, meaning that the fine fraction of one material can migrate into or through the voids of an adjacent material under a strong enough hydraulic gradient.
- **Overtopping** – water level in the impoundment exceeds the height of the containment structure, resulting in flow over the containment structure and subsequent erosion, potentially leading to a loss of containment.

Section 5 provides a detailed review of credible failure modes, including their likelihood of occurrence and corresponding risk management practices.

2.6. Operational Phase

CDA 2019 describes the different life cycle phases of mining dams, including site selection and design, construction, operation, transition, closure – active care, and closure – passive care. The MTD, WTD, and the GSP are all within the Operation Phase.

The Operation Phase for a facility can potentially last for decades and can vary from the original design duration due to changes in mine life as mining progresses (CDA 2019). It is noted that the permitted elevation of the MTD and WTD could potentially allow for placement of tailings into the TSF until at least 2055.

2.7. Design Basis and Design Criteria

2.7.1. Tailings Storage Facility

The current design basis and design criteria for the TSF, including the MTD and WTD is documented in the 1,740 m raise design report (Golder 2021a). A summary of the design criteria for the TSF and associated structures is presented in Table 1.

Table 1: Tailings Storage Facility Design Criteria

Criteria	Item	Design Value
Mine Planning	Annual Tailings Deposition	0.5 Mm^3 for 2023 reducing to 12,000 m^3 in 2024 and beyond
Geotechnical	Design Earthquake AEP	1:10,000 year
	EDGM	0.3
	Minimum FS – Static	1.5
	Minimum FS – Seismic Loading	1.1
	Minimum FS –Post Earthquake	1.2
	Deformation (if required seismic loading FS not met)	≤1-2% strain
Hydrotechnical	IDF [1]	814 mm
	IDF [1] Volume	1.1 Mm^3
	Catchment Area	2 km^2
	1:2 year Wind Runup	0.25m to 0.35 m [2]
	Minimum Required Freeboard [3]	2.4 m
	Maximum Operating Pond Level	1,732.5 m

AEP = annual exceedance probability; IDF = inflow design flood; EDGM = earthquake design ground motion; FS = factor of safety; Mm^3 = million cubic metres; mm = millimetres; m = metres; km^2 = square kilometres
[1] The inflow design flood is based on the 72-hour probable maximum flood event.
[2] Wave runup value of 0.4 m was conservatively used for design.
[3] Based on an operational water volume of approximately 400,000 m^3

2.7.2. Greenhills Settling Pond

The current design basis and design criteria for the GSP is documented in the most recent AFPR report (Golder 2022b). A summary of the design criteria for the GSP and associated structures is presented in Table 2.

Table 2: Greenhills Settling Pond Design Criteria

Criteria	Item	Design Value
Geotechnical	Design Earthquake AEP	1:10,000 year
	EDGM	0.3
	Minimum FS – Static	1.5
	Minimum FS – Seismic Loading	1.0
	Minimum FS – Post Earthquake	1.2
Hydrotechnical	IDF (1:200 year 24 hr event)	168 mm
	1:2 year Wind Runup	0.2 m
	Minimum Required Freeboard	0.4 m
	Maximum Operating Pond Level	1,512.4 m

AEP = annual exceedance probability; IDF = inflow design flood; EDGM = earthquake design ground motion; FS = factor of safety; mm = millimetres; m = metres

3. BACKGROUND REVIEW

3.1. Documents Reviewed

Documents and data reviewed as part of the DSR included:

- Relevant regulatory documents and industry guidelines (EMLI, EGBC, CDA, GISTM);
- Design report for the 1,740 m raise (includes design basis, deposition plan summary, water balance, closure plan) (Golder 2021a);
- GSP stability review reports (Golder 2016, Golder 2021b);
- Construction record reports (Golder 2017c, Golder 2019b, Golder 2021c, Golder 2022c);
- 2017 DSR report (KCB 2018);
- Annual Facility Performance Reviews and other annual Reports (Golder 2018, Golder 2019a, Golder 2020, Golder 2021d, Golder 2022a, Golder 2022b); and,

- OMS manuals and emergency response documentation (Teck 2022a, Teck 2022b, Teck 2022c, Teck 2018).

A complete list of references can be found following the body of the report.

3.2. 2017 Dam Safety Review

This is the second formal DSR completed for the GHO TSF and GSP. The first DSR was completed in 2017 by KCB (KCB 2018). The 2022 DSR primarily focused on changes to the TSF and GSP since the 2017 DSR was completed.

The 2017 DSR did not present any independent analyses for any of the structures reviewed but did include a comprehensive review of available documentation for the TSF and GSP. In general, KCB found that the MTD, WTD and GSP met or exceeded design and performance requirements, regulations, guidance and objectives in place at the time. They also felt that a strong dam safety management system was in place.

KCB presented a total of 13 recommendations in the 2017 DSR report, of which 3 were subsequently addressed in 2017 between the time of the 2017 DSR site visit and issuing of KCB's final report. Based on data reviewed for this DSR, NewFields can confirm that all 13 recommendations have been addressed since the last DSR.

The most recent design report has assessed the water balance for the TSF and included hydrogeological analysis. In addition, based on discussions with Teck, it is understood that the ditch and weir at the MTD (downstream of the Site C CCR) have been upgraded. The 2017 DSR also recommended that any outstanding issues identified during annual facility inspections be addressed. This is general best practice, and Teck tracks ongoing issues with the EoR on a monthly basis, at a minimum.

3.3. Annual Facility Performance Reviews

AFPRs are completed annually by the EoR for GHO TSF and GSP. The following sections outline the most recent AFPRs for both facilities.

3.3.1. Tailings Storage Facility AFPR

The following key changes to the TSF since the last DSR (KCB 2018) were outlined in the 2021 AFPR which was the most recent available for review as part of this DSR (Golder 2021a). Key changes highlighted include:

- In 2020, the TSF embankments were raised to an elevation of approximately 1,732.5 m. The TSF embankments were then raised to an elevation of 1,734 m in 2021; and,
- A permit amendment was completed in 2021 to raise the TSF embankments to an ultimate elevation of 1,740 m. This was in conjunction with a change in tailings management strategy for future operations at GHO, which consisted of co-deposition of fine tailings with CCR in Site F, reducing the tailings solids deposited into the TSF.

Outstanding issues identified by the EoR in the 2021 AFPR (Golder 2021a) include:

- Additional inundation study modelling of the downstream area, up to Lake Koocanusa (ID Number 2019-07, priority level 3). An update to the inundation study should be completed with additional modelling at the confluence of the Elk River and Fording River, and at Lake Koocanusa.
- OMS manual does not reflect the current geotechnical instrumentation details including revised quantifiable performance objectives (QPOs), revised MAC and Teck guidance documents, and multiple coordinate grid systems appear to be used in the OMS manual (ID Number 2019-02, priority level 3). The OMS manual should be updated to remove non-functioning geotechnical instrumentation and update QPOs, updated based on MAC and Teck guidance and updated to use a single coordinate grid system.

While the 2021 AFPR still listed the additional inundation study in the issues table, it had been noted as closed. The document stated that addressing this deficiency is not currently required to inform consequence classification of the TSF based on Teck's approach to risk management. The EoR stated that the existing inundation study was suitable for emergency planning. The need for updates to the inundation study will be reviewed in the future.

Since the 2021 AFPR has been issued, the OMS manual and EPRP have been updated. The most recent versions of these documents, reviewed for this DSR, were dated November and December 2022, respectively. It appears that the required updates have been made and NewFields suspects that ID number 2019-02 will be closed in the 2022 ARPR report.

3.3.2. Greenhills Settling Pond AFPR

There have been no key changes to the GSP since the 2017 DSR. The only work that has been completed at the GSP has been routine in nature. The outstanding issues identified by the EoR in the 2021 AFPR which was the most recent available for review during this DSR (Golder 2022b) involved updating the OMS manual. The GSP OMS manual was updated in December 2022, and addresses the issues identified in the 2021 AFPR report.

3.4. Tailings Storage Facility Construction

Construction activities at the TSF related to the MTD and WTD since the 2017 DSR (KCB 2018) include:

- 2017 – Raise the MTD to approximately 1,728.9 m and the WTD to approximately 1,728.8 m (Golder 2017c);
- 2018 – Raise the MTD to approximately 1,731.4 m and the WTD to approximately 1,731.3 m (Golder 2019b);
- 2020 – Raise the MTD and WTD to approximately 1,732.5 m (Golder 2021c);
- 2021 – Raise the MTD and WTD to approximately 1,734.0 m (Golder 2022c); and,
- 2022 – Raise the MTD and WTD to approximately 1,736 m (based on correspondence with Teck). It is noted that 2022 construction records were still being prepared and were not available for review during this DSR.

The construction record reports for the 2017, 2018, 2020, and 2021 raise projects were reviewed as part of the DSR. Dam raise construction has been completed by local contractors and construction quality assurance (CQA) was provided by WSP. Based on review of the construction record reports compiled by WSP, the dam raise projects completed in 2017, 2018, 2020, and 2021 were constructed to the intended geometry and performed in accordance with the specifications, meeting the intent of design.

3.5. Review of Instrumentation, Water Balance, Climate Data, and Deposition Plan

Long term monitoring trends that relate to the performance and safety of the facilities were reviewed. This included a review of instrumentation records, water balance, climate, and deposition planning.

Instrumentation data is evaluated regularly throughout the year by Teck and the EoR, and is reviewed annually as part of the AFPR. As part of this DSR, NewFields reviewed the instrumentation data for both the TSF and GSP as reported in the AFPR reports (Golder 2022a, Golder 2022b) for consistency and any data trends that may not have been previously reported on. As per the methodology for an audit-style DSR, in depth evaluation of the monitoring data was not undertaken.

Instrumentation review at the TSF included review of a GPS unit on the water reclaim barge to continuously monitor pond levels, survey prisms, GPS units that track long-term trends in displacement on the MTD and WTD, piezometers used to monitor ground water conditions around the MTD and WTD, inclinometers installed in the MTD to measure changes in slope movement, displacement or deformation, and V-notch weirs that are installed with a pressure transducer to measure continuous discharge located near the toe of the MTD and WTD (Golder 2022a).

Instrumentation review at GSP included review of a staff gauge that is used to manually record pond water level, and piezometers used to monitor ground water conditions on the downstream face of the southern portion of the ring dyke. The GSP does not include inclinometers or survey instrumentation to measure slope movement (Golder 2022b).

The water balance and climate data assessment included review of the IDF as it was reported for both the TSF (KWL 2017) and GSP (Golder 2017b). The water balance and climate data presented in the AFPR reports were also reviewed, supplemented by review of the TSF water balance and deposition plan presented in the most recent TSF design report (Golder 2021a).

4. FACILITY INSPECTION AND KEY PERSONNEL INTERVIEWS

A site inspection and key personnel interviews were conducted by NewFields as part of this DSR. The purpose of the site inspection and interviews were to verify the condition of the TSF and GSP and to gain a more thorough understanding of how GHO operates, maintains, and monitors the TSF and GSP.

4.1. Facility Inspection Observations

A tour of all facilities was completed by Mr. Leon Botham and Ms. Erin Moss Tressel of NewFields, accompanied by Mr. Patrick Lea from GHO, on November 21, 2022. The inspection of each facility and their related infrastructure included a drive-by inspection with an opportunity to stop and visually inspect various components of the facility, including the containment dams, discharge structures and other relevant infrastructure. Observations were made of the embankment crests, tailings surface, and upstream and downstream slopes.

Based on the observations made during the site visit, NewFields did not identify any immediate dam safety risks or concerns. Key observations applicable to both the TSF and GSP include:

- Conditions were snow covered at the time of the site visit. However, there were no visual signs of movement, seepage or erosion on any structure.
- Animal tracks were visible on each structure, however, there were no visual indication of burrows or wildlife damage to the structures.
- Instrumentation was present on all embankments, and generally appeared well protected.

A summary of the main observations specific to the TSF and the GSP are summarized below. Detailed inspection checklists and site photographs are included in the site inspection report in Appendix B.

4.1.1. Tailings Storage Facility Inspection Observations

Inspection of the TSF included both the MTD and WTD. Observations included:

- Tailings were being deposited from a single point approximately mid-way along the MTD for active beach development. Pond management was towards the center of the TSF.
- A decant barge was located on the east side of the MTD, near the process facilities.
- Both dams had recently been raised during the summer construction season.
- Downstream of both embankments, active construction activities were taking place. There were no visual signs of disruption to the embankment structures from this construction.
- Access to the TSF is restricted through the main site security gate. The area is not readily accessible to the public.

4.1.2. GHO Settling Pond Inspection Observations

The GSP is confined by a ring dyke. It is an unlined facility that is used for sediment control in local runoff water from the Greenhills Creek watershed. The following observations were made:

- A concrete lined spillway was located in the center of the southern portion of the ring dyke. The spillway was flowing and was reported to flow continuously. Water was of minimal depth, and velocity was not so great that the water was turbid. The spillway discharged into a concrete stilling basin which had outlet culverts.
- The site representative reported that the GSP has had continuous seepage through the foundation since it was constructed from local sandy fill. It was constructed more than 30 years ago, and construction records are not complete. No visible signs of seepage were noted during the visit.
- Minimal vegetation and small shrubs were noted on the upstream face of the ring dyke. This growth did not appear to impact dyke stability.
- Runoff upstream of the GSP is collected through a series of channels and culverts. Flow is generally from the northeast. This flow network generally appeared intact, and although the site representative

indicated that culverts at the overland conveyor may not handle a design storm event, they indicated that the excess flow would be diverted downstream of the GSP along the overland conveyor to the dryer plant area .

- The GSP is located near the main gate security office and the highway. The facility is surrounded by trees and an old tire storage area and is not visible from the public highway. Public access to the facility is controlled using signage, gates at vehicle access points, and security camera surveillance.

4.2. Key Personnel Interviews

Meetings and interviews with key site personnel were completed on November 21, 2022 with Teck management, operations, environment and engineering team members involved with the TSF and GSP. An interview with the EoR and Deputy EoR was also conducted via Teams on January 16, 2023. Interview summaries are included in the site inspection report in Appendix B. The purpose of the interviews was to evaluate the adequacy of the personnel knowledge for safe management and operation of the facilities. The personnel interviewed included:

- Patrick Lea, Site Tailings Engineer;
- Patrick Green, Tailings Qualified Professional (QP);
- Leigh Stickman, Water Management Lead;
- Ewen Koch, Process Planner and Acting General Supervisor;
- Curtis Pynnaken, Shift Supervisor;
- Andy Haynes, EoR (WSP); and,
- Martyn Willan, Deputy EoR (WSP).

The interviews were not specific to the TSF or the GSP, but generally covered the dam safety management system, policies and procedures in place at GHO. The topics covered during the interviews included:

- Design considerations and documentation, including critical failure modes;
- Dam performance from the site engineering and environmental point of view;
- Coordination including roles and responsibilities among the different operational groups, EoR and third-party review groups;
- Review of instrumentation monitoring systems, monitoring processes and procedures, and conformance with the OMS manual requirements;
- Operating authority under emergency conditions; and,
- Dam safety management training.

The following observations were made based on the results of the interviews:

- The different corporate and operational teams are engaged, well coordinated, understand their roles and responsibilities, and appear to have effective communication between groups. The interactions are conducted in the form of regular monthly meetings and inspections conducted at various times per shift and documented in daily inspection reports. The EoR is well integrated into the overall site team with respect to design, construction, operations and maintenance of the TSF and GSP. The Site Tailings Engineer is highly knowledgeable about both facilities.

- Process personnel inspect the TSF daily and have established on the job training procedures for this task. Observations are documented on daily inspection sheets/shift reports, and issues are elevated if needed.
- Monitoring of instrumentation is managed between the Site Tailings Engineer and an instrumentation technician. Data is collected at regular intervals by data loggers and is available to site personnel and the EoR at any time through an online platform. Effective role coverage for inspection of the TSF and monitoring of instrumentation has been generally established.
- The EoR completes annual inspections of the facilities and provides CQA staff as needed. Site staff felt that the engagement of the EoR was adequate and that issues or questions were addressed in a timely manner.
- The EoR indicated that GPS monitoring of the MTD and WTD at the TSF was useful for establishing long term trends but was not of sufficient accuracy to evaluate short term movement of the embankments.
- Staff understood their roles and responsibilities with respect to the OMS manual and knew where to find the document if needed. Training on the OMS manual is provided annually to the required staff.
- The authority structure under emergency conditions is understood and is tested at least at a desktop level every two years.

5. DAM SAFETY ASSESSMENT

According to the BC Mines Act and the HSRC, dam structures should undergo a DSR at least once every five years. These reviews should consider necessary aspects to confirm that the facilities meet the required safety standards. Such reviews are important in demonstrating that the facilities are operating safely and effectively.

The GHO TSF is impounded by the MTD and WTD, and the GSP is impounded by a perimeter ring dyke. Both facilities rely on earth fill embankments that are subject to three potential failure modes (instability, internal erosion, and overtopping). The dam safety assessment provides a review of the construction, operation, maintenance, and surveillance records to assess if the facility meets the applicable principals and guidelines, to identify if any credible deficiencies or non-conformance issues exist, and to identify any room for improvement in terms of operating the facility.

5.1. Geotechnical Assessment

5.1.1. Tailings Storage Facility

5.1.1.1. Slope Stability

The stability of the MTD and the WTD were assessed during the recent raise design to 1,740 m (Golder 2021a). This included updates to the design criteria that incorporated conformance with the most conservative interpretation of the GISTM. As such, the MTD and WTD were assessed based on extreme earthquake loading (1:10,000 year seismic event).

Slope stability analyses of the MTD and WTD were completed using commercially available 2-dimensional limit equilibrium software. Piezometric conditions were inferred based on seepage modelling completed during the design process. The seepage modelling was calibrated to measured groundwater conditions at the MTD and WTD.

Geotechnical properties of the embankment and foundation soils were based on geotechnical investigations and associated laboratory testing completed on samples recovered. Based on the data available, the foundation soils were over consolidated and are not expected to develop excess pore pressure if undergoing shearing. The EoR indicated that the soils are not susceptible to strain softening. Long term static and seismic loading conditions were evaluated. WSP (Golder 2021a) noted that factors of safety are expected to improve post-earthquake and therefore post-seismic conditions were not analysed. The FS for downstream slope stability at the MTD and WTD are summarized in Table 3.

Table 3: Minimum Calculated Factor of Safety for 1,740 m Crest Elevation

Structure	Minimum Calculated FS (Downstream Slope)	
	Static Loading Minimum Required FS = 1.5	Seismic Loading Minimum Required FS = 1.0
Main Dam	1.9	0.93
West Dam	1.7	0.92

The results indicate that the minimum FS exceeds design criteria at the MTD and WTD for static loading conditions. However, the minimum FS does not meet the design criteria for pseudo-static conditions for the 1:10,000 year seismic event. As set out in the design criteria for the TSF, deformation analysis was completed by WSP as a result.

WSP completed static and seismic deformation analysis as part of the TSF design to a crest elevation of 1,740 m (Golder 2021a). Static deformation analysis was completed using a simplified elastic deformation model in commercially available modelling software, and was completed using the methods developed by Bray and Travasarou (2007) and Swaisgood (2014).

Static deformation analysis used conservative fill parameters for the CCR fill. Results indicated that settlements resulting from the proposed facility raise would be less than 0.2 m. Horizontal deformation would be approximately 0.1 m and would not occur as horizontal shear at a single location, rather, would be distributed along the length of the dams. Static deformations would not adversely impact freeboard available in the TSF and is not considered a credible failure mode (Golder 2021a). Based on the information reviewed, NewFields agrees with this conclusion.

Seismic deformation analysis considered conservative uncompacted CCR dam shell fill and toe stockpiles parameters. Analyses indicated there is an approximately 50% probability of vertical dam displacements up to 0.6 m and horizontal displacements up to 0.3 m if the MTD is subject to a 1:10,000 year seismic event. These displacements would not occur as horizontal shear at a single location, rather, would be distributed along the length of the dam. Seismic induced deformations would not adversely impact freeboard available in the MTD and are not considered a credible failure mode (Golder 2021a). Based on the information reviewed, NewFields agrees with this conclusion. It is noted that the seismic deformation analysis completed as part of the 1,740 m design (Golder 2021a) only refers to the MTD. Based on the similar foundation conditions at the WTD, it is anticipated that similar results would be expected at the WTD, and seismic induced deformation is not considered a credible failure mode at the WTD.

The foundation soils were assessed for susceptibility to liquefaction based on the liquidity indices collected during the site characterization for the TSF (Golder 2017a). The results indicated that clay-like behaviour is expected from the foundation till materials and that under seismic loading till would display cyclic softening behaviour rather than a loss of strength due to liquefaction (Golder 2021a). This differs from the assumption made that conditions may improve post-earthquake and a post-earthquake assessment of the dam should be considered with reduced shear strength of the foundation till material. Post-earthquake conditions considering reduced shear strength in the till are not expected to result in the FS to fall below regulatory requirements and can be addressed during future studies.

5.1.1.2. Internal Erosion Assessment

Internal erosion of the MTD and WTD could potentially occur if clay particles from the upstream clay blanket were to migrate into the voids present in the coarser dam shell material. Compatibility of the upstream clay blanket with the CCR dam shell material was identified as an issue in the 2017 DSR. The EoR subsequently assessed the compatibility of the CCR, clay blanket and tailings materials, and determined that each material type would meet filter compatibility requirements (Golder 2022a, Golder 2021a).

Material specifications for the upstream clay blanket and CCR dam shell material were developed to meet filter compatibility criteria recommended by CDA (Golder 2022a). Grain size distribution testing completed on clay blanket and CCR samples as part of the 2020 embankment raise indicate that materials used for construction were within the construction specification envelopes (Golder 2022a) and are therefore filter compatible.

In addition to the filter compatibility studies and the material specifications that were established, Teck has updated the tailings deposition plan to develop tailings beaches along the majority of the upstream faces of the MTD and the WTD, moving the pond away from these slopes. This operational aspect also will reduce the potential for internal erosion of the TSF embankments from occurring. NewFields feels that the issue of filter compatibility raised in the 2017 DSR has been satisfactorily addressed by Teck and the EoR.

5.1.2. Greenhills Settling Pond

5.1.2.1. Slope Stability

The stability of the GSP was assessed in 2016 when QPOs were established for the ring dyke (Golder 2016). This stability analysis was reviewed as part of the 2017 DSR completed by KCB (KCB 2018) and no changes related to the dykes at the GSP facility have occurred since that time.

The analysis completed included static and pseudo-static analysis at one cross section of the GSP perimeter dyke located near the midpoint of the south dyke, west of the spillway, where the dyke is founded on sand. The stability analysis considered pseudo-static loading corresponding to the 1:1,000 year event

(Golder 2016). The analysis was updated in 2021 to assess the stability of the GSP ring dyke for pseudo-static loading corresponding to the 1:10,000 year event (Golder 2021b). The updated stability analysis was completed at two cross sections of the dyke, including one where the dyke is founded on sand and one where the dyke is founded on till.

Slope stability analyses were completed using piezometric conditions inferred from groundwater monitoring data and geotechnical properties presented in the original design report for the facility (Hardy 1981). Post-earthquake conditions were not considered as the foundation soils are not susceptible to strain softening (Golder 2016). This is a reasonable assumption for the sandy soils at the cross section considered. The 2021 analysis considered reduced shear strength of the till soils for post-seismic conditions (Golder 2021b). The FSs for the GSP ring dyke are summarized in Table 4.

Table 4: Minimum Calculated Factor of Safety at the GSP Perimeter Dyke

Location	Minimum Calculated FS	
	Static Loading Minimum Required FS = 1.5	Seismic Loading Minimum Required FS = 1.0
Sand Foundation	1.7	1.4
Till Foundation	-	1.3

The updated stability analysis did not present results for static conditions. However, since the configuration of the GSP and the inputs to the analysis have not changed, the previous results indicating that the static FS exceeded the required FS of 1.5 are still considered valid. The results indicate that the minimum FS exceeds design criteria for both static and pseudo-static conditions.

5.1.2.2. Internal Erosion Assessment

The GSP perimeter dyke was designed as a homogeneous earth fill embankment consisting of alluvial sand and gravel with a compacted clay blanket at select locations where the dam is founded on till. If internal erosion were to occur at the GSP perimeter dyke, it could potentially result from the movement of clay particles from the clay blanket into voids present in the sand and gravel dam fill.

Construction records for the perimeter dyke are not available, therefore assessments of filter compatibility are based on the original design report, which were stated in Golder 2022b, and the assumption that embankments were constructed as designed and materials from the borrow investigation were used for construction. Filter compatibility was assessed based on grain-size distributions from the original design report (Hardy 1981).

Based on the assumptions discussed above, the compatibility between the upstream clay blanket at the ring dam fill was achieved. This was confirmed in the 2017 DSR. As there have been no material changes to the GSP since the 2017 DSR, this conclusion is still valid.

5.2. Hydrotechnical Assessment

A hydrotechnical assessment of both the TSF and GSP have been completed by NewFields. This assessment provides review of the inflow design flood (IDF), freeboard, pond levels, climate data, and the water balance at each location in the following sections.

5.2.1. Tailings Storage Facility

The TSF is used to store process water and is impounded on the southeast and west sides. The tailings pond elevation is controlled by a reclaim barge that recirculates water from the TSF to the wash plant for use in processing. There is no operational or emergency overflow structure on the TSF as it is designed to contain a flood inflow for a 72-hour Probable Maximum Flood (PMF).

5.2.1.1. IDF Assessment

The IDF is based on a 72-hour PMF event estimated by Kerr Wood Leidal Associates Ltd. (KWL 2017), which would correspond to an extreme classification loading condition from the HSRC. An extreme loading condition for IDF management exceeds regulatory guidance and is in accordance with leading industry practice and the GISTM.

The total PMF is based on the Probable Maximum Precipitation (PMP) "rain on snow" event which is estimated to be 740 mm. A climate change allowance of 10% (EGBC 2018) was added to the total event resulting in an IDF of 814 mm. The catchment area of the TSF is estimated to be 2.0 km^2, of this area 0.7 km^2 represents the TSF and 1.3 km^2 represents a mixture of undisturbed ground and generally disturbed ground where a runoff coefficient of 1.0 was used. NewFields agrees with the methods used to determine the PMF as it follows industry best practice and is conservative.

Following a 1:100 year wet year, the TSF will continue to have capacity to store the 72 hour PMF inflows beginning with a freeboard of 2.4 m (Golder 2021a). During the operations, the TSF will be maintained to adequately store the PMF. During closure, a channel capable of conveying the flow rate from the PMF will be constructed. Teck's strategies to prevent the PMF from overtopping the TSF over the life of the facility are reasonable, exceed regulatory guidance, and are consistent with best practices.

5.2.1.2. Freeboard Assessment

The level of the tailings pond is controlled by a reclaim barge and there is no outlet structure to control overtopping. The elevation is monitored both visually and by a GPS survey instrument mounted on the reclaim barge. QPOs have been developed for the TSF freeboard. These are summarized in the OMS manual and have been used to develop a Trigger Action Response Plan (TARP) (Teck 2022a).

Freeboard allowance within the TSF is 2.4 m, and has been established by Teck to manage storage of the PMF, wave run up, and potential climate change effects. The observed performance from September 1, 2020, to August 31, 2021indicated that the tailings pond level did not exceed the standard operating maximum pond level. In NewFields' opinion, the freeboard allowance has been established based on industry leading practice.

Teck has a response framework to remove water from the tailing pond if water level encroaches into the operating freeboard. This framework, called the TSF Water Reduction Plan, was developed and implemented in 2020 to reduce the water stored within the TSF. The procedures in place by Teck to monitor and control freeboard levels at the TSF are adequate and considered acceptable by NewFields.

NewFields suggests that Teck consider revisiting the language used for the TSF in context of freeboard "alerts". NewFields suggests that Teck consider referring to the current water level as well as the freeboard QPO in each alert state for the associated TARPs. This may be better correlated to direct instrument readings for pond elevation and may clarify the current wording and reduce confusion for a new or uninformed employee which could lead to a misinterpreted reading during a critical condition.

5.2.1.3. Climate Data and Water Balance Assessment

Precipitation data is collected at the GHO Office climate station and missing data is infilled with Fording River Cominco synthetic data that is adjusted to the GHO Office station elevation. No data beyond those reported in previous DSR reports are available for review.

The water balance is completed using the GHO site wide water balance (SWWB) model (Golder 2021a) based on climate data and measured flow data provided by GHO. WSP describes the development of the water balance model using the GoldSim platform (Golder 2021a). The model incorporates site process data and includes trigger points to maintain the volume of supernatant water in the TSF. The model appears to be comprehensively constructed, based on the reports reviewed.

5.2.2. Greenhills Settling Pond

5.2.2.1. IDF Assessment

The IDF peak flow is based on a 24 hour 1:200 year event estimated to be 168 mm (Golder 2017b). According to the consequence classification, the GSP would be considered a Significant consequence facility. The 24 hr 1:200 year IDF event would meet suggested guideline criteria and industry standard practice for a Significant consequence classification.

A rainfall-runoff model was developed using the Hydrologic Engineering Centre Hydrologic Modeling System (HEC-HMS) software to define the IDF storm event, catchments, and assumptions used to estimate the peak inflow into the GSP (Golder 2017b). The Soil Conservation Service (SCS) curve number method (USDA-SCS 1989) was used to estimate infiltration losses.

The resultant IDF peak inflow from the HEC-HMS model was 32.3 m^3/s (Golder 2017b). The spillway at the GSP has a capacity of approximately 15.0 m^3/s but does not need to be designed to accept the full IDF peak inflow (Golder 2017b). This is because the catchment area used to determine the full IDF peak flow consists of an undiverted area and a diverted area that is separated by the overland conveyor embankment. The overland conveyor embankment has culverts with a capacity of 4.0 m^3/s (Golder 2022b) that are used to convey flow from the diverted area towards the GSP. The remaining flow is diverted by the embankment towards the Dryer Plant and/or stored behind the embankment, attenuating IDF peak stormflow to the GSP. Precipitation during the IDF onto the undiverted catchment area of 1.0 km^2 contributes flow directly to the GSP. The resultant IDF peak inflow that contributes to the GSP is a combination of the inflows from the culverts and the undiverted catchment area, totalling 9.1 m^3/s (Golder 2022b). As a result, the spillway with a capacity of 15 m^3/s can safely pass the IDF (Golder 2017b).

5.2.2.2. Freeboard Assessment

According to the 2021 AFPR (Golder 2022b), the minimum freeboard of 0.4 m is based on wave runup resulting from a 1:10 year wind event. A staff gauge is located on the spillway invert that is used to measure the pond level. The pond level is recorded during GHO's monthly site inspections. QPOs for freeboard have been established and are presented in the GSP OMS manual (Teck 2022c). A TARP has been developed with these QPOs in mind. During the reporting period of the AFPR from August 2020 to July 2021 the risk of overtopping was not apparent as freeboard levels remained in the "Blue Caution" level between 1.3 m and 0.8 m with a minimum freeboard of approximately 1.2 m to the embankment crest. The procedures in place by Teck to monitor and control freeboard levels are adequate and are considered acceptable by NewFields.

NewFields suggests that Teck consider revisiting the language used for the GSP in context of freeboard "alerts". NewFields suggests that Teck consider referring to the current water level as well as the freeboard QPO in each alert state for the associated TARPs. This may be better correlated to direct instrument readings for pond elevation and may clarify the current wording and reduce confusion for a new or uninformed employee which could lead to a misinterpreted reading during a critical condition.

5.2.2.3. Climate Data and Water Balance Assessment

The same climate data at the TSF were used for the GSP and discussed in Section 5.2.1.3.

The GSP is operated to maintain a constant water level. Inflows include direct precipitation, runoff from Greenhills Creek and surrounding catchment, the process plant during the frozen months, and seepage from the TSF pond. Outflows from the pond are evaporation, seepage, and outflow through the spillway. The GSP is managed to maintain a net zero change annually.

5.3. Tailings Deposition Planning

The 1,740 m TSF raise design report (Golder 2021a) includes a summary of tailings deposition modelling associated with the TSF raise project. The tailings deposition plan for the TSF going forward includes:

- Development of a 100 m beach on the upstream slope of both the MTD and WTD;
- Maintain a depth of approximately 3 m at the reclaim barge based on the average operating free water volume for the TSF; and
- Create a tailings surface that conforms to the desired closure geometry.

The tailings deposition plan has been initiated as tailings were being discharged from the MTD. As the current tailings deposition plan includes development of upstream beaches, the recommendation from the 2017 DSR (KCB 2018) to move the pond away from the upstream slope of the MTD has been addressed.

Teck intends to transition tailings storage to a dry stack facility (Golder 2021a). It is anticipated that the volume of tailings deposited in the GHO TSF will be reduced to approximately 24,000 m^3 annually in 2024 and then approximately 12,000 m^3 annually in 2025 and beyond (Golder 2021a). The intent is to place a small fraction of total mine tailings in the TSF at a significantly lower solids content with the ability to place all tailings in the facility in the event of plant upsets in the future. This updated tailings management strategy manages risks associated with long term tailings storage and encompasses leading industry practice.

5.4. Instrumentation, Monitoring, and Observed Performance

Monitoring and surveillance activities at the GHO are designed to identify and manage conditions that could signal a risk of a credible failure mode occurring at the TSF or GSP in a timely manner. Apart from visual inspections, QPO threshold values have been established for the instrumentation, with corresponding TARPs related to QPO exceedance levels.

5.4.1. Tailings Storage Facility

5.4.1.1. Pond Water Level Monitoring

According to the updated OMS (Teck 2022a), pond levels are monitored using a GPS unit installed at the water reclaim barge that provides continuous monitoring of the pond water levels. A staff gauge is located on the crest of the MTD to completement the GPS pond level readings. The staff gauge is viewable from the crest of the MTD, and a camera located at the process plant (Golder 2022a). During the DSR site visit, staff reported that the staff gauge had been removed during construction activities and had yet to be replaced.

QPOs for pond water elevations were established by Teck and the EoR based on the GHO TSF water reduction plan, operational water limits and water limits regarding dam safety. A TARP specific to TSF water levels has been developed and is included in the most recent OMS manual. The QPOs and TARP appear reasonable and satisfy current best practice.

Pond water levels were summarized in the most recent AFPR available for review (Golder 2022a). During this period, the TSF water levels were within normal operating levels. Instrumentation and monitoring procedures are sufficient to understand water levels within the TSF and comply with regulatory and industry best practices.

5.4.1.2. Survey Data

Survey data are used to monitor the displacement of the TSF embankments. The survey instrumentation include automated GPS units and survey prisms recorded via manual survey. There are 5 GPS units on the MTD and 3 on the WTD. There are 8 survey prisms on the MTD and 5 on the WTD. The coverage of survey instrumentation appears adequate to capture movement across the entire length of each dam.

The prisms generally exhibit a higher degree of accuracy than the GPS system and are used to identify movements within the dams in the short term. The GPS units are more suitable for tracking long-term trends in displacement. While the GPS units are not generally helpful in identifying movements which may lead to an emergency condition at the TSF, the long term trends can be used to confirm dam settlement predictions which support long term deposition and closure planning. QPOs for surveyed displacements were established by the EoR and summarized in the OMS (Teck 2022a).

The survey prisms are measured monthly. However, the survey prisms were removed from both tailings dams for embankment raise construction. Prism data were not available during this period. Prisms are reinstalled at the end of each construction season and have to be recalibrated. Data issues identified errors in calibration after the 2021 construction season, and prisms were consequently recalibrated. This process was documented in the 2021 AFPR, which illustrates the data management and quality control procedures applied to the monitoring data from the TSF embankments.

Survey prism readings generally remained below QPO threshold levels, and displacements were within the accuracy range of the GPS units. It was noted that since 2020, the application of QPOs to the GPS units has been discontinued due to the significant variability of short-term measurements. Displacement monitoring within the MTD and WTD is sufficient to identify movements within the embankments and satisfies regulatory and industry best practices.

5.4.1.3. Piezometers

A total of 24 vibrating wire piezometers (VWPs) are installed at MTD, with three additional VWPs installed at Site C and D CCR stockpiles downstream of the MTD (Teck 2022a, Golder 2022a). Six VWPs are located at the WTD. Multiple VWPs have been installed at each location to monitor piezometric pressures at different elevations around the TSF. VWPs are automated, and data is recorded in GeoExplorer (Golder 2022a).

The EoR established QPOs based on embankment stability analyses. The QPOs were established to trigger an alert if the VWP measurements reached levels corresponding to lower than desired FS (Teck 2022a). These QPOs appear reasonable and were developed based on industry best practices.

Upon reviewing the AFPR data from the previous five year period, it has been observed that all VWPs were indicating values below the QPO level (Golder 2018, Golder 2019a, Golder 2020, Golder 2021d, Golder 2022a). However, some of the VWPs installed within the bedrock at the TSF area indicated higher piezometric levels due to possible artesian conditions within an isolated hydrostratigraphic layer that is not hydraulically linked to the upper ground system (Golder 2022a). These possible artesian conditions will not impact dam stability or performance.

The total head readings obtained from the VWP monitoring system showed small seasonal fluctuations, however, these fluctuations were not sufficient to affect dam safety.

In general, the VWP network appears to adequately characterize water levels in the dam embankments and foundation materials and are capable of identifying changes to piezometric conditions.

5.4.1.4. Inclinometers

A total of five inclinometer casings have been installed in the Site C and D CCR stockpiles. These inclinometers were located in the area of some slope instability in 2012, which has since stabilized. Inclinometers have been anchored either into glacial till or bedrock beneath the CCR (Golder 2022a).

Inclinometer data were gathered on a monthly basis until the start of 2020. Based on a recommendation from the EoR, inclinometer monitoring frequency has been revised to annual readings, except for before and after dam construction activities (Teck 2022a). Readings have not indicated any movement in the Site C CCR since the original instability was noted, and inclinometer data has not identified any conditions which may indicate instability in the MTD. Movement within the inclinometer presented in the 2021 AFPR was attributed to movement within the inclinometer casing. If this is not confirmed in the 2022 AFPR, Teck may want to discuss the integrity of this instrument with the EoR.

5.4.1.5. Seepage Monitoring

Two weirs have been installed downstream of the MTD and WTD to monitor seepage from the TSF. One weir is located downstream of the Site C CCR stockpile, and one is located near the downstream toe of the WTD. Both weirs were upgraded in 2021 and data collection was automated with pressure transducer sensors (Golder 2022a). QPOs for the weirs have been established based on historical data and predictions from seepage analyses.

Seepage flow rates measured at each weir have been within expected operational values. Flow through the Site C CCR weir can increase during precipitation events due to surface runoff from the Site C CCR stockpile. Seepage and surface water flows are not measured separately at the Site C weir, and therefore, it is difficult to determine if seepage from the TSF is increasing with time (Golder 2022a). It is understood that alternative methods of monitoring seepage at the MTD have been recommended in past AFPRs. It is also understood that through a risk review by the EoR and Teck, it was determined that alternate methods of seepage monitoring are not required at this time. NewFields supports this assessment.

Historically, the flows through the WTD and Site C weirs have been clear and devoid of any visible suspended solids. Visual observations are sufficient and have not indicated any conditions that could be attributed to internal erosion of either the MTD or WTD structures.

5.4.1.6. Observed Performance

Visual inspections are outlined in the OMS manual and include two daily (routine) inspections by the process plant shift supervisor, monthly inspections by the tailings engineer, and annual AFPR inspections by the EoR and QP.

Routine visual inspections and monthly inspections are documented using inspection forms found in the OMS manual. Any deficiencies noted are captured in a maintenance or action log and communicated to the QP, EoR, and operations for remediation. Records of visual inspections are reviewed by the EoR and reported in each AFPR.

The visual inspections completed by Teck personnel and the EoR generally confirm interpretations of the data gathered by the surveillance programs employed at GHO and indicate that the MTD and WTD continue to exhibit adequate overall slope stability performance. The inspection program meets regulatory requirements, and documentation procedures incorporate industry best practices.

5.4.2. Greenhills Settling Pond

5.4.2.1. Pond Water Level Monitoring

According to the updated OMS (Teck 2022b), a staff gauge is installed at the spillway inlet to monitor water levels within the GSP. QPOs for pond water elevations were established by Teck and the EoR based on the spillway capacity, estimated pond levels during and IDF, and wave run up. A TARP for water levels exceeding QPO triggers has been developed and is included in the most recent OMS manual. The QPOs and TARP appear reasonable and satisfy current best practice.

Pond water levels were summarized in the most recent AFPR available for review (Golder 2022b). GSP is operated as a flow through facility, therefore no net gain in water volume was anticipated (or recorded). Pond elevation data indicated that water level within the GSP remains generally constant, which supports the flow through operation of the facility. Freeboard levels were maintained within normal operating levels. The instrumentation and monitoring procedures appear sufficient to understand water levels within the GSP and comply with regulatory and industry best practices.

5.4.2.2. Piezometers

Two VWPs are installed through the embankment crest near the GSP spillway. The VWPs indicate phreatic conditions within the embankment, and measurements are automated. The EoR established QPOs based on embankment stability analyses. The QPOs were established to trigger an alarm if the VWP measurements reached levels corresponding to lower than desired FS (Teck 2022c). These QPOs appear reasonable and were developed based on industry best practices.

According to the 2021 AFPR, the data obtained from the VWPs during the reporting period revealed that the tips of the instruments were dry. This appears to be on trend for this instrumentation, and the data does not indicate conditions that could lead to dam instability. Monitoring frequency is sufficient and follows best practices.

5.4.2.3. Observed Performance

Visual inspections are outlined in the OMS manual and include monthly inspections by the tailings engineer, and annual AFPR inspections by the EoR and QP. Monthly inspections are documented using inspection forms found in the OMS manual. Any deficiencies noted are captured in a maintenance or action log and communicated to the QP, EoR, and operations for remediation. Records of visual inspections are reviewed by the EoR and reported in each AFPR.

The visual inspections generally confirm interpretations of the data gathered by the surveillance programs and indicate that the GSP ring dyke continues to exhibit adequate overall slope stability performance. The inspection program meets regulatory requirements, and documentation procedures incorporate industry best practices.

5.5. Hazards and Failure Modes

Hazards and failure modes for a water or tailings impoundment can be defined as conditions that would result in a release of tailings with potential to cause damage to the environment, infrastructure, or loss of life. Hazards and credible failure modes for impoundments typically fall into three categories:

- Slope instability;
- Internal erosion; and,
- Overtopping.

The following subsections discuss each potential failure mode for the GHO TSF and the GSP, including their likelihood of occurrence and corresponding risk management practices. In summary, the controls in place to monitor and react to the credible failure modes at the TSF and GSP appear to be adequate and the risk of the occurrence of a credible catastrophic failure remains low.

5.5.1. Tailings Storage Facility

5.5.1.1. Slope Instability

Slope stability of the MTD and WTD has been reviewed and incorporated into the recent raise design to 1,740 m (Golder 2021a), incorporating the most conservative interpretation of the GISTM into the design. As such, stability analysis was completed based on the maximum credible earthquake loading. Based on review of the 2021 construction record report (Golder 2022c), which included raises to the MTD and WTD to an elevation of 1,734 m, construction was completed within bounds of the intended design. NewFields does not have any reason to think that the raise construction completed in 2022 would have a different outcome than that completed in 2021.

The analysis completed in the design phase confirmed that the FS of the facility would exceed design criteria for the static case and would not meet the required FS under seismic loading. Seismic deformation analysis however, indicated that deformations from the EDGM would be small and not impact the overall freeboard capacity within the TSF. Therefore, this is not considered a credible failure mode. Based on the information reviewed, NewFields agrees with this conclusion.

Post-earthquake assessment of the dams considering the potential for reduced shear strength of the till soils for post-seismic conditions was not considered during the design. Post-earthquake conditions considering reduced shear strength in the till are not expected to result in the FS to fall below regulatory requirements and can be addressed during future studies.

Surveillance and review of monitoring data at the MTD and WTD related to slope stability (i.e., visual inspections, piezometric conditions and displacements) have indicated that the dam has and continues to perform as intended as of the writing of this report. The risk of occurrence of slope failure resulting in a loss of containment remains low.

5.5.1.2. Internal Erosion

Internal erosion, specifically, migration of the upstream clay blanket into the coarser dam shell material has been assessed for filter compatibility. Quality assurance testing completed by WSP during the 2021 dam raise (Golder 2022c) indicated that materials used for construction were filter compatible. NewFields has not seen any information to indicate that filter compatibility will not be maintained during the TSF life cycle.

Surveillance and review of monitoring data at the MTD and WTD related to internal erosion (i.e., visual inspections and seepage rates) have indicated that the dam has and continues to perform as intended as of the writing of this report. The risk of occurrence of internal erosion resulting in a loss of containment remains low.

5.5.1.3. Overtopping

The TSF pond is currently designed and operated such that it can accommodate the 72 hour PMF storm event with allowance for wave run up. The pond level is monitored continuously via GPS and can be confirmed with visual readings from a staff gauge. Furthermore, Teck has a response framework to remove water from the tailings pond if levels exceed maximum operating level.

Surveillance and review of pond level monitoring data indicate that Teck has and continues to operate the pond within the permitted maximum operating level and effective response plans are documented for theoretical events when the maximum operating level is exceeded. The risk of occurrence of overtopping resulting in a loss of containment remains low.

5.5.2. Greenhills Settling Pond

5.5.2.1. Slope Instability

Slope stability at the GSP ring dyke has been reviewed by the EoR considering the most conservative interpretation of the GISTM. As such, stability analysis of the dyke was completed based on the maximum credible earthquake loading (Golder 2021b). Based on this analysis, it was confirmed that the ring dyke exceeds design criteria for the EDGM. Previous stability analyses indicated that the ring dyke would exceed stability criteria under static conditions. There have been no changes to the GSP since static stability was established.

Surveillance and review of monitoring data at the GSP related to slope stability (i.e., visual inspections and piezometric conditions) have indicated that the dam has and continues to perform as intended as of the writing of this report. The risk of occurrence of slope failure resulting in a loss of containment remains low.

5.5.2.2. Internal Erosion

Internal erosion, specifically, migration of the upstream clay blanket into the coarser dam shell material in the north section of the west portion of the ring dyke has been reviewed by the EoR for filter compatibility. The review was based on historic design reports and the assumption that embankments were constructed as designed. Based on these assumptions, the upstream clay blanket and the coarse dam fill are filter compatible.

Surveillance and review of monitoring data at the GSP related to internal erosion (i.e., visual inspections and piezometric conditions) have indicated that the perimeter dyke has and continues to perform as intended as of the writing of this report. The risk of occurrence of internal erosion resulting in a loss of containment remains low.

5.5.2.3. Overtopping

The GSP is currently operated as a flow through facility and it can accommodate the 1:200 year (24 hr) storm event with allowance for wave run-up, with the diversion system in place. The pond is monitored monthly visually (staff gauge).

Surveillance and review of pond level monitoring data indicate that Teck has and continues to operate the pond within the permitted maximum operating level. The risk of occurrence of overtopping resulting in a loss of containment remains low.

6. DAM SAFETY MANAGEMENT SYSTEM

Teck has established dam safety management documentation for both the TSF and the GSP. A review of available dam safety management documents, as well as information obtained from observations during the site visit and key personnel interviews, were used to assess the dam safety management system in place for both facilities.

6.1. Operations, Maintenance and Surveillance

6.1.1. Tailings Storage Facility

The TSF has an OMS manual, which was last updated in November 2022. It is reviewed and updated as needed on an annual basis, which is in compliance with HSRC requirements. The OMS manual appears to generally follow the guidance from the MAC (MAC 2021b) for such documents. Within the OMS manual, the roles and responsibilities of all personnel involved with management and operation of the TSF are described.

The QP is responsible for ensuring the TSF is maintained and the OMS manual outlines routine maintenance components. While general maintenance procedures for instrumentation are not explicitly stated, the OMS manual does include an instrumentation maintenance priority schedule to specify the timeline for dealing with malfunctioning instrumentation. The instrumentation maintenance priority list was prepared by the EoR, and the Tailings Engineer was aware of this system.

The OMS manual documents the routine inspection schedule, including frequency and responsibility, and there are procedures in place to elevate issues identified during routine inspections. There is good integration of the EoR should inspections identify an abnormal condition at the TSF.

QPOs have been developed and documented in the OMS manual for TSF freeboard, survey prisms, seepage weirs, the VWPs, and the tailings beach length. TARPs have been developed and include actions and responsibilities for key personnel should QPO levels be triggered. While the TARPs appear to be concise and well laid out, some of the triggers for freeboard, dam movement and seepage do not match the QPOs for those parameters. The differences are minor but should be reconciled in the next update.

In general, the OMS manual for the TSF is well put together. Everyone interviewed was aware that the manual existed and knew where to access it. Based on the review of the OMS manual, a few formatting corrections and opportunities for improvement were identified. These do not materially impact the interpretation or usefulness of the OMS manual. They are listed below for consideration during the next document update:

- The figures and appendices are compiled in a separate PDF document. It is important to ensure that if the main OMS document is referenced that the supporting PDF file is also available. If there is an opportunity to combine the OMS information with the appendices and figures, that may be more convenient and concise;

- If Teck wishes to condense the document in future revisions, Section 1.3 could be deleted unless there is a corporate requirement to include that information. Section 4 could be condensed by removing some of the technical details and referencing applicable technical reports, and just focusing on operational procedures. Specifically, Section 4.4 on water management could remove some of the technical information on the water management system and water balance and simply provide reference documentation if that information is needed. Section 4.4.5 is somewhat repetitive and could possibly be incorporated into Section 6.3.1 in the next revision;
- Section 3.2.2 refers to site vegetation, but does not identify any wildlife that may interact with the TSF. It is suggested that wildlife typically observed in the vicinity of the TSF or that may affect TSF operations be documented here (i.e: birds, ungulate, burrowing animals, etc.);
- Note “a” for Table 6 in Section 3.6.2 was not included with the table and should be added for clarity;
- Text discussing freeboard in Section 3.6.2 only includes a discussion on the IDF value and does not include wave allowances shown in Table 6. It is suggested that the text be edited to update total freeboard values to better correspond to information presented in Table 6;
- Section 4.4 states that water management for the TSF is a permit condition. It is suggested that any permit conditions that pertain to the operation of the TSF be summarized in the OMS manual;
- Section 4.4.1.indicates that the regulator approved plan states that TSF water levels will be managed in accordance with the OMS manual, however the OMS manual doesn’t explicitly state what the minimum, normal and maximum operating water levels in the TSF are. NewFields suggests that this is discussed with the EoR and included in the next revision;
- Section 4.4.1.3 describes the reclaim barge system. If there any contingency in the system if pumps need repair or maintenance, a description of this could be added to this section in the next revision;
- Section 4.4.1.4 describes seepage monitoring from the MTD and WTD. It is suggested that this discussion be moved into Section 6 in the next revision;
- The reference to Table 9 in Table 7 (Section 5.5.2) should be changed to Table 8, based on current table numbering in the document;
- Table 10 in Section 6.2 is numbered as Table 9. All table numbering and references to tables in the text require updating after this point in the document;
- Figure 6 presents the water balance, however, it is difficult to read and encompasses the entire GHO site water balance. It is suggested that this be simplified to just illustrate the water balance for the TSF, or at a minimum, a supporting table identifying different flow codes and numbering be included with the existing figure in future revisions.

6.1.2. Greenhills Settling Pond

The OMS manual for GSP was last updated in December 2022. The OMS manual appears to generally follow the guidance from the MAC (MAC 2021b) for such documents. It appears that the OMS manual has been updated every 2 to 3 years, although the current revision states that it will be reviewed and updated as required on an annual basis (Teck 2022c). Within the OMS manual, the roles and responsibilities for the GSP are described, and all activities being carried out around the GSP require prior approval from the Tailings and Water Retaining Structures (TWRS) team. The QP is responsible for the accuracy of the OMS manual.

Operations of the GSP are generally passive as it is designed as a flow through system. The QP is responsible for ensuring the GSP is maintained. A schedule and trigger for maintenance activities is documented in the OMS manual. Instrumentation maintenance is completed based on guidance from the EoR (Teck 2022c).

The OMS manual documents the routine inspection schedule, including frequency and responsibility. The Tailings Engineer completes an inspection on a monthly basis, with an AFPR being conducted by the EoR annually. In addition to the routine inspections, procedures are in place for inspections after unusual or unplanned events. There is good integration of the EoR should inspections identify an abnormal condition at the TSF.

QPOs have been developed and documented in the OMS manual for freeboard and the VWP levels. It was observed that there were gaps in the freeboard QPOs between levels of 0.8 to 0.4 m and 0.4 to 0.3 m. It is unclear what actions would be required if the QPOs were in those ranges. This should be addressed with the EoR for the next OMS manual updated. A TARP has been developed based on the established QPOs and observations from visual inspections, and include actions and responsibilities for key personnel should QPO levels be triggered. The TARP appears to be concise and well laid out.

In general, the OMS manual for GSP is well put together. Based on the review of the OMS manual, a few formatting corrections and opportunities for improvement were identified. These do not materially impact the interpretation or usefulness of the OMS manual but are listed below for consideration during the next document update:

- The entire document should be checked for appendix references as some appear to be out of date. There are references to appendix numbers greater than 3 (i.e.: Appendix VII is referenced in Section 3.6), and only three appendices are included in the document. In addition, it appears that some of the references to the 3 appendices included have not been updated in the document text;
- In Section 1.1, the reference to SP&O 1583 is out of date. This was most recently updated in December 2022;
- Text in Section 2 indicates that the TWRS group is responsible for stewardship of the GSP. The organization chart on Illustration 1 indicates that the TWRS group communicates with the Superintendent of Engineering, while the Superintendent Processing is the facility owner. It is suggested that Teck confirms that Illustration 1 is current, and if it is, is there are any formal communication protocols between groups;
- The last sentence on page 10 (Section 3.1) references Section 0. It appears that this should reference Section 3.3;
- Section 3.2.2 refers to site vegetation but does not identify any wildlife that may interact with the TSF. It is suggested that wildlife typically observed in the vicinity of the TSF or that may affect TSF operations be documented here (i.e: birds, ungulate, burrowing animals, etc.);
- The first paragraph of Section 3.5 appears to be out of date. In addition, if Teck would like to condense the OMS manual, this section could be removed (unless it has been included to meet internal documentation requirements);
- The text in Section 4.2.3 is not consistent with text in Section 3.6.2. This difference should be reconciled in the next document revision;

- Sections 4.3.1 and 4.3.2 may fit better in Section 6 as these sections appear to discuss monitoring programs not operational procedures;
- Unless there are hazardous materials used in the operation of the GSP, Teck could consider removing Section 4.3.4 in the next document revision;
- In Section 6.4, the heading of Table 12 is labelled as Table 13. All table numbers and references should be checked and updated from this point in the document in the next revision;
- Figure 4 (Greenhills Catchment Areas) cuts off some of the GSP. It is suggested that this be revised in the next document update; and,
- Figure 5 presents the water balance, however, it is difficult to read and encompasses the entire GHO site water balance. It is suggested that this be simplified to just illustrate the water balance for the GSP, or at a minimum, a supporting table identifying different flow codes and numbering be included with the existing figure in future revisions.

6.2. Emergency Preparedness and Response Plan

6.2.1. Tailings Storage Facility

The EPRP is an essential component of the dam safety system and is intended to provide a clear procedure for emergency response so that emergency conditions can be managed effectively. Teck has developed an EPRP for the TSF. In addition, an overall Mine Emergency Response Plan (MERP) is in place at GHO. The MERP covers higher level emergency organization for the entire site, while the EPRP provides specific actions based on potential emergency conditions specific to the TSF. These documents meet regulatory requirements outlined in the HSRC for emergency preparedness.

The EPRP was last updated in December 2022 and is reviewed, updated as needed, and tested on an annual basis (Teck 2022b). The EPRP includes specific roles and responsibilities, emergency preparedness procedures, emergency response procedures, resources available during emergency situations, and communication protocols. Potential failure modes identified include overtopping, internal erosion, and contaminated seepage release, although mitigative actions are also identified for a failure mode of instability.

An inundation study was completed for the MTD and WTD in 2017. The inundation study considered overtopping and internal erosion failure modes for the MTD and only an overtopping failure from the WTD. The results of this study have been used to guide emergency response actions for the TSF.

The EPRP generally clearly documents actions required based on observed conditions that could lead to an emergency event at the TSF, and documents personnel responsible for managing and carrying out the prescribed actions. NewFields noted that the TARP (and associated QPOs shown on the TARP) included in Appendix II does not appear to match the TARP in the November 2022 OMS manual. Teck has indicated that this inconsistency was noted during internal document reviews and the TARP within Appendix II of the EPRP was updated in February 2023 to be consistent with the TARP included in the current OMS manual.

While these will not materially impact emergency response, below are a few suggestions for strengthening the EPRP for the TSF:

- Table 4 (Section 4) outlines remedial responses to identified failure modes, however, it does not indicate when these responses should be implemented based on observed conditions in the TSF and its dams. As best practice, this information should be added in the next document revision; and,
- Figure 4 (WTD emergency response evacuation map) indicates that if the WTD were to breach, GH1 (the main site access road) would be inundated. If GH1 is inundated, can site personnel be evacuated, and is the WTD accessible? A secondary access route should be documented in case of emergency to meet best practice requirements.

The EPRP for is well put together. A few formatting and minor inconsistencies were identified and are listed below for consideration during the next document update:

- Table 4 in Section 4 outlines warning signs related to the identified failure modes, preventative measures and remedial responses. The failure modes described in Table 4 do not match those listed in Table 2. Table 4 includes instability while Table 2 does not. It is suggested that this inconsistency is addressed in the next document revision;
- Section 4.6 discusses mutual aid agreements but does not state when these would be activated. It is suggested that this information be added for completeness, or if it is documented in the MERP, that the MERP be referenced; and,
- Section 4.6.4 discusses emergency support from the STARS Emergency Link Centre and that this organization can coordinate emergency transportation as requested. It is assumed that this transportation would be by helicopter, however, the EPRP does not state where the helicopter access would be from, and a helipad is not indicated on any figures included in the document. It is suggested that this information be added for completeness, or if it is documented in the MERP, that the MERP be referenced.

6.2.2. Greenhills Settling Pond

An Emergency Preparedness Plan (EPP) was prepared for the GSP and last revised in 2018. Site staff indicated that this document has been reviewed annually, and that it is currently being updated and incorporated into the TSF EPRP.

In its current revision, the EPP for the GSP would not be very useful to site staff in responding to an emergency at the facility. NewFields recognizes that there are other established emergency procedures on site that staff are familiar with and could apply to an emergency at the GSP. NewFields supports the effort to incorporate emergency response for the GSP into the EPRP for the TSF, as similar failure modes, preventative measures, remedial responses, organization, and communication protocols would be applied during emergency situations at either facility. It is recommended that this be completed with priority to meet best practices standards for emergency response at the GSP.

6.3. Public Safety and Security

The TSF is located north of the GHO main access gate that is controlled via a gatehouse, adjacent to the Process Plant. There is no direct public access to the TSF and there are no public safety or security concerns with the facility.

The GSP is located to the east of the GHO main gatehouse and is north of Fording River Road. It is surrounded by trees and an old tire storage area, and the facility was not immediately visible from the highway. Public access is controlled through signage, gates across vehicle approaches, and through security camera surveillance. Site staff did not report any public safety concerns.

7. RECOMMENDATIONS

The assessment and recommendations presented in this this report are based on review of the documents provided by Teck for the GHO, observations made during the site inspection, and key personnel interviews. Recommendations made in this report were assigned priority ranking numbers consistent with Teck's method of rating and prioritizing issues related to dam safety. Priority rankings were provided by Teck and are presented in Table 5. Recommendations have been summarized in Table 6 and include a unique issue tracking number, reference to applicable regulation or best practice, a brief description of corrective actions, a priority ranking, and a suggested timeline for completion.

Table 5: General Description of Priority Rankings

Priority	Description
1	A high probability or actual dam safety issue considered immediately dangerous to life, health or the environment, or a significant regulatory concern.
2	If not corrected, could likely result in dam safety issues leading to injury, environmental impact or significant regulatory action; or a repetitive deficiency that demonstrates a systematic breakdown of procedures.
3	Single occurrences of deficiencies or non-conformances that alone would not be expected to result in dam safety issues.
4	Best Management Practice as a suggestion for continuous improvement towards industry best practices that could further reduce potential risks. This typically includes ongoing construction items within the appropriate construction cycle.

Table 6: DSR Recommendations Table for Greenhills Operations

Structure	ID No.	Deficiency or Non-Conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority	Recommended Deadline / Status
Previous Recommendations Closed / Suspended from Past DSRs						
GSP	1	Plug construction bypass culvert.		Bypass culvert for construction of GSP dam needs engineered plug.	Done, Doc. 75	Closed
WTD	2	Weir at WTD not maintained.		Repair and record readings on weir at least monthly.	H	Closed
WTD	3	Inadequate spillway on WTD.		The WTD spillway is simply a shallow ditch infilled with coarse granular material. As such, the spillway has little capacity and needs improvement.	Done, Doc. 74	Closed
MTD	4	MTD weir not maintained.		Repair and record readings on weir at least monthly.	Done, Doc. 76	Closed
MTD	5	Add new MTD weir.		Add new weir in creek downstream of MTD.	M	Closed
TSF	6	Water Balance at Tailings Impoundment.		Carry out annual mass balance and water balance to update dam raising schedule.	H	Closed

Structure	ID No.	Deficiency or Non-Conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority	Recommended Deadline / Status
GSP	7	Inadequate spillway at GSP.		Upgrade spillway capacity or divert flow around GSP during flooding.	M	Closed
MTD	8	Pond on upstream slope of MTD.		Move pond away from the upstream slope of the MTD or other equivalent measure.	M	Closed
MTD	9	Movement of Site C.		Add inclinometer at Site C into foundation.	M	Closed
TSF	10	Closure Plan update.		OMS for tailings dam (Doc. 69) identifies that closure plan does meet HSRC requirements. Also noted in 2010 DSR.	M	Closed
MTD, WTD, GSP	11	Risk Evaluation for MTD, WTD and GSP.		There are no documents which set out a risk evaluation of the dams.	M	Closed
TSF, GSP	12	Unresolved DSI (2106) deficiencies.		Table E-2 in the 2016 DSI (Doc. 65) lists deficiencies which need resolution.	H	Closed
TSF	13	ERP.		Test ERP against a tailings dam failure.	H	Closed

Structure	ID No.	Deficiency or Non-Conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority	Recommended Deadline / Status
Previous Recommendations Ongoing from Past DSRs						
n/a		None.		None.	n/a	n/a
Recommendations from Current DSR						
TSF	2022-01	Based on laboratory testing, foundation tills exhibit cyclic softening behaviour but post-earthquake slope stability analysis for the MTD and WTD has not been considered.		Complete a post-earthquake assessment of the TSF dams. Post-earthquake conditions considering reduced shear strength in the till should be considered.	3	March 2024
TSF	2022-02	The trigger values for freeboard, dam movement and seepage in the TARP do not fully correlate to QPOs for those parameters.	HSRC 10.4.2(1)(f)	While differences are minor, the trigger values should be correlated to the QPOs for freeboard, survey prism movement and seepage weir measurements.	4	March 2024.
GSP	2022-03	The EPP is out of date and does not provide emergency response procedures for the GSP.		Teck has indicated that they are working to incorporate ERP for GSP into the TSF EPRP. This should be completed, and staff should be informed.	3	December 2023

Opportunities for improvement that were found during the DSR assessment are listed below:

- Alert descriptions referring to freeboard QPOs instead of pond levels at the TSF and GSP may be confusing during an emergency event. Wording describing alert actions could be clarified by referring to both freeboard QPO values and pond elevation, which may be more directly related to instrumentation readings.
- If the WTD were to breach, the main site access road (GH1) would be inundated. A secondary access/egress route is not identified on site plans in the EPRP. As best practice, the secondary access route should GH1 not be passible could be identified on site figures in the EPRP.
- There are gaps in the GSP freeboard QPOs between levels of 0.8 m to 0.4 m and 0.4 m to 0.3 m. It is unclear what actions would be required if the QPOs were in those ranges. Teck should clarify this with the EoR and update QPOs and the TARP if required.

8. LIMITATIONS

NewFields has prepared this document in a manner consistent with the level of care and skill ordinarily exercised by the engineering and geoscience professions practicing in similar conditions within the jurisdiction that the services are provided, subject to time limits and physical constraints applicable to this work. No other warranty, express or implied, is made.

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9. CLOSURE

NewFields would like to thank Teck for the support its personnel provided during this review. We trust that this information meets your needs at this time. Should any portion of this report require further information or clarification, please do not hesitate to contact the undersigned.

Sincerely,

NewFields Canada Mining & Environment ULC

Prepared by:

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24/MAR/23

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EGBC PERMIT TO PRACTICE – PERMIT #1001896

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APPENDIX A

DAM SAFETY REVIEW ASSURANCE STATEMENT

APPENDIX C2: DAM SAFETY REVIEW ASSURANCE STATEMENT – MINING DAMS

Note: This statement is to be read and completed in conjunction with the current *APEGBC Professional Practice Guidelines – Legislated Dam Safety Reviews in British Columbia*, ("APEGBC Guidelines") and is to be provided for dam safety review reports in accordance with permit conditions and the *Health, Safety and Reclamation Code for Mines in British Columbia* or the *Dam Safety Regulation*, B.C. Reg. 40/2016 as amended (refer to Table B-1 in Appendix B). Italicized words are defined in the APEGBC Guidelines. An assurance statement is required for each dam that is assessed.

To: The Owner(s)

Date: March 24, 2023

Teck Coal Limited

Name

Greenhills Operations, PO Box 100, Elkford, BC V0B 1H0

Address

With reference to the permit conditions and the *Health, Safety and Reclamation Code for Mines in British Columbia* or the *Dam Safety Regulation*, B.C. Reg. 40/2016 as amended (refer to Table B-1 in Appendix B).

For the *dam*:

UTM (Location): Zone 11

Located at (Description): Greenhills Operations: approx. 8 km NE of Elkford, BC

Name of dam or description: Main Tailings Dam and West Tailings Dam at Greenhills Operations

Provincial dam number:

Dam function: Tailings Storage Facility

Owned by: Teck Coal Limited

(the "Dam")

Current Dam classification is:

Check one

- ☐ Low
- ☐ Significant
- ☒ High
- ☐ Very High
- ☐ Extreme

The undersigned hereby gives assurance that he/she is a Qualified Professional Engineer.

I have signed, sealed and dated the attached dam safety review report for the Dam in accordance with the APEGBC Guidelines. That report must be read in conjunction with this Statement. In preparing that report I have:

Check to the left of applicable items (see Guideline Section 3.2):

- [x] 1. Collected and reviewed available and relevant background information, documentation and data
- [ ] 2. Reviewed the environmental objectives for the materials stored in the impoundment and related design requirements
- [x] 3. Understood the current classification for the Dam, including performance expectations
- [x] 4. Undertaken an initial facility review
- [x] 5. Reviewed and assessed the Dam safety management obligations and procedures
- [x] 6. Inspected the condition of the Dam, impoundment area and relevant areas upstream and downstream of the facility
- [x] 7. Interviewed operations and maintenance personnel
- [x] 8. Interviewed Engineer of Record
- [x] 9. Reviewed available maintenance and operating records, the Operations, Maintenance and Surveillance (OMS) Manual and the Dam Emergency Plan
- [x] 10. Confirmed proper functioning of mine waste and water management systems and environmental control systems
- [ ] 11. After the above, reassessed the consequence classification, including the identification of required dam safety criteria
- [ ] 12. Carried out a dam safety analysis based on the classification in Item 11
- [x] 13. Evaluated facility performance and conformance with design basis and operating criteria
- [x] 14. Identified, characterized and determined the magnitude of deficiencies in the safe operation of the dam and non-conformances in the dam safety management system
- [x] 15. Recommended and prioritized actions to be taken in relation to deficiencies and non-conformances
- [x] 16. Prepared a dam safety review report for submittal to the regulatory authority by the Owner and reviewed the report with the Owner
- [x] 17. The dam safety review report has been reviewed in meeting the intent of APEGBC Bylaw 14(b)(2).

Based on my dam safety review, the dam classification is:

Check one

- [x] Appropriate
- [ ] Should be reviewed and amended

I undertook the following type of dam safety review:

Check one

■ Audit

☐ Comprehensive

☐ Detailed design-based multi-disciplinary

☐ Comprehensive, detailed design and performance

I hereby give my assurance that, based on the attached dam safety review report, at this point in time:

Check one

■ The dam is reasonably safe in that the dam safety review did not reveal any unsafe or unacceptable conditions in relation to the design, construction, maintenance and operation of the dam as set out in the attached dam safety review report.

☐ The dam is reasonably safe but the dam safety review did reveal non-conformances with the regulatory requirements as set out in section(s) ____ of the attached dam safety review report.

☐ The dam is reasonably safe but the dam safety review did reveal deficiencies and non-conformances as set out in section(s) ____ of the attached dam safety review report.

☐ The dam is not safe in that the dam safety review did reveal deficiencies and/or non-conformances which require urgent action as set out in section(s) ____ of the attached dam safety review report.

Leon C. Botham

Name

March 24, 2023

Date

[signature]

Signature

(Affix Professional Seal here)

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA L. C. BOTHAM # 35852 24 MAR /23

204 - 640 Broadway Avenue, Saskatoon, SK S7N 1A9

Address

306-955-2777

Telephone

If the Qualified Professional Engineer is a member of a firm, complete the following:

I am a member of the firm and I NewFields Canada Mining & Environment ULC sign this letter on behalf of the firm.

(Print name of firm)

APPENDIX C2: DAM SAFETY REVIEW ASSURANCE STATEMENT – MINING DAMS

Note: This statement is to be read and completed in conjunction with the current *APEGBC Professional Practice Guidelines – Legislated Dam Safety Reviews in British Columbia*, ("APEGBC Guidelines") and is to be provided for dam safety review reports in accordance with permit conditions and the *Health, Safety and Reclamation Code for Mines in British Columbia* or the *Dam Safety Regulation*, B.C. Reg. 40/2016 as amended (refer to Table B-1 in Appendix B). Italicized words are defined in the APEGBC Guidelines. An assurance statement is required for each dam that is assessed.

To: The Owner(s)

Date: March 24, 2023

Teck Coal Limited

Name

Greenhills Operations, PO Box 100, Elkford, BC V0B 1H0

Address

With reference to the permit conditions and the *Health, Safety and Reclamation Code for Mines in British Columbia* or the *Dam Safety Regulation*, B.C. Reg. 40/2016 as amended (refer to Table B-1 in Appendix B).

For the *dam*:

UTM (Location): Zone 11

Located at (Description): Greenhills Operations: approx. 8 km NE of Elkford, BC

Name of dam or description: Ring dyke at Greenhills Settling Pond

Provincial dam number:

Dam function: Water retaining structure

Owned by: Teck Coal Limited

(the "Dam")

Current Dam classification is:

Check one

- ☐ Low
- ☒ Significant
- ☐ High
- ☐ Very High
- ☐ Extreme

The undersigned hereby gives assurance that he/she is a Qualified Professional Engineer.

I have signed, sealed and dated the attached dam safety review report for the Dam in accordance with the APEGBC Guidelines. That report must be read in conjunction with this Statement. In preparing that report I have:

Check to the left of applicable items (see Guideline Section 3.2):

- ☑ 1. Collected and reviewed available and relevant background information, documentation and data
- ☐ 2. Reviewed the environmental objectives for the materials stored in the impoundment and related design requirements
- ☑ 3. Understood the current classification for the Dam, including performance expectations
- ☑ 4. Undertaken an initial facility review
- ☑ 5. Reviewed and assessed the Dam safety management obligations and procedures
- ☑ 6. Inspected the condition of the Dam, impoundment area and relevant areas upstream and downstream of the facility
- ☑ 7. Interviewed operations and maintenance personnel
- ☑ 8. Interviewed Engineer of Record
- ☑ 9. Reviewed available maintenance and operating records, the Operations, Maintenance and Surveillance (OMS) Manual and the Dam Emergency Plan
- ☑ 10. Confirmed proper functioning of mine waste and water management systems and environmental control systems
- ☐ 11. After the above, reassessed the consequence classification, including the identification of required dam safety criteria
- ☐ 12. Carried out a dam safety analysis based on the classification in Item 11
- ☑ 13. Evaluated facility performance and conformance with design basis and operating criteria
- ☑ 14. Identified, characterized and determined the magnitude of deficiencies in the safe operation of the dam and non-conformances in the dam safety management system
- ☑ 15. Recommended and prioritized actions to be taken in relation to deficiencies and non-conformances
- ☑ 16. Prepared a dam safety review report for submittal to the regulatory authority by the Owner and reviewed the report with the Owner
- ☑ 17. The dam safety review report has been reviewed in meeting the intent of APEGBC Bylaw 14(b)(2).

Based on my dam safety review, the dam classification is:

Check one

■ Appropriate

☐ Should be reviewed and amended

I undertook the following type of dam safety review:

Check one

■ Audit

☐ Comprehensive

☐ Detailed design-based multi-disciplinary

☐ Comprehensive, detailed design and performance

I hereby give my assurance that, based on the attached dam safety review report, at this point in time:

Check one

■ The dam is reasonably safe in that the dam safety review did not reveal any unsafe or unacceptable conditions in relation to the design, construction, maintenance and operation of the dam as set out in the attached dam safety review report.

☐ The dam is reasonably safe but the dam safety review did reveal non-conformances with the regulatory requirements as set out in section(s) ____ of the attached dam safety review report.

☐ The dam is reasonably safe but the dam safety review did reveal deficiencies and non-conformances as set out in section(s) ____ of the attached dam safety review report.

☐ The dam is not safe in that the dam safety review did reveal deficiencies and/or non-conformances which require urgent action as set out in section(s) ____ of the attached dam safety review report.

Leon C. Botham

Name

March 24, 2023

Date

Signature

204 - 640 Broadway Avenue, Saskatoon, SK S7N 1A9

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(Affix Professional Seal here)

PROFESSIONAL
PROVINCE OF
L. C. BOTHAM
35852
24 MAR/23
BRITISH COLUMBIA
ENGINEER

If the Qualified Professional Engineer is a member of a firm, complete the following:

I am a member of the firm and I NewFields Canada Mining & Environment ULC sign this letter on behalf of the firm.

(Print name of firm)